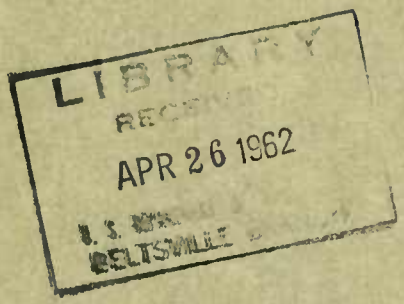
Present and Potential

Commercial Timbers of The Caribbean

With Special Reference to

- The West Indies
- The Guianas
- And British Honduras



Agriculture Handbook No. 207

U.S. Department of Agriculture Forest Service

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- The West Indies
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by

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Agriculture Handbook No. 207

U.S. Department of Agriculture
Washington, D.C.

Forest Service
March 1962

ACKNOWLEDGMENT

The author is indebted to Dr. B. Francis Kukachka, U.S. Forest Products Laboratory, Madison, Wis., for his assistance in preparing the timber descriptions, and to Dr. Elbert L. Little, Jr., Forest Service Dendrologist, for his exhaustive check and verification of the common and scientific names and geographical distribution of the timbers and his thorough review of the text and tabular material.

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Present and Potential Commercial Timbers of The Caribbean

INTRODUCTION

The steady improvement of social and economic conditions in the Caribbean countries has brought about a comparable increase in the consumption of timber and other wood products. Although the Caribbean region includes many millions of acres of forests containing untold billions of cubic feet of timber, most of the increased demand is met by imports from outside the region. Softwoods are imported principally from the United States; hardwoods, from Europe, Africa, and the Philippines. Many hundred, even thousands of different timbers are available in the Caribbean forests; many of them are qualified for the uses filled by imported timbers, yet the intra-Caribbean trade in this commodity is limited to a few species. The present wood consumption in a large part of the region consists mainly of imported softwood (coniferous) species for construction work and a limited use of homegrown hardwoods (broadleaf) for furniture, construction, posts, and fuel.

Hardwood timber is, in general, plentiful throughout the continental area of the Caribbean and on a number of the West Indies islands. But some areas, including Puerto Rico, Jamaica, Barbados, and some of the smaller islands of the Lesser Antilles, are handicapped by a scarcity of both hardwood and softwood species.

The coniferous resources of the region are largely confined to British Honduras, Honduras, Nicaragua, and Mexico on the continent, and to a limited supply in Haiti, Cuba, Dominican Republic, and the Bahamas in the West Indies. Excepting British Honduras, all Caribbean countries are importers of softwood timber, though British Guiana's requirements are nearly met by local hardwoods. The Caribbean area is considered in this work to include the three Guianas and the northern part of Venezuela and Colombia, Central America, southern Mexico, the southern tip of Florida, and the West Indies from Cuba and the Bahamas to Trinidad and Tobago. An increasing proportion of the softwood lumber imports is coming from within the Caribbean region. Nevertheless, the volume of the softwood resources is so limited that the bulk of future requirements will have to be supplied from the outside, largely from the United States.

In British Honduras the pine industry has reached its full development, and further expansion must be based on the utilization of lesser known timbers. In fact, the best pine stands in Central America are being consumed so rapidly that a sharp decline is predicted within the next two or three decades. But in the Guianas the volume of exportable timbers is increasing with advancement in the timber production industry. In this area, vast tracts of unexploited hardwood forests remain untouched.

Many hundreds, even thousands, of different woods are available in the forests of the Caribbean countries. Yet the local commerical production and utilization and the exportation of timbers from the area over the past 300 years, and even today, are confined to a relatively few of these woods. Less than twenty timbers are of importance in the present export market. Consequently, many of the smaller islands and Central American countries import and use softwood timbers where indigenous hardwood species would be satisfactory. Also, many local hardwood timbers, if well manufactured and if properly marketed in quantity, could satisfy similar needs in other countries in the region.

Furthermore, it is reasonable to assume that among the immense number of unused timbers are many with qualities equal or superior to the relatively few native hardwood timbers presently accepted. Some probably possess outstanding beauty, durability, resistance to insects or marine organisms, or have such high strength properties that they would be readily accepted by the local and export trade.

In view of the expanding market and the uncertainty of the present resources of the small number of timbers being utilized, the need for using the lesser known species is of first importance. This applies both to the areas having abundant timber supplies and to the islands having insufficient forest reserves, yet many unused timbers.

Lack of knowledge, particularly by the consumer, seems the principal deterrent to the utilization of lesser known woods. Needed is information on physical and mechanical properties, as well as knowledge of air seasoning, kiln drying, durability, machining characteristics, and resistance to insects and marine organisms. Prospective users should also have the benefit of reliable recommendations on the acceptable uses for the different timbers and an estimate of their present and potential availability.

In view of the above considerations, the Fourth Session of the West Indian Conference held in 1950 recommended that a future conference be convened to consider the agricultural potentialities of the Caribbean area, with special reference to developing the timber trade. Later, the objective was restricted to a study of the present and potential timber trade. The conference, held at Port of Spain, Trinidad, in April 1953, was attended by representatives from most countries and islands of the Caribbean area.

Conference delegates agreed on the need for compiling and publishing a list of the timbers of present and potential regional importance. They also agreed that this document should cover the entire Caribbean, including the independent republics, and should contain all available information on the selected timbers. The principal timbers described in the text were selected largely by member countries of the Caribbean Commission and do not necessarily include all timbers of present or potential importance in the entire Caribbean region.

Countries represented in the selection of timbers are as follows: British Guiana, French Guiana, Surinam, and British Honduras on the continent; Jamaica, Dominican Republic, and Puerto Rico in the Greater Antilles; Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, Trinidad, and Tobago in the Lesser Antilles. Although Cuba and Haiti are not included in this group, they are well represented by the selections made for other islands in the Greater Antilles. But important timbers in other parts of the Caribbean area are not discussed in detail unless they are also presently or potentially important in the above countries or islands.

The conference by resolution directed the Secretariat of the Caribbean Commission to ask the Tropical Forest Research Center of the U.S. Forest Service for assistance in the project. In answer to that request, this publication was prepared. It presents, to the best of the author's knowledge, a summary of all available and worthwhile information on the 71 important timbers in that part of the Caribbean area described above.

SELECTION OF IMPORTANT CARIBBEAN TIMBERS

Foresters and other representatives of the Government attending the 1953 Timber Conference in Port of Spain, Trinidad, selected an initial list of 54 timbers of present or potential commercial importance. The number was later increased to 71 as additional timbers were suggested. This number will surely increase in the years ahead: Remote areas will become more accessible to improved markets, and further studies will be made of the quantity and quality of many woods, currently little known. The final selection of timbers covered in this work and the species chosen are essentially as suggested by the participating governments. The timbers are listed by their preferred trade and botanical names in table 1.

TABLE 1.—*Present and potential commercial timbers of the Caribbean*

Trade name	Scientific name	Page
Angelin	*Andira inermis* (W. Wright) H.B.K.	27
	A. spp.	27
Angelique	*Dicorynia guianensis* Amsh.	28
Aromata	*Clathrotropis macrocarpa* Ducke	30
	C. brachypetala (Tul.) Kleinh.	30
Baboen	*Virola surinamensis* (Rol.) Warb.	30
Bagasse	*Bagassa guianensis* Aubl.	33
	B. tiliaefolia (Desv.) R. Ben.	33
Balata	*Manilkara bidentata* (A. DC.) Chev.	34
Balsa	*Ochroma pyramidale* (Cav.) Urban	36
Banak	*Virola koschnyi* Warb.	30
Baromalli	*Catostemma commune* Sandw.	38
	C. fragrans Benth.	38
Bethabara	*Tabebuia serratifolia* (Vahl) Nicholson	39
Bois gris	*Licania ternatensis* Hook. f.	41
Broadleaf	*Terminalia latifolia* Sw.	42
Bullhoof	*Drypetes brownii* Standl.	43
Bustic	*Dipholis salicifolia* (L.) A. DC.	44
	D. spp.	44
Cedar, Central American	*Cedrela mexicana* M. J. Roem.	45
	C. odorata L.	45
	C. guianensis A. Juss.	45
Courbaril	*Hymenaea courbaril* L.	47
	H. davisii Sandw.	47
Crabwood	*Carapa guianensis* Aubl.	49
Dakama	*Dimorphandra conjugata* (Splitg.) Sandw.	52
Determa	*Ocotea rubra* Mez	53

TABLE 1.—*Present and potential commercial timbers of the Caribbean*—Continued

Trade name	Scientific name	Page
Dukali	*Parahancornia amapa* (Huber) Ducke	54
Encens	*Protium attenuatum* (Rose) Urban	55
Gommier	*Dacryodes excelsa* Vahl	55
Greenheart, Demerara.	*Ocotea rodiaei* (R. Schomb.) Mez	57
Gronfoeloe	*Qualea rosea* Aubl.	60
	Q. coerula Aubl.	60
	Q. albiflora Warm.	60
Gumbo-limbo	*Bursera simaruba* (L.) Sarg.	62
Haiari	*Alexa imperatricis* (Schomb.) Baill.	63
	A. leiopetala Sandw.	63
Hura	*Hura crepitans* L.	64
Inyak	*Antonia ovata* Pohl	65
Kauta	*Licania laxiflora* Fritsch	66
	L. mollis Benth.	66
	L. persaudii Fanshawe & Maguire	66
Kautaballi	*Licania venosa* Rusby	66
	L. majuscula Sagot	66
Kereti silverballi	*Ocotea wachenheimii* R. Ben.	68
	O. puberula Nees	68
Kopie	*Goupia glabra* Aubl.	69
Kurokai	*Protium crenatum* Sandw.	70
	P. decandrum March.	70
	P. sagotianum March.	70
	P. schomburgkianum Engl.	70
Kwarie	*Vochysia guianensis* Aubl.	72
	V. tomentosa DC.	72
Lignumvitae	*Guaiacum officinale* L.	73
	G. sanctum L.	73
Magnolia	*Talauma dodecapetala* (Lam.) Urban	75
Mahoe	*Hibiscus elatus* Sw.	76
Mahogany, Honduras.	*Swietenia macrophylla* King	76
Mahogany, West Indies.	*Swietenia mahagoni* Jacq.	79
Manbarklak	*Eschweilera longipes* (Poit.) Miers	81
	E. subglandulosa (Steud.) Miers	81
Manni	*Symphonia globulifera* L. f.	82
Manniballi	*Inga alba* Willd.	84
Marblewood	*Marmaroxylon racemosum* (Ducke) Killip	85
Marish	*Licania buxifolia* Sandw.	66
	L. densiflora Kleinh.	66
	L. macrophylla Benth.	66
	L. micrantha Miq.	66
Mora	*Mora excelsa* Benth.	86
	M. gonggrijpii (Kleinh.) Sandw.	86
Nargusta	*Terminalia amazonia* (J. F. Gmel.) Exell	86
Pakuri	*Platonia insignis* Mart.	90
Parakusan	*Swartzia jenmanii* Sandw.	92
	S. polyphylla DC.	92
	S. schomburgkii Benth.	92
Pine, Caribbean	*Pinus caribaea* Morelet	92
Podocarp	*Podocarpus coriaceus* L. C. Rich.	95
	P. guatemalensis Standl.	95
Purpleheart	*Peltogyne pubescens* Benth.	96
	P. porphyrocardia Griseb.	96
	P. venosa (Vahl) Benth. var. *densiflora* (Spruce) Amsh.	96
Resolu	*Chimarrhis cymosa* Jacq.	99
Roble	*Tabebuia rosea* (Bertol.) DC.	99
	T. heterophylla (DC.) Britton	99
Rosewood, Honduras.	*Dalbergia stevensonii* Standl.	101
Saman	*Pithecellobium saman* (Jacq.) Benth.	102
Santa-maria	*Calophyllum brasiliense* Camb.	104
	C. lucidum Benth.	104
Sara	*Vouacapoua macropetala* Sandw.	106
Simarouba	*Simarouba amara* Aubl.	107
	S. glauca DC.	107
Snakewood	*Piratinera guianensis* Aubl.	108
Sterculia	*Sterculia pruriens* (Aubl.) K. Schum.	110
	S. caribaea R. Br.	110
	S. rugosa R. Br.	110
Suradan	*Hyeronima laxiflora* (Tul.) Muell.-Arg.	112
	H. alchorneoides Fr. Allem.	112
	H. caribaea Urban	112
	H. clusioides (Tul.) Griseb.	112
Tabebuia, white	*Tabebuia insignis* (Miq.) Sandw. var. *monophylla* Sandw.	114
	T. stenocalyx Sprague & Stapf	114
Tatabu	*Diplotropis purpurea* (Rich.) Amsh.	115
Tauroniro	*Humiria balsamifera* (Aubl.) J. St. Hil.	116
Teak	*Tectona grandis* L. f.	118
Tonka	*Dipteryx odorata* (Aubl.) Willd.	120
Wacapou	*Vouacapoua americana* Aubl.	121
Wallaba	*Eperua falcata* Aubl.	123
	E. grandiflora (Aubl.) Benth.	123
	E. jenmanii Oliver	123
	E. schomburgkiana Benth.	123
Wamara	*Swartzia leiocalycina* Benth.	125
	S. benthamiana Miq.	125
Yemeri	*Vochysia hondurensis* Sprague	126
Yokewood	*Catalpa longissima* (Jacq.) Sims	128

Timbers of similar characteristics are commonly marketed in many parts of the world under a common trade name. Examples of such group marketing are the commercial white oak, hickory, and black gum timbers of the United States, which commonly include from two to ten or more different species. Individual species of these and many other timbers are not available separately on the commercial market. In the Caribbean area where several hundred species reach saw-log size, the opportunities for group marketing are not only more favorable but almost imperative for the successful exploitation of the tropical forests. Consequently, species have been grouped in this work according to the present marketing practices in the countries concerned when available knowledge justifies such a grouping. Many additional species are excluded for lack of information on their physical and mechanical properties. The presently accepted groups will undoubtedly be enlarged with added research and more practical experience.

There is probably less variation between species in any one timber group than is accepted in the usual trade groupings used in other areas. Hence, additional species can eventually be listed in many of the commercial groups without exceeding the accepted range of variability in commercial timber. In some instances, species listed as secondary in importance can be included with the principal species now listed under the accepted trade name.

NOMENCLATURE

The timber trade names in this work were selected principally by members of the interested governments. The author made only a few changes or modifications to clarify the origin of certain timbers or to separate them more clearly from others with similar trade names. Trade names used in the principal country of export are preferred unless subject to confusion with the names of other timbers. The trade names accepted in this work are generally in agreement with those adopted by the British Standards Institute as listed in its "Nomenclature of Commercial Timbers Including its Sources of Supply" (*36*).[1]

Most tropical timbers are known by different common names in each country or territory of origin and often by several names even within each territory. These names are sometimes variations of connotations of the tree's form, fruit, or other morphological characteristics, the uses for its wood and other parts, or certain characteristic features of the tree or its products. Many of these local names are misleading. Some are used repeatedly for different species throughout the Caribbean area. They are, on the whole, unreliable and only of local value, but are listed in this work to assist the reader in identifying local timbers with the preferred trade and accepted botanical names.

The scientific names, including those mentioned incidentally, have been checked and conform to current usage under the International Code of Botanical Nomenclature. Synonyms in use are also listed in the text and index. Further taxonomic studies of tropical trees and woods may result in slight revision of the nomenclature.

DISTRIBUTION AND HABITAT

Most tropical American tree species and timbers of related species are not uniformly distributed throughout the Caribbean area but may be arranged into several geographical groups. Timbers found in one country may be absent from a nearby country. Several examples will illustrate the main patterns of tree distribution of the timbers described here.

Balsa (*Ochroma pyramidale*) is found widely in tropical America, including West Indies, Central America, and northern South America. Some species, such as gommier (*Dacryodes excelsa*), are confined to the West Indies, and a few, such as one kind of magnolia (*Talauma dodecapetala*), are known from only one or a few islands. Others, such as Honduras rosewood (*Dalbergia stevensonii*), are restricted to Central America, or occur also in the West Indies, as does Caribbean pine (*Pinus caribaea*).

The trees and timbers of the Guianas and other parts of northern South America for the most part are different from those of Central America and the West Indies. Many timbers described here are limited to South America (*Catostemma, Eperua, Goupia, Qualea, etc.*). In the Guianas are found many trees of the Amazon rain forest. Trinidad, which is within sight of the continent, has trees of South American relationship, not West Indian. However, some South American trees extend slightly northward into Central America and the southern West Indies.

The section on Distribution and Habitat of the one or more species providing each timber is based on published information. For many species this section is not complete and may be subject to certain revisions as additional botanical classifications are made. Further botanical exploration will likely extend the distribution or range of many timbers and bring about some reclassification or combination of species. Many "species" have already been combined to increase the range of certain timbers. Further published accounts of species occurrence and habitat will also allow the correction of present knowledge.

TREE DESCRIPTIONS

The section under each timber headed The Tree should be of special interest to the forester and other technicians. It will help them correlate the other descriptive material with the botanical species where tree identity is in doubt. To the nontechnical reader, this information can provide a measure of the potential size and the quality of products available from the trees. For example, it should be clear to the reader that snakewood (*Piratinera guianensis*), although moderately resistant to marine borers, does not grow to sufficient size, length, or in suitable form for use as marine piling. Similarly, it is evident that Demerara greenheart (*Ocotea rodiaei*) is generally of adequate size for this use.

The text also shows the variation in tree size between countries and, to some extent, localities and sites. Most writers tend to quote the upper size limits of trees growing on good sites rather than the average or common size at maturity. Detailed botanical descriptions of trees do not appear justified in a text primarily for the reader interested in timber products. This information is

[1] Italic numbers in parentheses refer to Bibliography, p. 131.

available in other publications dealing especially with the subject.

DESCRIPTION OF THE WOOD

Description of the physical characteristics of each timber covered in this text is largely confined to those macroscopic characteristics and other superficial features easily seen by the unaided eye and easily understood by the average wood user. Each timber's description is for the average of that species or group of species. The wood of any species commonly varies between countries of origin, from one locality to another, from tree to tree, and even within the individual tree. Color and grain are the most variable characteristics.

The description of the wood of each timber is a summary of the published information on that timber. Where differences between published references exist, the most logical and generally accepted description was used. As would be expected, disagreement concerning color and texture occurs most often. This is attributable in part to variation in the timber and in part to the lack of established standards for judging these properties.

Descriptions frequently refer to tangential or radial surfaces and transverse or end grain. Tangential surfaces of boards or other specimens are those more or less parallel or tangent to the growth rings of the trees. Radial surfaces are at right angles to the growth rings. Transverse or end-grain surfaces are perpendicular to the main axis of the tree. Thus, if a board is cut from the perimeter of a log, parallel to the growth rings, the wide surface of the board will be termed the tangential surface, the edges of the board will be radial surfaces, and both ends will show transverse or end-grain surfaces, sometimes called the cross-sectional surfaces.

Correspondingly, boards cut parallel to the perimeter or growth rings of the tree are termed "flat-grained," "flat-sawed," or "plainsawed." Those cut across or at right angles to the growth rings are termed "quartersawed" or "edge-grained" lumber. Certain advantages and disadvantages are inherent in either plainsawed or quartersawed lumber (*242*). The principal differences are as follows:

1. Flat-sawed lumber generally reveals better figure patterns resulting from growth rings than quartersawed stock.
2. Flat-sawed lumber is less subject to loss of surface appearance and reduction in strength by round or oval knots or shakes and pitch pockets.
3. Flat-sawed boards shrink less in thickness and more in width than quartersawed boards.
4. Flat-sawed stock is less subject to collapse in drying than quartersawed lumber.
5. Quartersawed lumber cups and twists less in drying than flat-sawed lumber.
6. Quartersawed lumber shows up figures resulting from pronounced rays, interlocked grain, and wavy grain more clearly than flat-sawed lumber.
7. Quartersawed lumber is generally more costly to produce from the log.
8. Quartersawed lumber will surface-check and split less in seasoning than flat-sawed lumber.
9. Quartersawed boards wear more evenly and often hold paint better than flat-sawed boards.

Two other terms commonly used in wood descriptions are texture and grain. Texture is a term that describes the size of the vessels or pores; degrees of texture are very coarse, coarse, medium, fine, or very fine. Grain is a description of the direction of the wood elements. The grain may be straight, wavy, or interlocked. When the grain is straight, the fibers run parallel to the main axis of the tree and generally more or less straight to the length of sawed lumber. Wavy grain, sometimes termed curly grain, undulates back and forth across the surface of lumber. In interlocked or roey-grain timber, the direction of the fiber alinement alternates at intervals, resulting in a ribbon figure on the quartersawed surface. Splitting specimens having interlocked grain reveals an uneven surface on the radial plane.

WEIGHT AND SPECIFIC GRAVITY

Solid wood with all air and moisture excluded is about 1.5 times the weight of water, regardless of the species. The fact that the dry wood of most species floats in water demonstrates that a large part of wood consists of cell cavities and pores. Consequently, variations in the size of cell openings and in the thickness of cell walls result in some species having more wood substance than others and, thereby, a higher specific gravity or weight. Specific gravity is thus a direct index of the amount of wood substance a piece of dry wood contains.

Specific gravity is defined as the ratio of the weight of a given volume of wood to that of an equal volume of water. The weight and volume of wood change with the shrinkage and swelling caused by changes in moisture content. The weight changes with moisture content both above and below the fiber saturation point (around 30 percent). However, volume changes only in wood below the fiber saturation point, as shrinkage does not begin until this point is reached. Hence, a figure for the specific gravity of wood is meaningless unless it includes the moisture content at which the weight and volume of the wood were determined in arriving at the specific gravity figure.

Specific gravity is commonly calculated on two bases: (1) True specific gravity; and (2) nomi-

nal specific gravity. True specific gravity is generally based on the volume and weight of wood in either the air-dry or the green condition. Nominal specific gravities are usually based on volumes when green and weights when ovendry. This specific gravity is based on conditions that could never occur simultaneously. However, true specific gravity can be calculated from nominal specific gravity with perfect accuracy for wood of any moisture content above the fiber saturation point (green timber), and with fair accuracy between the fiber saturation point and air-dry by simply increasing it by a percentage corresponding to the moisture content in question. Thus, by quoting the nominal specific gravity based on green volume and ovendry weight, the reader is able to compute the true specific gravity for wood at any moisture content.

The weight of wood per cubic foot is determined by multiplying true specific gravities by 62.4, or by multiplying nominal specific gravities by the product of 62.4 times the sum of one plus the moisture content of the specimen at the time of test. The weight per cubic foot for each timber when air dry at about 12 percent moisture content and when green is given in table 2.

TABLE 2.—*Specific gravity and weight of Caribbean timbers*

Trade name	Scientific name	Specific gravity based on—		Weight per cubic foot	
		Green volume and ovendry weight	Air-dry volume and weight	Green	Air dry
				Pounds	*Pounds*
Angelin	*Andira inermis*	0. 63	0. 76	74	47
Angelique	*Dicorynia guianensis*	. 60	. 72	67	45
Aromata	*Clathrotropis brachypetala*	----------	1. 10	--------	69
	C. macrocarpa	----------	1. 00	--------	62
Baboen	*Virola surinamensis*	. 42	. 51	51	32
Bagasse	*Bagassa guianensis*	. 68	. 80	67	50
Balata	*Manilkara bidentata*	. 85	. 89	76	64
Balsa [1]	*Ochroma pyramidale*	----------	. 16	--------	10
Banak	*Virola koschnyi*	. 44	. 53	51	33
Baromalli	*Catostemma commune*	. 45	. 60	70	37
Bethabara	*Tabebuia serratifolia*	. 92	1. 10	75	69
Bois gris	*Licania ternatensis*	----------	1. 12	--------	70
Broadleaf	*Terminalia latifolia*	----------	. 65	--------	41
Bullhoof	*Drypetes brownii*	----------	. 74	--------	46
Bustic	*Dipholis salicifolia*	. 86	. 95	77	59
Cedar, Central American	*Cedrela mexicana*, *C. odorata*, *C. guianensis*	. 40	. 48	44	30
Courbaril	*Hymenaea courbaril*	. 70	. 84	70	52
	H. davisii	. 67	. 84	70	52
Crabwood	*Carapa guianensis*	. 56	. 64	56	40
Dakama	*Dimorphandra conjugata*	----------	1. 06	--------	66
Determa	*Ocotea rubra*	. 52	. 62	59	39
Dukali	*Parahancornia amapa*	----------	. 60	--------	37
Encens	*Protium attenuatum*	----------	. 52	--------	32
Gommier	*Dacryodes excelsa*	. 53	. 64	52	40
Greenheart, Demerara	*Ocotea rodiaei*	. 88	1. 04	78	65
Gronfoeloe	*Qualea rosea*	. 53	. 62	60	39
	Q. coerula	----------	. 58	60	36
	Q. albiflora	. 49	. 59	79	37
Gumbo-limbo	*Bursera simaruba*	. 30	. 34	38	21
Haiari	*Alexa imperatricis*, *A. leiopetala*	----------	. 48	--------	30
Hura	*Hura crepitans*	. 38	. 46	40	28
Inyak	*Antonia ovata*	----------	. 53	--------	33
Kauta	*Licania laxiflora*, *L. mollis*, *L. persaudii*	----------	1. 20	--------	75
Kautaballi	*Licania venosa*, *L. majuscula*	----------	1. 15	--------	72
Kereti silverballi	*Ocotea wachenheimii*, *O. puberula*	----------	. 53	--------	32
Kopie	*Goupia glabra*	. 70	. 83	73	52

See footnote at end of table.

TABLE 2.—*Specific gravity and weight of Caribbean timbers*—Continued.

Trade name	Scientific name	Specific gravity based on—		Weight per cubic foot	
		Green volume and ovendry weight	Air-dry volume and weight	Green	Air dry
				Pounds	*Pounds*
Kurokai	*Protium decandrum*	0. 53	0. 64	50	40
	P. schomburgkianum	. 48	. 53	56	33
Kwarie	*Vochysia guianensis*	. 40	. 54	67	34
	V. tomentosa	----------	. 43	67	27
Lignumvitae	*Guaiacum officinale* / *G. sanctum*	----------	1. 28	--------	80
Magnolia	*Talauma dodecapetala*	. 59	. 64	72	44
Mahoe	*Hibiscus elatus*	----------	. 75	--------	47
Mahogany, Honduras:	*Swietenia macrophylla*				
Forest-grown	----------	. 45	. 53	44	33
Plantation-grown	----------	. 42	. 50	40	31
Mahogany, West Indies	*Swietenia mahagoni*	. 56	. 77	68	48
Manbarklak	*Eschweilera subglandulosa*	. 87	1. 08	78	67
Manni	*Symphonia globulifera*	. 58	. 72	67	44
Manniballi	*Inga alba*	----------	. 57	--------	36
Marblewood	*Marmaroxylon racemosum*	----------	1. 15	--------	72
Marish	*Licania buxifolia*	. 88	1. 09	75	68
	L. macrophylla	. 76	. 93	71	58
Mora	*Mora excelsa*	. 78	1. 00	77	62
	M. gonggrijpii	----------	1. 03	--------	64
Nargusta	*Terminalia amazonia*	. 66	. 80	71	50
Pakuri	*Platonia insignis*	----------	. 80	--------	50
Parakusan	*Swartzia jenmanii* / *S. polyphylla* / *S. schomburgkii*	----------	. 78	--------	49
Pine, Caribbean	*Pinus caribaea*	. 65	. 77	57	48
Podocarp	*Podocarpus coriaceus*	----------	. 51	41	32
Purpleheart	*Peltogyne pubescens*	. 74	. 87	75	54
	P. venosa var. *densiflora*	. 75	. 87	77	54
Resolu	*Chimarrhis cymosa*	----------	. 75	--------	47
Roble	*Tabebuia rosea*	. 49	. 58	56	36
	T. heterophylla	. 58	. 67	59	42
Rosewood, Honduras	*Dalbergia stevensonii*	----------	1. 00	--------	62
Saman	*Pithecellobium saman*	. 48	. 56	51	35
Santa-maria	*Calophyllum brasiliense*	. 52	. 61	51	38
Sara	*Vouacapoua macropetala*	----------	. 93	--------	58
Simarouba	*Simarouba amara* / *S. glauca*	. 38	. 44	40	27
Snakewood	*Piratinera guianensis*	----------	1. 20	--------	75
Sterculia	*Sterculia pruriens*	. 44	. 59	53	37
Suradan	*Hyeronima laxiflora*	. 65	. 79	74	49
Tabebuia, white	*Tabebuia insignis* var. *monophylla*	. 55	. 68	65	42
Tatabu	*Diplotropis purpurea*	. 78	. 93	78	58
Tauroniro	*Humiria balsamifera*	. 66	. 80	67	50
Teak:	*Tectona grandis*				
Forest-grown	----------	----------	. 68	62	42
Plantation-grown	----------	----------	. 69	63	43
Tonka	*Dipteryx odorata*	. 89	1. 08	81	67
Wacapou	*Vouacapoua americana*	. 79	. 95	75	59
Wallaba	*Eperua falcata*	. 78	. 93	76	58
Wamara	*Swartzia leiocalycina*	. 87	1. 06	75	66
	S. benthamiana	----------	. 88	--------	55
Yemeri	*Vochysia hondurensis*	. 37	. 45	67	28
Yokewood	*Catalpa longissima*	----------	. 80	--------	50

[1] Wood selected for export generally weighs 7 to 10 pounds per cubic foot air-dry with a specific gravity of 0.11 to 0.18 based on air-dry volume and weight.

Table 2 also carries both the nominal specific gravity based on green volume and ovendry weight of wood, and the true specific gravity based on the air-dry volume and weight of the timber. Several different specific gravity values are often reported in the literature for each timber, and sometimes cover a considerable range. This is to be expected as many factors are included that influence the density of wood. Density often varies considerably between sites and country of orgin and, as many of the timbers have extensive distribution, a considerable range in density is expected. The specific gravities and weights in table 2 are, therefore, the averages of the individual published results from the areas included.

Most specific gravities and weights per cubic foot quoted in the tables and text for air-dry wood are based on a moisture content of 12 percent. The change between 12 and 15 percent moisture content is so minor that no reference is made to the few data based on the higher moisture content.

Some difficulty is encountered in listing specific gravities and weight per cubic foot for the wood of those timbers with two or more species. Where the difference between species is great, the gravity and weight are cited for each species. In other cases, these are combined and represent the timber group. Where this information is available for only one or two species of a trade group, it is stated for the individual species rather than the entire group.

SEASONING

Wood can be air-seasoned in the open or kiln-seasoned in dry kilns using artificial heat and humidity. Few dry kilns are available in the Caribbean area so most lumber is air-seasoned. Because of their diffuse porous nature, tropical hardwoods generally season with less defect than most ring porous woods in the temperate zones.

The tropical climate of the Caribbean area presents both favorable and unfavorable conditions for air-seasoning. One combination bringing about favorable conditions is high temperature and relative humidity throughout the year that allow continuous and uniform drying. This reduces the possibility of serious surface checking, end splitting, cup, bow, and other seasoning defects.

On the other hand, lumber piles should be roofed or under some cover for successful air-seasoning; otherwise, the frequent tropical rains may prevent any appreciable amount of drying during the rainy season or, for that matter, any time of the year. When properly protected from rain, lumber will season throughout the year in most areas of the American tropics. Under cover, lumber 1¼ inches thick will usually air-season in 2 to 6 months. Lumber will normally air-season to a moisture content between 15 and 20 percent, depending on the species, location, and time of year.

Table 3 groups the different timbers according to their ease of air-seasoning. The timbers, divided into three groups, are rated on the time required for each to season and the amount and severity of defects that normally occur. Of necessity, only a small number of groups are used. Thus, where two timbers are quite similar, one may fall in the bottom of one class and the other in the top of the next lower class. This is unavoidable. To a marked extent, the grouping presents the average air-seasoning; it does not cover the possibilities of improving the seasoning qualities of the different timbers by bettering seasoning practices.

Many timbers are degraded during seasoning because of an excessive rate of drying. This can be largely overcome by reducing air circulation; that is, by closer piling, by use of thinner stickers, and by placing shields or covers on one or more sides of the lumber stacks. Other factors such as sticker spacing, width of lumber stacks, and exposure to sun or rain are important in the drying rate and amount of seasoning defect.

End splitting and end checking occur during the seasoning of some timbers. But these faults may be prevented by coating the ends of boards with a moisture-resistant paint, pigments, waxes, or other material to prevent the over-rapid loss of moisture at these places. A commercial mixture of asphalt and plastic roof coating has been used by the Tropical Forest Research Center with excellent success; when end-coated with this material, 60 species of tropical hardwoods were seasoned with no appreciable end defect. The nailing of end cleats or narrow wooden strips to the ends of boards or planks is of only limited value in air-seasoning; during kiln-seasoning this practice can even cause end splits to develop or extend.

The humidity and temperature conditions in the Caribbean area are very favorable for the development of sap-stain fungi in logs and lumber. The best ways to prevent this type of damage are early conversion of logs after felling or storage of logs under water. The application of antiseptic sprays to ends and places from which the bark is removed will also protect most species of logs for 1 or 2 months if wood-infesting insects are not prevalent. Unfortunately, insects are a problem in tropical areas. To prevent their entry into logs and the transmission of fungi to the wood, applying an insecticide to the log is also necessary. In some species, adding an end coating is also required to prevent seasoning checks through which insects or fungi can enter (*242*).

Molds and stains are confined largely to the sapwood; their colors vary. Molds are not responsible for much staining. The discoloration caused by them is mostly superficial and largely due to the cottony or powdery surface growths easily removed by brushing or light surfacing.

TABLE 3.—*Caribbean timbers grouped as to their ease of air-seasoning*

Trade name	Scientific name
EASY TO SEASON	
Angelin	*Andira* spp. / *A. inermis*
Bagasse	*Bagassa guianensis*
Bethabara	*Tabebuia serratifolia*
Cedar, Central American.	*Cedrela guianensis* / *C. mexicana* / *C. odorata*
Encens	*Protium attenuatum*
Gommier	*Dacryodes excelsa*
Gumbo-limbo	*Bursera simaruba*
Kereti silverballi	*Ocotea wachenheimii* / *O. puberula*
Magnolia	*Talauma dodecapetala*
Mahogany, Honduras.	*Swietenia macrophylla*
Mahogany, West Indies.	*Swietenia mahagoni*
Manni	*Symphonia globulifera*
Podocarp	*Podocarpus coriaceus* / *P. guatemalensis*
Roble	*Tabebuia heterophylla* / *T. rosea*
Saman	*Pithecellobium saman*
Simarouba	*Simarouba amara* / *S. glauca*
Tabebuia, white	*Tabebuia insignis* var. *monophylla* / *T. stenocalyx*
Teak	*Tectona grandis*
Tonka	*Dipteryx odorata*
MODERATELY DIFFICULT TO SEASON	
Angelique	*Dicorynia guianensis*
Baboen	*Virola surinamensis*
Banak	*Virola koschnyi*
Baromalli	*Catostemma commune* / *C. fragrans*
Bois gris	*Licania ternatensis*
Bullhoof	*Drypetes brownii*
Courbaril	*Hymenaea courbaril*
Crabwood	*Carapa guianensis*
Determa	*Ocotea rubra*
Greenheart, Demerara	*Ocotea rodiaei*
Gronfoeloe	*Qualea rosea* / *Q. coerula* / *Q. albiflora*
Hura	*Hura crepitans*
Kauta	*Licania laxiflora* / *L. mollis* / *L. persuadii*
Kautaballi	*Licania venosa* / *L. majuscula*
Kopie	*Goupia glabra*
Kurokai	*Protium crenatum* / *P. decandrum* / *P. sagotianum* / *P. schomburgkianum*
Kwarie	*Vochysia guianensis* / *V. tomentosa*
Manbarklak	*Eschweilera longipes* / *E. subglandulosa*
Manniballi	*Inga alba*
Marish	*Licania buxifolia* / *L. macrophylla* / *L. densiflora* / *L. micrantha*
Nargusta	*Terminalia amazonia*
Pine, Caribbean	*Pinus caribaea*
Purpleheart	*Peltogyne pubescens* / *P. perphyrocardia* / *P. venosa* var. *densiflora*
Resolu	*Chimarrhis cymosa*
Rosewood, Honduras.	*Dalbergia stevensonii*
Santa-maria	*Calophyllum brasiliense* / *C. lucidum*
Sara	*Vouacapoua macropetala*
Sterculia	*Sterculia pruriens* / *S. caribaea* / *S. rugosa*
Suradan	*Hyeronima laxiflora* / *H. alchorneoides* / *H. caribaea* / *H. clusioides*
Tatabu	*Diplotropis purpurea*
Tauroniro	*Humiria balsamifera*
Wacapou	*Vouacapoua americana*
Wallaba	*Eperua falcata* / *E. grandiflora* / *E. jenmanii* / *E. schomburgkiana*
Wamara	*Swartzia leiocalycina* / *S. benthamiana*
Yemeri	*Vochysia hondurensis*
DIFFICULT TO SEASON	
Balata	*Manilkara bidentata*
Balsa	*Ochroma pyramidale*
Courbaril	*Hymenaea davisii*
Haiari	*Aleza imperatricis* / *A. leiopetala*
Lignumvitae	*Guaiacum sanctum* / *G. officinale*
Mora	*Mora excelsa* / *M. gonggrijpii*

Stains resulting from sap-staining fungi penetrate into the sapwood (not heartwood) and cannot be removed by surfacing. The discoloration of the wood is visible as specks, spots, streaks, or patches. At times it can be seen throughout the entire sapwood layer. Shortly after the lumber is cut from the logs, it may become infected by airborne fungi. Stains develop rapidly and noticeable discoloration may be evident within 24 hours after conversion.

Stain may be controlled by piling products immediately after conversion, so that the wood's surface dries rapidly. This is often impractical, or results in excessive seasoning degrade from the too rapid loss of moisture during the early stages of drying. Stain may also be controlled by dipping, spraying, or brushing the wood with antiseptic solutions, such as chlorinated phenols, organic mercury compounds, and borax. Numerous commercial products are also on the market for this use. Early treatment is imperative: once sap stain is established it cannot be controlled by treating the wood surface with chemicals. Rapid air-seasoning or kiln-drying below 20 percent moisture content is the most effective control measure once sap stain is present.

Most information on kiln-seasoning of Caribbean timbers has been developed by the Forest Products Research Laboratory in England. Frequent reference is made in this text to the kiln schedules recommended for different timbers in their "Kiln Operator's Handbook" (*222*). One of their more recent publications, No. 42, provides new schedules for faster drying and more severe kiln conditions. Any reader interested in kiln-seasoning of tropical American timbers should acquire these publications for details on kiln schedules and recommended operating techniques. The U.S. Forest Products Laboratory, Madison, Wis., also lists kiln schedules in its report D–1791 that may be used for tropical hardwoods by experienced kiln operators.

SHRINKAGE AND MOVEMENT

Freshly sawed lumber contains from 30 to more than 300 percent water, based on the ovendry weight of the wood. The percentage of moisture varies according to species. In the green condition, dense, close-grained wood contains less moisture than open-grained, less dense wood. As an example, very heavy woods often contain 30 to 40 percent moisture in the green condition, compared to as much as 300 percent or more in some very light woods such as balsa.

Water is present in wood in two forms; as free water in the cell cavities and intercellular spaces of the wood and as absorbed water held in the walls of the wood elements. When the free water is removed but all the absorbed water remains in the cell walls, the wood is said to have reached the fiber saturation point. This condition occurs at about 30 percent moisture content but may vary considerably between species. Shrinkage does not occur in wood until this point has been reached. However, as a piece of wood dries, the outer part is reduced to a moisture content below the fiber saturation point sooner than the interior. Consequently, the whole piece may show some shrinkage near the surface before the average moisture content reaches the fiber saturation point.

Wood shrinks as it loses moisture below the fiber saturation point. Wood that has reached the air-dry condition at 15 percent moisture content has undergone about half the shrinkage possible. For each 1 percent loss of moisture below the fiber saturation point (30 percent moisture content), wood shrinks about one-thirtieth of the total possible shrinkage. Shrinkage values are normally calculated and reported as the total shrinkage from green to ovendry wood, and expressed as a percent of the original green volume.

For Caribbean timbers, shrinkage values are presented on this basis in table 4, and in the sections discussing shrinkage of the timbers in the text. Shrinkage from green to 15 percent moisture content (the air-dry moisture content often used for timbers in this area) amounts to half the total shrinkage. Shrinkage to 10 percent and 20 percent moisture contents amounts to ⅔ and ⅓ of the total shrinkage respectively.

Wood generally shrinks about twice as much in the direction of growth rings (tangential) as across the growth rings (radial) and very little along the grain (longitudinal). Consequently, wood that contains cross grain (interlocked) or irregular grain will shrink more longitudinally than straight-grained wood because of the tangential and radial surfaces. The total shrinkage in all directions quoted as one sum is termed volumetric shrinkage.

The relationship of radial shrinkage to tangential shrinkage is often an indication of the inherent tendency of a wood to cup and otherwise distort during seasoning. Generally, woods that have a low ratio of tangential to radial shrinkage season with less cupping and other defects than woods with a higher ratio. Likewise, because of the greater shrinkage in the direction of the growth rings, "flat-sawed" or "plainsawed" boards are more apt to cup and surface check than "quartersawed" or "edge-grained" boards. Flat-sawed boards are also subject to greater shrinkage across the surface and less in thickness than quartersawed boards.

In general, heavier pieces of wood shrink more than lighter pieces of the same species. There are, however, many exceptions where heavy species shrink less than those that weigh less and where lightweight woods have large shrinkage values. Recent studies at Yale University (*250*) show that tropical woods, with few exceptions, undergo lower shrinkage than United States woods of similar density. They found no correlation between volumetric shrinkage and specific gravity, indicating something other than weight was the dominant factor controlling shrinkage.

Shrinkage during drying is to some extent a criterion of subsequent shrinkage and swelling that will occur in the wood as a result of changes in atmospheric conditions. Wood is exposed to continuous daily and seasonal changes in relative humidity. Its tendency to absorb or give off moisture to come into balance with the surrounding air is accompanied by swelling or shrinking of the wood. This movement may be in the same proportions as the initial shrinkage in seasoning. In the absence of specific movement values, it is reasonable to assume a dimensional change of one-thirtieth of the shrinkage from green to ovendry for each 1-percent change in moisture content. However, recent studies at the Forest Products Research Laboratory in England show that all woods do not undergo dimensional changes in response to changed atmospheric conditions in proportion to their initial shrinkage values (*108*). They found that some woods shrink appreciably in drying, yet may undergo comparatively small dimensional changes in use.

TABLE 4.—*Shrinkage properties of Caribbean timbers*

Trade name	Scientific name	Shrinkage—green to ovendry			
		Radial	Tangential	Longitudinal	Volumetric
		Percent	*Percent*	*Percent*	*Percent*
Angelin	*Andira inermis*	3. 6	7. 1	0. 24	10. 6
Angelique	*Dicorynia guianensis*	4. 6	8. 2	. 16	14. 0
Baboen	*Virola surinamensis*	5. 3	12. 4		17. 6
Bagasse	*Bagassa guianensis*	5. 2	6. 6	. 09	10. 2
Balata	*Manilkara bidentata*	6. 3	9. 4	. 23	16. 9
Balsa (17 lbs./cu. ft.)	*Ochroma pyramidale*	3. 0	7. 6	. 47	10. 8
Banak	*Virola koschnyi*	4. 8	13. 4		
Baromalli	*Catostemma fragrans*	5. 4	11. 7		17. 1
Bethabara	*Tabebuia serratifolia*	6. 6	8. 0	. 16	13. 2
Cedar, Central American	*Cedrela guianensis*, *C. odorata*, *C. mexicana*	4. 1	4. 9		8. 9
Courbaril	*Hymenaea courbaril*	4. 5	8. 5	. 27	12. 7
	H. davisii	4. 1	7. 6	. 51	14. 8
Crabwood	*Carapa guianensis*	3. 1	7. 6	. 10	10. 4
Determa	*Ocotea rubra*	3. 7	7. 6	. 26	10. 4
Gommier	*Dacryodes excelsa*	4. 1	6. 4	. 24	10. 5
Greenheart, Demerara	*Ocotea rodiaei*	8. 2	9. 6		16. 8
Gronfoeloe	*Qualea rosea*	4. 4	8. 4	. 08	11. 4
	Q. coerula	3. 7	7. 9		
	Q. albiflora	4. 0	7. 7	. 14	12. 7
Gumbo-limbo	*Bursera simaruba*	2. 3	3. 6		8. 6
Hura	*Hura crepitans*	2. 7	4. 5	. 48	7. 3
Kereti silverballi	*Ocotea wachenheimii*	3. 6	7. 2		
Kopie	*Goupia glabra*	4. 5	8. 0	8. 18	12. 6
Kurokai	*Protium schomburgkianum*	4. 2	6. 8		10. 7
Kwarie	*Vochysia guianensis*	4. 8	8. 2	. 07	15. 4
	V. tomentosa	2. 5	8. 8		
Mahogany, Honduras:	*Swietenia macrophylla*				
Forest-grown		3. 1	4. 2		7. 6
Plantation-grown		2. 4	4. 2	. 42	6. 6
Mahogany, West Indies	*Swietenia mahagoni*	4. 6	5. 4		6. 9
Manbarklak	*Eschweilera subglandulosa*	5. 8	10. 3	. 28	15. 9
Manni	*Symphonia globulifera*	5. 7	9. 7	. 15	15. 6
Manniballi	*Inga alba*	3. 1	7. 2		
Marblewood	*Marmaroxylon racemosum*				14. 3
Marish	*Licania buxifolia*	7. 5	11. 7	. 21	17. 2
	L. macrophylla	6. 8	10. 6	. 31	16. 2
Mora	*Mora excelsa*	6. 9	9. 8	. 36	18. 8
Nargusta	*Terminalia amazonia*	4. 8	7. 9	. 18	12. 7
Pakuri	*Platonia insignis*				17. 3
Pine, Caribbean	*Pinus caribaea*	6. 3	7. 8		12. 9
Purpleheart	*Peltogyne pubescens*	5. 8	8. 4		13. 2
Roble	*Tabebuia rosea*	3. 6	6. 1	. 16	9. 5
	T. heterophylla	4. 1	5. 5	. 28	9. 7
Rosewood, Honduras	*Dalbergia stevensonii* [1]	2. 9	4. 6	. 34	7. 2
Saman	*Pithecellobium saman*	2. 9	4. 4	. 26	7. 1
Santa-maria	*Calophyllum brasiliense*	4. 8	7. 1	. 03	12. 3
Simarouba	*Simarouba amara*	2. 3	5. 0	. 27	8. 0
Sterculia	*Sterculia pruriens*	5. 7	9. 2		13. 6
Suradan	*Hyeronima laxiflora*	5. 3	9. 4	. 34	14. 4
Tabebuia, white	*Tabebuia insignis* var. *monophylla*, *T. stenocalyx*	5. 8	7. 7		13. 7
Tatabu	*Diplotropis purpurea*	4. 6	7. 0	. 15	11. 8
Tauroniro	*Humiria balsamifera*	7. 2	9. 7	. 09	15. 7
Teak:					
Forest-grown	*Tectona grandis*	2. 3	4. 2		6. 8
Plantation-grown	*Tectona grandis*	2. 1	4. 6	. 37	5. 1
Tonka	*Dipteryx odorata*	5. 0	7. 6	. 13	12. 0
Wacapou	*Vouacapoua americana*	4. 9	6. 9	. 12	13. 0
Wallaba	*Eperua falcata*	3. 6	6. 9	. 17	10. 0
Wamara	*Swartzia benthamiana*				13. 3
Yemeri	*Vochysia hondurensis*	2. 0	8. 0	. 17	9. 8

[1] From *Dalbergia* sp.

Several factors may be responsible for this phenomenon; the most apparent is the difference in the fiber saturation point between species. Those woods having a low fiber saturation point are likely to shrink or swell more than woods having a high fiber saturation point. Another factor is the range in moisture content of the different woods at any given range of atmospheric moisture conditions. The method of seasoning may also affect the initial shrinkage. It may cause collapse or honeycombing, and thereby change the wood structure enough so that subsequent movements do not correspond to the initial shrinkage values. Other minute but important cellular changes may also occur in seasoning that may alter the wood's response to changes in moisture content.

Shrinkage and movement values have practical application in determining the proper moisture content for woods used in different conditions. Movement values are often important in the selection of wood for certain uses. The preference for teak for ship decking is a prime example of this.

STRENGTH PROPERTIES

The uses for many timbers are based largely on their strength or mechanical properties. Tests of mechanical properties have been conducted on most of the Caribbean timbers discussed in this report. Tables 10 and 11 in the appendix present results of tests for green and air-dry wood for most of the timbers covered in the text. For comparison, data for a number of well-known woods from Europe and the United States are also included.

Tests were made on small clear specimens 2 by 2 inches or smaller in cross section and of specific lengths, according to the test specifications. Standard testing procedures of the American Society for Testing Materials or the "Monnin System" as used in most European countries were followed (*13*). Actually, these values are not safe working stresses because they were obtained for material free from all defects, such as knots, checks, shakes, and distorted grain that have an appreciable effect on the strength of seasoned timber.

Anyone designing timber structures will find table 12 in the appendix of some value, as it shows the maximum allowable stresses for certain tropical timbers under different circumstances. Data for these tables were taken from J. Ph. Pfeiffer's "De Houtsoorten Van Surinam" (Surinam Timbers), v. 2, pp. 192–193 (*175*). The conversion from kilograms per cubic inch to pounds per cubic inch was computed in the Central Secretariat of the Caribbean Commission (*50*). Any changes in species botanical names from those listed by Pfeiffer were made in accordance with a more recent publication by the Surinam Forest Service.

As it dries, wood increases in strength (*260*) but not until the fiber saturation point is reached. However, not all strength properties are increased with a decrease in moisture content. In fact, toughness or shock resistance, which is dependent upon both strength and pliability, sometimes decreases as the wood dries. This is largely due to the inability of dry wood to bend as far as green wood before failure, even though it will sustain a greater load.

In general, the strength of wood increases about in proportion to the increase in specific gravity. Thus, in most woods, the heavier of two pieces or species at the same moisture content will be superior in most strength properties. Yet there may be marked differences in certain specific properties between timbers of the same weight due to differences in the structure of the wood. This point is illustrated by the toughness of ash compared to other woods of similar weight.

Strength tests of 126 tropical American hardwoods, conducted at Yale University (*250*), show that tropical timbers in the green condition are usually superior in bending strength, crushing strength, and a number of other properties to hardwoods of similar density growing in the United States. After seasoning, however, the tropical woods generally show less improvement in most strength properties than domestic woods. As a result, tropical woods lose much of their superiority in strength over woods from the United States after air-drying. Also tropical woods are commonly lower in cleavage and tension perpendicular to the grain when air-dried than when green.

The strength properties cited in the tables and discussed later in the timber descriptions are listed below. The descriptions are largely from the Wood Handbook (*242*) and Technical Bulletin 479 (*160*) prepared by the U.S. Forest Products Laboratory.

Fiber stress at proportional limit in static bending.—This property is the measure of the computed stress at which the strain (or deflection) becomes no longer proportional to the stress (load). It is, therefore, the stress (load) at which the load-deflection curve departs from a straight line. This is the upper limit to the stresses or loads that can be used in the design of permanent structures.

Modulus of rupture in static bending.—This is a measure of the capacity of a beam to support a slowly applied load for a short time. Of particular importance in timbers subject to transverse bending, it is used to determine the safe working stresses (loads) for timbers of different species and with certain defects.

Modulus of elasticity in static bending.—A measure of stiffness or rigidity. In a beam, the modulus of elasticity is a measure of its resistance to deflection (bending); hence, the greater the

stiffness the less the deflection. It is useful for computing the deflection of beams, joists, and stringers under loads that do not cause stresses beyond the proportional limit. It is also used in computing the load that can be carried by a long column.

Work to proportional limit in static bending.—A measure of the energy absorbed by a beam when it is stressed to the proportional limit. While the values cannot be used directly in strength calculations, they are a comparative measure of the toughness of a piece to the elastic limit. It is also a value by which different species can be compared in their ability to absorb shock without permanent damage.

Work to maximum load in static bending.—The ability of timber to absorb shock with some permanent deformation and more or less injury to the timber. It is a measure of combined strength and toughness of wood under bending stresses, and is of particular importance where timbers are subjected to considerable bending under heavy loads.

Fiber stress at proportional limits in compression parallel to the grain.—The greatest stress at which the compressive load remains proportional to the shortening of the specimen. This property helps to determine safe working stresses for short columns as well as design values for bolted joints and similar values.

Maximum crushing strength in compression parallel to the grain.—The maximum capacity of a short piece to withstand loads applied on the end grain. It is a means to estimate the endwise crushing of wood in short structural timbers, design of bolted joints, and other similar uses in the development of safe working stresses. It is of considerable importance where short columns or props are to be used.

Modulus of elasticity in compression parallel to the grain.—A measure of stiffness useful in calculating the strength of long columns.

Hardness.—Represents the resistance of wood to wear and marring. Values are presented for end-grain surfaces and side-grain surfaces. Side-grain values are the calculated average for the radial and tangential surfaces combined. Hardness is important when timber is used for such purposes as flooring, furniture, paving blocks, bearing blocks, and railway ties.

Compression perpendicular to grain-fiber stress at proportional limit.—The maximum across-the-grain stress of a few minutes duration that can be applied through a plate covering only part of a timber surface without causing injury to the timber. It is especially useful in deriving safe working stresses for computing the bearing area for beams, stringers, and joists and in comparing species for railway ties.

Tension perpendicular to grain.—An expression of the average maximum stress sustained across the grain by the wood. It is useful in comparing species and for estimating the resistance of timber to forces acting across the grain.

Shear (parallel to the grain).—A measure of the ability of timber to resist slipping of one part upon another along the grain. It is an important property in beams, where the stress tends to cause the upper half of the beam to slide upon the lower and in timbers fastened by bolts and other connectors.

Cleavage.—The maximum load required to cause splitting. It is an important factor where timbers are nailed or bolted. However, a low cleavage value can be advantageous where timbers must be split prior to use.

Toughness.—A measure of the ability of a wood to withstand shock or impact loads. It is a means of comparing species and of selecting stock of known properties, particularly when used in conjunction with specific gravity.

WORKING PROPERTIES

The working properties of the different timbers are often an important factor in their selection for specific uses. These properties are important when either hand or machine tools are used, for timbers vary in their workability as they do in other properties. The section on working properties for each timber summarizes the published information concerning the various operations in woodworking. Unless otherwise stated, the descriptions are for air-dry timber, ordinarily from 12 to 18 percent moisture content. One general exception are the tests at the U.S. Forest Products Laboratory in which wood was seasoned to 6 percent moisture before testing (*68*).

Table 5 lists the different timbers by their working qualities, including the ease with which the timbers can be sawed or machined, as well as the quality or grade of the machined surface. A wood that works with considerable ease but produces many defective pieces would not be classed as a timber that is "easy to work." However, the more dense woods tend to be more difficult to machine.

In the absence of a specific method for rating the different working properties, the ratings are based on the general opinion and experience of woodworkers and research technicians as reported in various publications. Consequently, a timber at the bottom of one class may not be much different from one in the top of the next lower class.

The machining tests on Caribbean timbers have usually been made under standard working conditions on commercial machines. Ordinarily developed for timber of average properties, these working conditions are often not entirely suitable for very dense or light timber, or for those woods having a particular machining problem. Consequently, the working properties of many timbers can be improved under different or special ma-

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TABLE 5.—*Classification of Caribbean timbers as to their working properties*

Trade name	Scientific name
EASY TO WORK	
Angelin	*Andira* spp.
	A. inermis
Angelique	*Dicorynia guianensis*
Baboen	*Virola surinamensis*
Bagasse	*Bagassa guianensis*
	B. tiliaefolia
Balsa	*Ochroma pyramidale*
Banak	*Virola koschnyi*
Broadleaf	*Terminalia latifolia*
Bustic	*Dipholis* spp.
Cedar, Central American.	*Cedrela guianensis*
	C. mexicana
	C. odorata
Crabwood	*Carapa guianensis*
Determa	*Ocotea rubra*
Dukali	*Parahancornia amapa*
Encens	*Protium attenuatum*
Gommier	*Dacryodes excelsa*
Gumbo-limbo	*Bursera simaruba*
Haiari	*Alexa imperatricis*
	A. leiopetala
Hura	*Hura crepitans*
Inyak	*Antonia ovata*
Kereti silverballi	*Ocotea wachenhemii*
	O. puberula
Kurokai	*Protium crenatum*
	P. decandrum
	P. sagotianum
	P. schomburgkianum
Magnolia	*Talauma dodecapetala*
Mahoe	*Hibiscus elatus*
Mahogany, Honduras.	*Swietenia macrophylla*
Mahogany, West Indies.	*Swietenia mahagoni*
Manni	*Symphonia globulifera*
Manniballi	*Inga alba*
Parakusan	*Swartzia jenmanii*
	S. polyphylla
	S. schomburgkii
Pine, Caribbean	*Pinus caribaea*
Podocarp	*Podocarpus coriaceus*
	P. guatemalensis
Resolu	*Chimarrhis cymosa*
Roble	*Tabebuia heterophylla*
	T. rosea
Saman	*Pithecellobium saman*
Santa-maria	*Calophyllum brasiliense*
	C. lucidum
Sara	*Vouacapoua macropetala*
Simarouba	*Simarouba amara*
	S. glauca
Sterculia	*Sterculia pruriens*
	S. caribaea
	S. rugosa
Tabebuia, white	*Tabebuia insignis* var. *monophylla*
	T. stenocalyx
Teak	*Tectona grandis*
Yokewood	*Catalpa longissima*

Trade name	Scientific name
MODERATELY DIFFICULT TO WORK	
Aromata	*Clathrotropis brachypetala*
	C. macrocarpa
Balata	*Manilkara bidentata*
Baromalli	*Catostemma commune*
	C. fragrans
Bethabara	*Tabebuia serratifolia*
Bullhoof	*Drypetes brownii*
Courbaril	*Hymenaea courbaril*
	H. davisii
Dakama	*Dimorphandra conjugata*
Greenheart, Demerara.	*Ocotea rodiaei*
Gronfoeloe	*Qualea rosea*
	Q. albiflora
Kopie	*Goupia glabra*
Mora	*Mora excelsa*
	M. gongrijpii
Nargusta	*Terminalia amazonia*
Pakuri	*Platonia insignis*
Purpleheart	*Peltogyne pubescens*
	P. porphyrocardia
	P. venosa var. *densiflora*
Suradan	*Hyeronima laxiflora*
	H. alchorneoides
	H. caribaea
	H. clusioides
Tatabu	*Diplotropis purpurea*
Tauroniro	*Humiria balsamifera*
Wacapoua	*Vouacapoua americana*
Wallaba	*Eperua falcata*
	E. grandiflora
	E. jenmanii
	E. schomburgkiana
Wamara	*Swartzia leiocalycina*
	S. benthamiana
DIFFICULT TO WORK	
Bois gris	*Licania ternatensis*
Kauta	*Licania laxiflora*
	L. mollis
	L. persaudii
Kautaballi	*Licania venosa*
	L. majuscula
Kwarie	*Vochysia guianensis*
	V. tomentosa
Lignumvitae	*Guaiacum officinale*
	G. sanctum
Manbarklak	*Eschweilera longipes*
	E. subglandulosa
Marblewood	*Marmaroxylon racemosum*
Marish	*Licania buxifolia*
	L. macrophylla
	L. densiflora
	L. micrantha
Rosewood, Honduras.	*Dalbergia stevensonii*
Snakewood	*Piratinera guianensis*
Tonka	*Dipteryx odorata*
Yemeri	*Vochysia hondurensis*

chining conditions. Changing the cutting angle, feed rate, spindle or rim speed, or using special cutters or saw blades can often improve the machinability of a timber. Tests at the U.S. Forest Products Laboratory have indicated that "in general the tropical hardwoods machined as well as do our native hardwoods and with most of them at least it seems unlikely that machining difficulties would restrict their use much" (*68*).

RESISTANCE TO DECAY

The ability to resist decay is important when woods are selected for certain uses, but it is of little consequence where the wood will not be subject to

conditions favorable for decay. Decay is an ever-present hazard in the tropics where the conditions of moisture and temperature are ordinarily ideal for the development of fungi. Unless preservative treatment is applied, only timbers with considerable decay resistance should be used for posts, poles, railway ties, foundations, and other uses where the timber may become damp or wet. Decay resistance is not important where wood is used for furniture, cabinetwork, millwork, and other interior or protected uses. Then too, wood will not ordinarily decay in exterior uses where it is subject to frequent wetting, unless the construction is such that the wood is prevented from drying out after each wetting.

Most decay occurs in wood with a moisture content above the fiber saturation point—about 30 percent moisture content. On the other hand, wood that is continuously water soaked or continuously dry will not decay. Thus, the underwater portion of piling and bridgework or air-dry timber at 20 percent or less moisture content is safe from damage. Wood kept at the air-dry moisture content of 15 to 20 percent in the Caribbean area is, consequently, in no danger of decay. However, decay is almost certain to occur if the construction allows any part of a board or timber to remain wet for long periods of time.

The description in the text of the decay resistance of each timber is based on the durability of untreated heartwood, which is more durable than sapwood. It is doubtful if the sapwood of any species is durable without preservative treatment. Information on durability was available from published results of graveyard tests, pure culture laboratory tests, and from published observations on the durability of the different woods while in use.

Information derived from graveyard tests, in which untreated heartwood posts of tropical species (either round or square) are set in the ground and inspected periodically for decay, is available from Surinam, British Guiana, Trinidad, St. Lucia, Panama, Puerto Rico, England, and the United States. The results sometimes vary between countries but are generally in good agreement.

In pure culture tests small heartwood specimens are exposed to fungal attack under closely controlled laboratory conditions, and the relative durability of different woods is determined on the basis of the loss in weight through decay. The results of these tests at Yale University and the U.S. Forest Products Laboratory are in very good agreement. However, the results of graveyard tests and pure culture tests are not in agreement for some timbers. When this occurs, the laboratory tests generally show the higher decay resistance. It appears that the laboratory tests conducted under closely controlled conditions may be the most reliable. In the laboratory, it is not difficult to distinguish heartwood from sapwood; but in graveyard tests, it is sometimes very difficult in timbers without well-defined heartwood to be certain whether the posts used contain heartwood or sapwood. This may be the reason for some of the discrepancies between different graveyard tests.

Table 6 lists the timbers by durability classes, according to the published results of field and laboratory tests. Four classifications are used: Very resistant, resistant, moderately resistant, and nonresistant. When authors report differences in tests and results, the most consistent or reliable rating is used. Timbers reported to be quite variable in durability and those rated on the basis of general reputation alone are indicated by footnotes.

RESISTANCE TO ATTACK BY TERMITES AND OTHER INSECTS

The sections on durability in the timber descriptions contain a brief summary of the published information on damage by wood-attacking insects. Unfortunately, very little information is available concerning insect attack on the Caribbean timbers except for the comprehensive laboratory tests conducted by G. N. Wolcott (*262*, *263*) on the resistance of woods to attack by the West Indian dry-wood termite (*Cryptotermes brevis* Walker) and a less comprehensive study of damage by subterranean termites of Trinidad timbers (*39*). Most information on other insect damage to logs and sawed products is based on casual observations and experience which, although generally reliable, is often influenced by local conditions peculiar to a small area.

The most common wood-attacking insects in the Caribbean region are the ambrosia beetles (Scolytidae and Platypodidae), both dry-wood and subterranean termites (Order Isoptera), and powder-post beetles (Bostrychidae and Lyctidae). Ambrosia beetles, more often called pinhole borers, are a common menace in green logs and lumber and sometimes attack living trees. Both unseasoned sapwood or heartwood may be attacked. Attack by these insects is evidenced by numerous holes 1/50 to 1/8 inch in diameter, according to the species of pinhole borer responsible. Entry of pinhole borers is often associated with staining of the wood around the holes. Damage by this insect is liable to be severe if logs are not converted soon after felling or if they are not protected by insecticide sprays.

Attack ceases when the timber is seasoned. Damage can be prevented in freshly sawed lumber or living beetles destroyed by dipping the product in a water solution containing 0.2 percent of gamma benzene hexachloride. It is also a common practice to include in the same solution an ingredient to prevent sap stain and keep the lumber bright.

TABLE 6.—*Classification of Caribbean timbers as to their resistance to decay*

Trade name	Scientific name
VERY RESISTANT TO DECAY	
Bagasse	*Bagassa guianensis* *B. tiliaefolia*
Balata	*Manilkara bidentata*
Bethabara	*Tabebuia serratifolia*
Greenheart, Demerara.	*Ocotea rodiaei*
Haiari	*Alexa imperatricis* *A. leiopetala*
Lignumvitae	*Guaiacum officinale* *G. sanctum*
Mahogany, West Indies.	*Swietenia mahagoni*
Manbarklak	*Eschweilera longipes* *E. subglandulosa*
Rosewood, Honduras	*Dalbergia stevensonii*
Snakewood	*Piratinera guianensis*
Tatabu [1]	*Diplotropis purpurea*
Tonka	*Dipteryx odorata*
Wacapou	*Vouacapoua americana*
Wallaba	*Eperua falcata* *E. grandiflora* *E. jenmanii* *E. schomburgkiana*
Wamara	*Swartzia leiocalycina* *S. benthamiana*
RESISTANT TO DECAY	
Angelin	*Andira* spp. *A. inermis*
Angelique	*Dicorynia guianensis*
Bois gris [2]	*Licania ternatensis*
Bustic [2]	*Dipholis* spp.
Cedar, Central American.[1]	*Cedrela mexicana* *C. odorata* *C. guianensis*
Courbaril	*Hymenaea courbaril* *H. davisii*
Determa	*Ocotea rubra*
Kopie	*Goupia glabra*
Mahoe [2]	*Hibiscus elatus*
Mahogany, Honduras.	*Swietenia macrophylla*
Manni	*Symphonia globulifera*
Marblewood [2]	*Marmaroxylon racemosum*
Mora	*Mora excelsa* *M. gonggrijpii*
Nargusta	*Terminalia amazonia*
Pakuri [2]	*Platonia insignis*
Pine, Caribbean	*Pinus caribaea* (also moderately resistant).
Podocarp	*Podocarpus coriaceus* *P. guatemalensis*
Purpleheart	*Peltogyne pubescens* *P. porphyrocardia* *P. venosa* var. *densiflora*
Resolu [2]	*Chimarrhis cymosa*
Roble	*Tabebuia heterophylla* *T. rosea*
Saman	*Pithecellobium saman*
Santa-maria [1]	*Calophyllum brasiliense* *C. lucidum*
Suradan	*Hyeronima laxiflora* *H. alchorneoides* *H. caribaea* *H. clusioides*
Teak	*Tectona grandis*
Yokewood [2]	*Catalpa longissima*
MODERATELY RESISTANT TO DECAY	
Aromata	*Clathrotropis brachypetala* *C. macrocarpa*
Broadleaf	*Terminalia latifolia*
Bullhoof	*Drypetes brownii*
Cedar, Central American.[1]	*Cedrela mexicana* *C. odorata* *C. guianensis*
Crabwood [1]	*Carapa guianensis*
Dakama [2]	*Dimorphandra conjugata*
Gommier	*Dacryodes excelsa*
Gronfoeloe	*Qualea rosea* *Q. coerula* *Q. albiflora*
Hura	*Hura crepitans*
Inyak	*Antonia ovata*
Kautaballi	*Licania venosa* *L. majuscula*
Kereti silverballi	*Ocotea wachenheimii* *O. puberula*
Kwarie [1]	*Vochysia guianensis* *V. tomentosa*
Magnolia [2]	*Talauma dodecapetala*
Marish	*Licania macrophylla* *L. densiflora* *L. micrantha*
Parakusan [2]	*Swartzia jenmanii* *S. polyphylla* *S. schomburgkiana*
Pine, Caribbean	*Pinus caribaea* (also resistant)
Sara	*Vouacapoua macropetala*
Tabebuia, white	*Tabebuia insignis* var. *monophylla* *T. stenocalyx*
Tauroniro	*Humiria balsamifera*
Yemeri [1]	*Vochysia hondurensis*
NONRESISTANT TO DECAY	
Baboen	*Virola surinamensis*
Banak	*Virola koschnyi*
Balsa	*Ochroma pyramidale*
Baromalli	*Catostemma fragrans* *C. commune*
Dukali [1]	*Parahancornia amapa*
Encens	*Protium attenuatum*
Gumbo-limbo	*Bursera simaruba*
Kauta	*Licania laxiflora* *L. mollis* *L. persaudii*
Kurokai	*Protium crenatum* *P. decandrum* *P. sagotianum* *P. schomburgkianum*
Manniballi	*Inga alba*
Simarouba [1]	*Simarouba amara* *S. glauca*
Sterculia	*Sterculia pruriens* *S. rugosa* *S. caribaea*

[1] Variable in decay resistance. [2] Based on reputation for durability; not substantiated by research.

Subterranean termites are a more widespread menace in the Caribbean area than the dry-wood termite. Subterranean termites develop and maintain their colonies in the ground, but reach their food supply by building tunnels through the earth and over obstructions to the wood above. They must keep contact with the ground or perish for lack of moisture. Although this insect often works in obscure locations, the presence of the above-ground tunnels signifies their presence. Termites can be controlled by thoroughly poisoning the soil beneath and adjacent to wooden structures, by placing barriers or shields between the ground and wooden members, or by using treated or termite-resistant wood.

Dry-wood termites are more difficult to control than subterranean termites because they are able to exist concealed in either damp or dry wood without contact with the ground. Consequently, their depredations are often severe before their presence is noted; and once found, they are still difficult to exterminate except by thorough fumigating. Most control methods, such as dipping infested wood in insecticides and injecting poisonous dust or solutions into the nests or tunnels, are not successful in the Caribbean areas, where these insects are the most active.

Attack by the winged adults can be controlled by full-length treatment of all wood with wood preservatives or insecticides or by using wood having a high natural resistance to their attack. However, the slow volatization of many preservatives eventually reduces their toxicity to a point where the termites can survive. In the absence of other treatments, a heavy unbroken coverage of paint or other similar material will normally prevent the entrance of dry-wood termites.

The timbers are rated in table 7 according to their resistance to attack by both dry-wood and subterranean termites. These ratings are based largely on work by Wolcott in Puerto Rico (*262*, *263*) and Brooks, Adamson, Baker, and Crowdy in Trinidad (*39*). Ratings not substantiated by research are so indicated. In all woods examined, their respective ratings are based on the resistance of heartwood to termite attack as the sapwood of all species is considerably more susceptible to attack than the heartwood. Where the published information indicates a difference in a timber's resistance to dry-wood and subterranean termites, the lower rating was usually accepted. These differences are generally discussed in the sections on insect attack of the respective timbers.

Powder-post beetles attack either freshly cut or seasoned wood of both softwoods and hardwoods, but generally prefer the sapwood of timber having pores of sufficient size for the female to deposit her eggs. Larvae emerging from these eggs burrow through the wood, leaving tunnels $\frac{1}{16}$ to $\frac{1}{12}$ of an inch in diameter, which are packed with a fine powder. The packed, fine powder serves as a means of identification. Later, small holes are left in the surface of the wood when the winged adults emerge. Powder-post infestations can be prevented or controlled by sterilizing the wood with steam or by soaking it in DDT, pentachlorophenol, or other suitable insecticide.

Tropical hardwoods may also be attacked by wood-boring grubs, roundheaded borers, flatheaded borers, and other wood-boring insects. As a rule, they are considerably less destructive than the insects discussed above.

RESISTANCE TO MARINE BORERS

No timber is known to be entirely resistant to marine borers or teredo. A number of Caribbean timbers do exhibit a high resistance to these marine animals. However, the service life of these timbers is often influenced by local conditions and the particular species of marine borers present. Of course, resistance of timbers to marine boring animals is important only when the timber is used in salt or brackish waters. Timbers that show high resistance to teredo in Caribbean waters are sometimes far less resistant along the Atlantic coast of the United States or in the vicinity of Hawaii. Similarly, timbers may vary in their resistance between salt and brackish waters. These differences are considered to be the result of different types and species of marine borers from one place to another.

The silica content of the wood may be important in resistance to marine borers as many of the most resistant woods contain appreciable amounts of silica. One explanation may be that the high silica content wears down or blunts the teeth of the boring apparatus of the mollusk, thereby preventing his penetration into the wood. However, some nonsilicious woods exhibit considerable resistance to marine borers, indicating other factors may also have an effect on a timber's natural resistance.

The most practical protection for piling and other timbers used in sea water is heavy treatment with coal-tar creosote or creosote-coal-tar solution. Concrete casing or metal armor that prevents the marine borers from attaching themselves to the wood is also used with success.

Resistance of the different timbers to marine borers is covered in the sections on durability and is summarized in table 8, in which the timbers are rated by classes of resistance—high, moderate, and low. This information was principally available from recent tests made in Hawaii, the Canal Zone, and along the Atlantic coast of the United States. Also identified in the table are timbers rated by reputation rather than by research, and those that exhibit considerable variability in resistance to marine borers. Further research may change many of these ratings.

TABLE 7.—*Classification of Caribbean timbers as to their resistance to termite attack*

Trade name	Scientific name
VERY RESISTANT TO TERMITES	
Balata	*Manilkara bidentata*
Bethabara	*Tabebuia serratifolia*
Courbaril	*Hymenaea courbaril* *H. davisii*
Greenheart, Demerara.	*Ocotea rodiaei*
Lignumvitae	*Guaiacum officinale* *G. sanctum*
Mahogany, West Indies.	*Swietenia mahagoni*
Manbarklak	*Eschweilera longipes* *E. subglandulosa*
Mora	*Mora excelsa* *M. gonggrijpii*
Purpleheart	*Peltogyne pubescens* *P. porphyrocardia* *P. venosa* var. *densiflora*
Snakewood	*Piratinera guianensis*
RESISTANT TO TERMITES	
Angelin	*Andira* spp. *A. inermis*
Bois gris [1]	*Licania ternatensis*
Cedar, Central American.	*Cedrela mexicana* *C. odorata* *C. guianensis*
Kauta [1]	*Licania laxiflora* *L. mollis* *L. persaudii*
Kautaballi [1]	*Licania venosa* *L. majuscula*
Kopie	*Goupia glabra*
Marblewood	*Marmaroxylon racemosum*
Marish	*Licania buxiflora* *L. macrophylla* *L. densiflora* *L. micrantha*
Nargusta	*Terminalia amazonia*
Pakuri	*Platonia insignis*
Pine, Caribbean [2]	*Pinus caribaea*
Resolu [1]	*Chimarrhis cymosa*
Saman	*Pithecellobium saman*
Tatabu	*Diplotropis purpurea*
Tauroniro	*Humiria balsamifera*
Teak	*Tectona grandis*
Wacapou	*Vouacapoua americana*
Wallaba	*Eperua falcata* *E. grandiflora* *E. jenmanii* *E. schomburgkiana*
Wamara	*Swartzia leiocalycina* *S. benthamiana*

Trade name	Scientific name
MODERATELY RESISTANT TO TERMITES	
Angelin	*Andira inermis*
Angelique	*Dicorynia guianensis*
Aromata	*Clathrotropis brachypetala* *C. macrocarpa*
Broadleaf [1]	*Terminalia latifolia*
Bullhoof	*Drypetes brownii*
Determa	*Ocotea rubra*
Gronfoeloe	*Qualea rosea* *Q. coerula* *Q. albiflora*
Kereti silverballi	*Octotea wachenheimii* *O. puberula*
Kwarie	*Vochysia guianensis* *V. tomentosa*
Mahogany, Honduras.	*Swietenia macrophylla*
Magnolia [1]	*Talauma dodecapetala*
Manni	*Symphonia globulifera*
Suradan	*Hyeronima laxiflora* *H. alchorneoides* *H. caribaea* *H. clusioides*
Yokewood	*Catalpa longissima*
VERY SUSCEPTIBLE TO TERMITES	
Baboen	*Virola surinamensis*
Balsa	*Ochroma pyramidale*
Banak	*Virola koschnyi*
Baromalli	*Catostemma commune* *C. fragrans*
Dukali [1]	*Parahancornia amapa*
Encens [1]	*Protium attenuatum*
Gommier	*Dacryodes excelsa*
Gumbo-limbo	*Bursera simaruba*
Hura	*Hura crepitans*
Kopie	*Goupia glabra*
Kurokai	*Protium crenatum* *P. decandrum* *P. sagotianum* *P. schomburgkianum*
Manniballi	*Inga alba*
Roble	*Tabebuia heterophylla* *T. rosea*
Santa-maria	*Calophyllum brasiliense* *C. lucidum*
Simarouba	*Simarouba amara* *S. glauca*
Sterculia	*Sterculia pruriens* *S. caribaea* *S. rugosa*
Tabebuia, white	*Tabebuia insignis* var. *monophylla* *T. stenocalyx*
Yemeri	*Vochysia hondurensis*

[1] Rating based on reputation or resistance of closely related species.

[2] Resistance dependent on resin content in wood.

PERMEABILITY

The preservative treatment of wood, especially that used in the ground or in damp or exposed locations, often lengthens the life of the wood as much as five times. However, the treatment value depends primarily on the kind of preservatives used, the depth to which it penetrates into the wood, and the amount of the preservative retained in the wood after treatment.

Thus, the resistance of a wood to impregnation by preservatives is of primary importance. Unfortunately, this property cannot be determined from the superficial appearance of the timber, but must be gotten by carefully controlled tests in the laboratory.

Little is known concerning the resistance of the different Caribbean timbers to the penetration of preservatives. Available information on this subject is included in the timber descriptions

TABLE 8.—*Classification of Caribbean timbers as to their resistance to marine borers*

Trade name	Scientific name
HIGH RESISTANCE	
Kauta	*Licania laxiflora* *L. mollis* *L. persaudii*
Kautaballi	*Licania venosa* *L. majuscula*
Lignumvitae	*Guaiacum officinale* *G. sanctum*
Manbarklak	*Eschweilera longipes* *E. subglandulosa*
Marish	*Licania buxifolia* *L. macrophylla* *L. densiflora* *L. micrantha*
Suradan	*Hyeronima laxiflora*
Wacapou	*Vouacapoua americana*
MODERATE RESISTANCE	
Angelin	*Andira* spp. *A. inermis*
Angelique	*Dicorynia guianensis*
Bagasse	*Bagassa guianensis* *B. tiliaefolia*
Bois gris [1]	*Licania ternatensis*
Bustic [1]	*Dipholis salicifolia* *D.* spp.
Crabwood [1]	*Carapa guianensis*
Determa	*Ocotea rubra*
Greenheart, Demerara.[2]	*Ocotea rodiaei*
Snakewood	*Piratinera guianensis*
Suradan	*Hyeronima clusioides*
LOW RESISTANCE	
Baboen	*Virola surinamensis*
Balata	*Manilkara bidentata*
Balsa	*Ochroma pyramidale*
Banak	*Virola koschnyi*
Bethabara	*Tabebuia serratifolia*
Broadleaf [1]	*Terminalia latifolia*
Cedar, Central American.	*Cedrela mexicana* *C. odorata* *C. guianensis*
Courbaril	*Hymenaea courbaril* *H. davisii*
Dukali [1]	*Parahancornia amapa*
Encens [1]	*Protium attenuatum*
Gommier	*Dacryodes excelsa*
Gronfoeloe [1]	*Qualea rosea* *Q. coerula* *Q. albiflora*
Hura [1]	*Hura crepitans*
Kereti silverballi	*Ocotea wachenheimii* *O. puberula*
Kopie	*Goupia glabra*
Kwarie [1]	*Vochysia guianensis* *V. tomentosa*
Mahogany, Honduras.	*Swietenia macrophylla*
Mahogany, West Indies.	*Swietenia mahagoni*
Manni [1]	*Symphonia globulifera*
Manniballi [1]	*Inga alba*
Marblewood	*Marmaroxylon racemosum*
Mora	*Mora excelsa* *M. gonggrijpii*
Nargusta [1]	*Terminalia amazonia*
Pine, Caribbean	*Pinus caribaea*
Purpleheart	*Peltogyne pubescens* *P. porphyrocardia* *P. venosa* var. *densiflora*
Roble	*Tabebuia heterophylla*
Santa-maria	*Calophyllum brasiliense* *C. lucidum*
Simarouba	*Simarouba amara* *S. glauca*
Sterculia	*Sterculia pruriens* *S. caribaea* *S. rugosa*
Tabebuia, white	*Tabebuia stenocalyx* *T. insignis* var. *monophylla*
Tatabu	*Diplotropis purpurea*
Tauroniro	*Humiria balsamifera*
Teak	*Tectona grandis*
Wallaba	*Eperua falcata* *E. grandiflora* *E. jenmanii* *E. schomburgkiana*
Wamara	*Swartzia leiocalycina* *S. benthamiana*
Yemeri	*Vochysia hondurensis*

[1] Rating based on published reputation or rating of closely related species rather than research results.

[2] Resistance varies according to location. Recent tests indicate this timber is not highly resistant in many areas.

under Permeability. Wherever possible, reference is made to the ease with which a timber absorbs preservatives under both open-tank (nonpressure) and pressure treatments. The absence of a section on permeability in the timber descriptions indicates that reliable information is not available.

Heartwood ordinarily resists preservative treatment more than sapwood, although the sapwood of some timbers is also extremely resistant to preservatives. And when a sapwood resists preservatives, the wood is virtually eliminated from use where decay is a problem, for sapwood is always more susceptible to decay than heartwood. On the other hand, posts and poles with wide easily impregnated sapwood can give good service after thorough treatment, even though the heartwood may be only moderately resistant to decay.

Preservatives are applied by either pressure or nonpressure methods. The various nonpressure processes include the following: (1) Superficial application of preservatives to the wood with brushes or a spray nozzle or by a brief dipping; (2) soaking in preservative oils or steeping in water solutions; (3) diffusion process using waterborne preservatives; (4) various adaptations of the hot-and-cold-bath process; (5) vacuum treatment; and (6) a number of other miscellaneous nonpressure processes. The superficial application of preservatives with brushes or by momentary dips is used to some extent in the Caribbean area and, with an oilborne preservative, may add

from 1 to 3 years to the life of wood placed in the ground. However, exposure to the weather or contact with soil or water will quickly leach out a waterborne preservative applied by brush. Such superficial treatments are most successful in those timbers that have little resistance to impregnation.

Other nonpressure methods are used with considerable success, depending on the preservative, the permeability of the timber, and the use of the treated material. Wood can be impregnated as successfully with the hot-and-cold-bath processes, cold soaking and steeping, or some of the other nonpressure methods, as with the pressure processes, if the wood has a low resistance to treatment. The value of preservative treatment depends on the retention and penetration achieved and not on the process used. But, if the wood resists treatment, one of the pressure processes will give better results for they have the advantage of giving more uniform and dependable treatment.

Many preservatives are used with good results. Coal-tar creosote, the most important and most extensively used, is considered the best preservative for general outdoor use in structural timbers and for marine use, but it is not adapted for material that will be painted or where its odor is objectionable. Where creosote is unsuitable, pentachlorophenol and copper napthenate in petroleum oil solutions are substituted extensively. Pentachlorophenol in mineral spirits or other volatile light-colored solvents is generally used for window sash, millwork, interior trim, and other material requiring clean, paintable surfaces. Copper napthenate and pentachlorophenol in various grades of petroleum oil are also used extensively for the commerical treatment of lumber, posts, and poles. Both preservatives provide a high degree of protection against decay and termites, but are less effective than creosote against marine borers.

Paintability of wood is affected by the type of petroleum oil used in the treating solutions; usually, the heavier oils of low volatility give the best preservative service but are most likely to interfere with painting. The use of "bloom" preservatives, such as ester gum, is required when pentachlorophenol solutions are used with volatile solvents; bloom preservatives prevent the formation of crystals on the surface of the wood after treatment.

In the United States, several water-repellent preservatives are sold under various trade names for the treatment of millwork and other interior work. Containing either pentachlorophenol or copper napthenate, they are valued for retarding moisture changes in wood and for protection against decay and insects.

Wood preservatives used in water solution are also effective against insects and decay, but are acceptable only where the wood will not come in contact with the ground or water. Preservatives of this type include zinc chloride, chromated zinc chloride, Tanalith (Wolman Salts), acid copper chromate (Celcure), and chromated zinc arsenate (Greensalt or Erdalith). These preservatives leave the surfaces clean, paintable, and free from any objectionable odor, but, in general, they are more subject to leaching when exposed to the elements than the oilborne preservatives. However, they are generally more acceptable for inside use than creosote and other preservatives in heavy petroleum oils, and give long service when not exposed to the elements.

WOOD USES

The most common uses for each timber in the countries of origin and in the importing countries when applicable are included in the timber descriptions. The recommended uses for each timber are also discussed in the descriptions and summarized in table 9. These recommendations are made on the basis of the timber's combined physical, mechanical, and machining properties. Only those timbers most suited for each use are cited, although other Caribbean species could be utilized for the same purposes with some success.

The use made of timbers in the countries of their origin is generally a good indication of their usefulness and qualities, but often includes uses for which they are not suited and may omit others for which they are most suited. Timbers are often utilized for many purposes simply because they are readily available in good quantity at moderate prices. Despite the many species growing in most areas of the Caribbean, relatively few are produced in commercial quantities. As a result, some woods are used for certain purposes only, because other timbers better qualified for those uses are not readily available. Nevertheless, the local acceptance of a timber for any specific use over a long period indicates reasonably good service given for that purpose.

SUPPLY

The paragraph on supply in each timber description is based largely on information furnished by interested governments in the Caribbean area. This in no way implies that the timbers are not available from other Central and South American countries. Countries or areas having exportable quantities of the different timbers are listed in this section. Moderate quantities of some timbers many become available from certain other Caribbean islands and countries as the export demand develops, but these are not listed as exportable at this time.

TABLE 9.—*Present and potential uses for Caribbean timbers based on their physical and mechanical properties and accepted uses*

AGRICULTURAL IMPLEMENTS

Angelique	Gronfoeloe	Purpleheart	Tatabu
Balata	Kopie	Roble	Tonka
Bethabara	Kurokai	Santa-maria	Tauroniro
Bullhoof	Mora	Sara	Wamara
Bustic	Parakusan	Suradan	Yokewood
Courbaril	Pine, Caribbean	Tabebuia, white	

BENT PARTS OR ITEMS

Balata	Determa	Manni	Tatabu
Courbaril	Kopie	Nargusta	Tonka

BOAT AND SHIP CONSTRUCTION

Keel and Underwater Structural Parts

Angelique	Greenheart, Demerara [1]	Pine, Caribbean	Wacapou
Aromata	Kauta	Purpleheart	Yokewood
Bagasse	Kautaballi	Santa-maria	
Balata	Kopie	Suradan	
Bethabara	Lignumvitae	Tabebuia, white	
Bois gris	Manbarklak [1]	Tatabu	
Courbaril	Marish	Teak	
Determa	Mora	Tonka	

Frames and Timbers

Angelin	Determa	Pine, Caribbean	Tauroniro
Angelique	Greenheart, Demerara	Purpleheart	Teak
Aromata	Mahoe	Roble	Tonka
Bagasse	Manni	Santa-maria	Wamara
Balata	Mora	Suradan	Yokewood
Bethabara	Nargusta	Tabebuia, white	
Courbaril	Pakuri	Tatabu	

Planking

Angelique	Courbaril	Nargusta	Saman
Bagasse	Determa	Pine, Caribbean	Santa-maria
Cedar, Central American	Mahogany, Honduras	Roble	Tabebuia, white
			Teak

Decking

Angelique	Nargusta	Roble	Teak
Bagasse	Purpleheart	Tabebuia, white	Wacapou
Courbaril			

Finish and Trim

Cedar, Central American	Crabwood	Mahogany, West Indies	Rosewood
Courbaril	Mahogany, Honduras	Purpleheart	Santa-maria

BOXES AND CRATES

Baboen	Gommier	Kwarie	Roble
Banak	Gumbo-limbo	Manni	Simarouba
Baromalli	Haiari	Manniballi	Sterculia
Crabwood	Hura	Pakuri	Yemeri
Dukali	Inyak	Pine, Caribbean	
Encens	Kereti silverballi	Podocarp	

See footnote at end of table.

FRAME CONSTRUCTION

Framing Members for Walls, Floors, Roofs, etc.

Angelin	Determa	Manniballi	Simarouba
Angelique	Dukali	Marish	Sterculia
Aromata	Gommier	Mora	Suradan
Bagasse	Gronfoeloe	Nargusta	Tabebuia, white
Baromalli	Gumbo-limbo	Pine, Caribbean	Tatabu
Bois gris	Haiari	Podocarp	Tauroniro
Broadleaf	Kereti silverballi	Purpleheart	Teak
Bulletwood [Bustic]	Kopie	Resolu	Wacapou
Bullhoof	Kurokai	Roble	Wallaba
Cedar, C. A.	Kwarie	Saman	Wamara
Courbaril	Mahoe	Santa-maria	Yokewood
Crabwood	Manni	Sara	

Exterior Siding, Sheathing, and Other Exposed Uses

Angelique	Gumbo-limbo	Pine, Caribbean	Suradan
Aromata	Haiari	Podocarp	Tabebuia, white
Baromalli	Inyak	Purpleheart	Tatabu
Broadleaf	Kereti silverballi	Resolu	Tauroniro
Cedar, C. A.	Kwarie	Roble	Teak
Crabwood	Manni	Saman	Wallaba
Determa	Manniballi	Santa-maria	Yemeri
Dukali	Mora	Simarouba	Yokewood
Gommier	Nargusta	Sterculia	

Inside Sheathing

Baboen	Dukali	Kopie	Santa-maria
Banak	Gommier	Kurokai	Simarouba
Baromalli	Gumbo-limbo	Manni	Sterculia
Broadleaf	Haiari	Manniballi	Suradan
Cedar, C. A.	Hura	Nargusta	Tabebuia, white
Crabwood	Inyak	Pine, Caribbean	Yemeri
Determa	Kereti silverballi	Resolu	

HEAVY CONSTRUCTION (general)

Angelin	Courbaril	Manbarklak	Tatabu
Angelique	Crabwood	Manni	Tauroniro
Aromata	Dakama	Marish	Teak
Bagasse	Determa	Mora	Tonka
Balata	Greenheart, Demerara	Pakuri	Wacapou
Bethabara	Gronfoeloe	Pine, Caribbean	Wallaba
Bois gris	Kauta	Roble	Wamara
Bullhoof	Kautaballi	Santa-maria	Yokewood
Bustic	Kopie	Suradan	

COOPERAGE, SLACK

Baboen	Banak	Manni	

COOPERAGE, TIGHT

Angelique	Broadleaf	Manni	Tauroniro
Baromalli	Determa	Pakuri	Wallaba

FURNITURE AND CABINETWORK

First Grade

Angelin	Crabwood	Mahoe	Saman
Angelique	Determa	Mahogany, Honduras	Santa-maria
Baboen	Encens	Mahogany, W. I.	Tabebuia, white
Bagasse	Gommier	Manni	Tatabu
Balata	Gronfoeloe	Marblewood	Tauroniro
Banak	Hura	Nargusta	Teak
Bethabara	Kopie	Purpleheart	Wacapou
Cedar, C. A.	Kurokai	Roble	Wamara
Courbaril	Magnolia	Rosewood, Honduras	Yokewood

Utility Grade

Baromalli	Kereti silverballi	Manniballi	Simarouba
Dukali	Kwarie	Podocarp	Yemeri

FLOORING

Angelique	Gronfoeloe	Mora	Tabebuia, white
Aromata	Hura	Nargusta	Tatabu
Balata	Kopie	Pine, Caribbean	Teak
Bethabara	Magnolia	Purpleheart	Tonka
Broadleaf	Mahoe	Resolu	Wacapou
Courbaril	Manni	Roble	Yokewood
Crabwood	Manniballi	Santa-maria	
Greenheart, Demerara	Marblewood	Sara	

INTERIOR TRIM AND FINISH

Angelique	Determa	Kurokai	Purpleheart
Baboen	Encens	Magnolia	Roble
Banak	Gommier	Mahoe	Rosewood, Honduras
Baromalli	Gronfoeloe	Mahogany, Honduras	Saman
Broadleaf	Gumbo-limbo	Mahogany, W. I.	Santa-maria
Cedar, C. A.	Haiari	Manni	Simarouba
Courbaril	Hura	Manniballi	Tabebuia, white
Crabwood	Kereti silverballi	Marblewood	Teak
			Yokewood

INSTRUMENTS

Bethabara	Podocarp	Rosewood, Honduras	Wamara
Nargusta	Purpleheart	Simarouba	

MARINE PILING AND CONSTRUCTION (UNDERWATER)

Teredo Infested Waters [1]

Angelique	Determa	Manbarklak	Suradan
Bagasse	Greenheart, Demerara	Marish	Wacapou
Bois gris	Kauta	Pine, Caribbean (with treatment)	
Bustic	Kautaballi		

Nonteredo Waters

Angelin	Bustic	Manbarklak [2]	Tatabu
Angelique [2]	Courbaril	Manni	Tauroniro
Aromata	Determa [2]	Marish	Teak
Bagasse [2]	Greenheart, Demerara [2]	Mora	Tonka
Balata	Gronfoeloe	Pakuri	Wacapou [2]
Bethabara	Kauta [2]	Pine, Caribbean	Wallaba
Bois gris [2]	Kautaballi [2]	Santa-maria	Wamara
Bullhoof	Kopie	Suradan [2]	Yokewood

See footnotes at end of table.

MARINE AND BRIDGE CONSTRUCTION (ABOVE WATER)

Angelique	Courbaril	Manni	Tauroniro
Aromata	Crabwood	Mora	Teak
Bagasse	Dakama	Nargusta	Tonka
Balata	Determa	Pine, Caribbean	Wacapou
Bethabara	Greenheart, Demerara	Purpleheart	Wallaba
Bois gris	Gronfoeloe	Santa-maria	Wamara
Bustic	Kopie	Suradan	Yokewood
	Manbarklak	Tatabu	

MILLWORK

Angelique	Dukali	Magnolia	Roble
Baboen	Encens	Mahoe	Saman
Banak	Gommier	Mahogany, Honduras	Santa-maria
Baromalli	Gronfoeloe	Mahogany, W.I.	Simarouba
Broadleaf	Haiari	Manni	Sterculia
Cedar, C.A.	Hura	Manniballi	Tabebuia, white
Courbaril	Inyak	Pine, Caribbean	Teak
Crabwood	Kereti silverballi	Podocarp	
Determa	Kurokai	Purpleheart	

MUSICAL INSTRUMENTS

Balata	Mahogany, Honduras	Rosewood, Honduras	Wamara
Cedar, C. A.	Mahogany, W.I.	Simarouba	
Courbaril	Purpleheart	Snakewood	

PATTERNMAKING

Cedar, C.A.	Mahogany, Honduras	Podocarp	Simarouba
Gumbo-limbo	Mahogany, W.I.	Saman	

POSTS AND SHORT POLES

Angelin	Courbaril	Manni	Suradan
Angelique	Determa	Mora	Tatabu
Bagasse	Greenheart, Demerara	Nargusta	Teak
Balata	Haiari	Pine, Caribbean	Tonka
Bethabara	Kopie	Resolu	Wacapou
Bois gris	Mahoe	Roble	Wallaba
Bustic	Mahogany, Honduras	Saman	Wamara
Cedar, C.A.	Manbarklak	Santa-maria	

SHINGLES

Broadleaf	Gommier	Santa-maria	Yokewood
Cedar, C.A.	Mahoe	Simarouba	
Crabwood	Roble	Wallaba	

SPORTING AND ATHLETIC ITEMS

Bagasse	Bethabara	Parakusan	Snakewood
Balata	Courbaril	Purpleheart	Tabebuia, white
Balsa	Greenheart, Demerara	Roble	Tonka
Baromalli	Lignumvitae	Rosewood, Honduras	

TOOL HANDLES

Balata	Courbaril	Roble	Tatabu
Baromalli	Parakusan	Rosewood, Honduras	Tonka
Bethabara	Purpleheart	Tabebuia, white	Wamara

TURNING

Angelin	Greenheart, Demerara	Pakuri	Tatabu
Balata	Lignumvitae	Parakusan	Tonka
Bethabara	Mahogany, Honduras	Purpleheart	Wamara
Bullhoof	Mahogany, W.I.	Roble	
Courbaril	Marblewood	Rosewood, Honduras	
Crabwood	Nargusta	Snakewood	

UTILITY POLES

Balata	Bulletwood [Bustic]	Pine, Caribbean	Wallaba
Bethabara	Manbarklak	Suradan	

VENEER AND PLYWOOD

Decorative

Angelin	Gommier	Nargusta	Tabebuia, white
Baboen	Gumbo-limbo	Purpleheart	Tauroniro
Banak	Hura	Roble	Tonka
Cedar, C.A.	Kurokai	Rosewood, Honduras	Wacapou
Courbaril	Mahogany, Honduras	Saman	
Crabwood	Mahogany, W.I.	Santa-maria	
Determa	Manni	Suradan	

Utility Grade

Baromalli	Haiari	Kwarie	Podocarp
Bullhoof	Inyak	Manniballi	Simarouba
Dukali	Kereti silverballi	Pakuri	Yemeri
Gronfoeloe	Kopie	Pine, Caribbean	

Core Stock

Baboen	Crabwood	Hura	Kwarie
Banak	Gumbo-limbo	Inyak	Podocarp
Cedar, C.A.	Haiari	Kereti silverballi	Simarouba
			Yemeri

[1] Timbers with known resistance to marine borers. Other timbers require preservative treatment for optimum use.
[2] Also suitable for use in teredo infested waters because of varying degrees of resistance to marine borers.

TIMBER DESCRIPTIONS

ANGELIN

Andira inermis, Andira spp.

Nomenclature.—Angelin is the preferred trade name for the timber from several species of *Andira* growing in the American tropics of which *A. inermis* (W. Wright) H. B. K. (*A. jamaicensis* (W. Wright) Urban) is the best known and most widely distributed. Other species sold as angelin are principally *A. coriacea* Pulle, *A. racemosa* Lam., *A. surinamensis* (Bondt) Splitg. (*A. retusa* H. B. K.), and *A. wachenheimii* R. Ben. Angelin is a close relative of the rosewoods, paduks, and tonka. (Legume family, Leguminosae.)

The timber is usually known as angelin in the West Indies islands of Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, Trinidad, and other islands in the Lesser Antilles. It is commonly called koraro or batseed in British Guiana, rode kabbes in Surinam, moca in Puerto Rico, yaba in Cuba, and St. Martin in French Guiana. This wood has been imported into the United States under the trade names of cabbage angelin, partridge wood, and cabbage bark. In England it is known as angelin and also incorrectly as partridgewood, a name used also for *Vouacapoua* and more correctly applied to species of *Caesalpinia*. Other common names used in the Caribbean area include pheasant wood, corn wood, almendro, chaperno, cuja, quira, quinillo, macaya, and almendro colorado.

Distribution and habitat.—Angelin occurs throughout the West Indies and on the continent from southern Mexico through Central America to northern South America and Brazil. The genus is also represented in West Africa. *Andira inermis* is the principal species in the West Indies, although the closely related *A. racemosa* grows in Martinique and Guadeloupe and possibly other areas. In the Guianas the principal timber species are *A. coriacea*, *A. inermis*, and *A. surinamensis* (*18*, *50*, *231*).

Angelin is not exacting as to rainfall or soil conditions in most locations. It is a very common tree on many sites in Cuba, Trinidad, and other West Indies islands, but in the Guianas it generally occurs only in swamp and marsh forests. In Trindad it is a rare to occasional tree on a variety of sites from the dry acurel-moussara forests to the inundated crappo-roseau type (*207*, *165*, *82*, *231*).

The tree.—The trees are evergreen, unbuttressed with flat rounded crowns, and often adventitious shoots. The trunk presents a ragged appearance due to its loose, black-colored, malodorous bark. In British Guiana under good conditions, *Andira surinamensis* and *A. inermis* frequently attain a diameter of 60 inches. Diameters of 20 to 28 inches, heights of 90 to 120 feet, and clear boles 60 to 70 feet long are not uncommon. However, the trees are usually somewhat shorter and of only moderately good form (*82*). In Trinidad, angelin grows to a diameter of 40 inches but seldom has good form (*165*).

The wood.—Varying somewhat between species and localities, the wood is generally hard, heavy, coarse textured, with straight to slightly irregular grain. The narrow sapwood is pale brown to grayish yellow and usually clearly demarcated from the yellowish-brown to dark reddish-brown heartwood. The heartwood resembles somewhat the color of the darker type of Honduras mahogany. Dark wavy belts of growth, crossed by very definite, fine, and strong medullary rays are visible on the cross-sectional surfaces. The pores are large and fairly evenly distributed, sometimes containing gummy deposits.

A distinct feature of the wood is the soft tissue that appears on the end grain as wavy bands linking the large pores. On the flat surface of a plainsawed board, these lighter wavy bands alternate between darker fiber bands giving a palmlike appearance similar to partridge wood. This feature gives the wood its high figure and very decorative appearance. The wood generally has rather low luster due to the abundant parenchyma; it is also somewhat fissile (*190*, *143*, *231*). Seasoned wood has no noticeable odor or taste.

Weight.—Air-dry wood is reported to weigh 59 pounds per cubic foot in Surinam (*231*) and 45 to 60 pounds in British Guiana (*82*). Wood from Puerto Rico weighs 47 pounds per cubic foot when air-dry and 74 pounds when green. Specific gravity based on green volume and ovendry weight averages 0.63 in Puerto Rico.

Seasoning.—Angelin air-seasons at a moderate rate and under normal care develops only slight degrade during the seasoning period (*153*, *11*). However, during the early stages of drying, the sapwood is very susceptible to discoloration by sap-stain fungi.

Shrinkage.—Shrinkage from green to ovendry is commensurate with the wood's density, amounting to 3.6 percent radially, 7.1 percent tangen-

tially, and 10.6 percent in volume. Shrinkage from green to air-dry would amount to half these values. In comparison with white mora and dukaliballi, which are similar in weight, angelin has roughly twice their radial movement in response to atmospheric changes, about equal tangential movement, a somewhat lower longitudinal movement, and an overall volumetric change about 25 percent greater than either species (*175*, *231*). On this basis, angelin is a somewhat unstable wood when used where the relative humidity varies considerably.

Mechanical properties.—Pfeiffer's calculations of the allowable stresses for Surinam timbers (*175*) shows *Andira coriacea* comparing very favorably with wallaba, mora, kopie, and other woods of similar density. It can be assumed that the other species of *Andira* also have good strength properties.

Working properties.—Angelin saws and works fairly well except that it is difficult to plane to a smooth surface because of the alternating bands of hard and soft tissue. Even using sharp cutting edges, a fine ridgy appearance commonly results. This surface, called raised grain, is usually eliminated in the final sanding. The wood works well in the lathe, takes nails and screws well, and glues satisfactorily. But the surface lacks luster after planing and sanding because of the large amount of soft tissue. This soft tissue also absorbs polish more readily than the hard fiber tissue and may cause some difficulty in French polishing. However, the wood is generally reported to finish smoothly (*135*, *231*, *153*).

Durability.—The heartwood of *Andira surinamensis* is rated about as resistant to the dry-wood termite as West Indies mahogany, while *A. inermis* rates somewhat below Honduras mahogany in this respect (*263*). However, the sapwood is often attacked by pinhole borers and is not resistant to termites. It is considered highly durable in water and resistant to decay in contact with the soil. Field tests in Surinam indicate *A. coriacea* posts will last 15 years in contact with moist soil and exposed to all influences in the temperate zone and at least 5 years under unfavorable conditions in the low countries of the tropics (*175*, *231*). *A. inermis*, the moca of Puerto Rico, was found to be moderately resistant to marine borers in Hawaiian waters (*76*).

Data on silica content, which is often closely associated with marine borer resistance, are not available for these species. However, the closely related species *Andira surinamensis* from British Guiana, which contains only 0.03 percent silica by weight, is considered a nonsiliceous timber (*14*).

Uses.—Angelin is used locally for heavy construction, bridge timbers, house framing, and sheathing. Because of its high figure and attractive coloration, it is best suited for turned items, furniture, billiard cue butts, and cabinetwork. The wood has no resonance, making it particularly suitable for radio and television cabinets and other similar uses. Small amounts have been imported into England for many years where it is used for umbrella handles, walking sticks, police truncheons, and other turned products. It is suitable for piling in nonteredo waters and has been recommended for plywood and veneer because of its attractive and unusual appearance.

Supply.—Commercial supplies of this timber are available in the Guianas and Cuba, and possibly in limited quantities from other West Indies islands.

ANGELIQUE

Dicorynia guianensis

Angelique is not only in plentiful supply, but also possesses more than the usual number of valuable mechanical properties in addition to its attractive appearance, good working qualities, and resistance to decay, insects, and marine borers. Consequently, the timber is suitable for a wide range of uses; it has been used extensively to replace greenheart and manbarklak in the underwater parts of the Panama Canal.

Nomenclature.—*Dicorynia guianensis* Amsh. has also been known as *D. paraensis* Benth. Two distinct types of angelique wood are recognized, angelique rouge and angelique gris. Angelique rouge is darker in color than angelique gris but has the same physical and mechanical properties. (Legume family, Leguminosae.)

The wood is commonly known as basralocus or basra locus in Surinam and angelique or ébène rouge in French Guiana. A frequent substitute for teak, the timber is also called teck de la Guyane.

Distribution and habitat.—Angelique is one of the most common trees within its range in French Guiana and Surinam, but it does not extend into other parts of the Guianas and lower Amazon Basin. It is particularly abundant in eastern Surinam and western French Guiana, where it comprises up to 10 percent of the forest stands. The tree thrives best in deep, loamy, well-drained soils of the lowland plains but is also found in wetter areas. In Surinam it is most plentiful in the transition zone between the rain and savanna forests (*231*). Angelique rouge is more abundant than angelique gris, which is a comparatively rare tree within its range and of minor commercial importance.

The tree.—Angelique is a large, well-formed, heavy buttressed tree, reaching a maximum height of 150 feet and a diameter up to 5 feet on the best sites. Piling 40 to 60 feet long and timbers 1 to 2 feet square and 30 feet in length are commonly available (*71*).

The wood.—The sapwood of angelique rouge has a reddish cast and is sharply demarcated from the heartwood. The heartwood is a russet color

when first cut, turning on exposure to a lustrous brown, often with a distinct reddish cast (*143*). A pattern resembling walnut is often visible on flat-sawed or side-grain surfaces due to the prominence of vessels. Growth layers are indistinct, texture is medium, and the grain usually straight. No distinctive odor or taste is present in seasoned wood. The surface luster is very low, but an unusual golden subsurface luster is evident (*190*).

Weight.—Wood from Surinam showed a specific gravity of 0.60, based on green volume and ovendry weight, in tests at Yale University (*71*). The specific gravity of air-dry timber averaged about 0.72 in the Yale tests. On this basis, air-dry wood averages about 45 pounds per cubic foot and 67 pounds when green at 79 percent moisture content.

Seasoning.—The timber is considered moderately difficult to season but seasons rapidly (*118*). It has some tendency to split and check and to warp slightly during seasoning. Thick stock develops severe casehardening. Close piling in air-drying and the use of low temperature kiln schedules are recommended as possible means of correcting this difficulty.

Shrinkage.—Angelique undergoes about the same shrinkage as red oak and hard maple and about twice the rate of teak, which it so closely resembles in mechanical properties. It has a volumetric shrinkage of 14.0 percent from green to ovendry, which is intermediate to that of maple and red oak; its radial and tangential shrinkages of 4.6 percent and 8.2 percent, respectively, are also comparable to those of red oak and hard maple. Shrinkage from green to air-dry amounts to about half these values. The wood is relatively stable when in use, as changes in moisture content are accompanied by moderate rates of swelling or shrinkage. The heartwood is quite resistant to absorption of moisture and is comparable in this respect to white oak.

Mechanical properties.—In the green condition, angelique is similar to teak in most strength properties and clearly superior to white oak. It is about equal to the average for timbers of similar density in bending strength, elastic resilience, hardness, compression across the grain, shear, and toughness. It is above average in stiffness and in work to maximum load, slightly above average in crushing strength, but falls slightly below the average in tension across the grain and cleavage resistance.

Tests at Yale University report the following results for green angelique from Surinam (*71*): "Comparison of the data shows a distinct margin of superiority over oak in bending properties except for work to maximum load in which the two species are nearly identical. Angelique is almost 50 percent stiffer than oak. Crushing strength is also notably higher than for oak, but smaller and sometimes insignificant differences exist for the remaining properties. The comparison with teak is quite consistent throughout, indicative of the similarity of the two woods from a mechanical standpoint."

In the air-dry condition, angelique is superior to teak in all mechanical properties except tension perpendicular to the grain. It is superior to white oak in static-bending properties, compression parallel to the grain, and end hardness; comparable in shock resistance, side hardness, and compression across the grain; and inferior to white oak in shear, tension across the grain, and cleavage resistance.

Working properties.—The working qualities vary according to the density and silica content but are generally rated as satisfactory. The wood finishes smoothly, splits easily, glues moderately well, and holds its place well under changes in atmospheric conditions.

Durability.—The wood was rated durable to very durable in resistance to a white-rot fungus, and durable to a brown-rot fungus in pure culture tests at Yale University (*249*). This is in agreement with other reports that the timber is resistant to very resistant to decay (*231*). Generally, it is considered highly resistant to all insects but not as resistant to marine borers as angelique gris. However, Wolcott (*263*) rates the wood only moderately resistant to the West Indies dry-wood termite.

The wood called angelique but probably angelique gris has been used extensively to replace Demerara greenheart in the lock gates in the Panama Canal, where it is reported to be considerably more resistant to marine borers infesting brackish water than Demerara greenheart or teak (*188*, *247*), but not as resistant as manbarklak. Timbers exposed for 15 years in the heavily infested waters at Balboa in the Canal Zone have undergone only insignificant teredo attack.

Results of recent published tests at the U.S. Forest Products Laboratory in Madison, Wis., showed angelique gris to contain 1.31 percent silica as compared to 0.61 percent in angelique rouge and 0.77 percent in angelique blanc, a form of angelique rouge.

Uses.—High resistance to decay and moderate resistance to damage by marine borers as well as its very good strength properties make angelique highly acceptable in marine construction for piling, poles, posts, and other similar uses where teredo are not a major factor. The wood is commonly used for construction purposes, bridge flooring, boat framing, carriage work, and crossties. To a limited extent, it is also used for furniture, barrel staves, and parquet strips and blocks. Because of small radial shrinkage, quartersawed material is considered suitable for flooring and for boat decks, frames, planking and millwork, general building construction, and agricultural

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implements. For many years, small quantities have been exported to Europe, England, and the United States.

Supply.—The timber is in good supply. With the exception of wallaba, it is the most plentiful timber in Surinam. In French Guiana, angelique composes about 10 percent of the stand in the western part of the colony (*91*). The supply is sufficient to fill all export requirements of the near future.

AROMATA

Clathrotropis macrocarpa, Clathrotropis brachypetala

Nomenclature.—The aromata timber of British Guiana is supplied by two relatively little-known species, *Clathrotropis macrocarpa* Ducke and *C. brachypetala* (Tul.) Kleinh. *C. brachypetala* is also known as blackheart or mayaro poui in Trinidad and *C. macrocarpa* as cabary, cabarí, cabory, timbó pau, and timbó rana in Brazil. Both species have, at times, been included in the genus *Diplotropis* (*190*). (Legume family, Leguminosae.)

Distribution and habitat.—Both trees are native to British Guiana (*82*) with *Clathrotropis brachypetala* extending into Trinidad (*165*), Grenada (*18*), Surinam, and Venezuela, and *C. macrocarpa* having extensive distribution in Brazil and reaching Colombia. Another species, *C. nitida* (Benth.) Harms, commonly called acapú, occurs in Brazil (*190*) and Venezuela and might also grow in British Guiana and other areas.

Aromata is generally distributed throughout British Guiana as an occasional tree in the rain and mora forests (*82*). *Clathrotropis brachypetala* is an abundant tree in the mora forests of Trinidad, often exceeded only by *Mora excelsa* Benth. in numbers of large trees. The trees stand inundation in swampy areas and thrive on hillsides having a high rainfall, but do not occur in dry sites or in areas of low precipitation (*165*).

The tree.—The trees are unbuttressed but basally swollen, and usually 16 to 20 inches in diameter and 90 to 100 feet tall in British Guiana. The main stem is usually clear for 40 to 50 feet and often somewhat flattened (*82*). *Clathrotropis brachypetala* is a very large tree in Trinidad, often attaining a diameter of 4 to 5 feet but generally not more than 80 to 90 feet in height. The grayish-brown bark is not fissured, and is fairly smooth and corky textured, with a whitish underbark that rapidly darkens on exposure (*165*).

The wood.—The sapwood is thick, sharply defined, and yellowish to brownish white. The heartwood is pinkish brown to dark brown with lighter streaks due to the prominent vessel lines. It is straight grained, nonlustrous, and coarse textured with a harsh feel but a waxy appearance. The wood is odorless and tasteless when seasoned. It is hard, heavy, tough, and strong but is not very attractive in comparison to many other tropical American woods (*142*, *179*, *190*, *82*).

Weight.—Aromata from British Guiana weighs from 62 to 75 pounds per cubic foot air-dry with a specific gravity of 1.00 to 1.20 based on air-dry volume and weight (*50*). *Clathrotropis brachypetala* from Trinidad is reported to average 62 pounds per cubic foot air-dry (*165*).

Seasoning and shrinkage.—Information is lacking on seasoning and shrinkage of aromata. However, its high density indicates it may be somewhat difficult to season, although the generally straight grain is a favorable factor.

Mechanical properties.—Detailed strength tests for aromata are lacking, but it is generally reported to be a very hard, tough, strong wood and, according to Marshall, is difficult to split under vertical compression (*190*, *82*, *165*, *179*, *142*).

Working properties.—The wood is considered only moderately difficult to work, finishes smoothly, and takes a high polish.

Durability.—The timber is moderately resistant to decay in contact with the ground and moderately resistant to subterranean termites (*39*) and probably has moderate to low resistance to marine borers. The silica content, which is often associated with high resistance to attack by marine borers (*14*), is reported at only 0.01 percent.

Uses.—In Trinidad the wood is preferred for oil-derrick substructures because of its high density, hardness, and resistance to splitting. It should be well suited for heavy construction, piling in nonteredo areas, boatbuilding, bridge timbers, and other uses requiring a heavy, hard, strong wood where high resistance to decay or insects is not important.

Supply.—British Guiana and Trinidad can supply aromata for export.

BABOEN and BANAK

Virola surinamensis, Virola koschnyi

Nomenclature.—Both banak and baboen lumber and plywood are the product of two very closely related species of *Virola*. Banak plywood and lumber have been exported from Central America and the Guianas to the United States for at least 30 years. More recently, a new plywood industry in Surinam has produced the baboen plywood of widespread use in the Caribbean and the United States (*50*, *226*). (Nutmeg family, Myristicaceae.)

The principal difference between the well-known banak plywood and lumber and the newer baboen plywood appears to be not a matter of quality but of species. Banak plywood and lumber has principally been the product of *Virola koschnyi* Warb., formerly known as *V. merendonis* Pittier. The new baboen plywood industry in Surinam

uses largely *V. surinamensis* (Rol.) Warb. combined with small quantities of *V. koschnyi* and bearing the local Surinam name of baboen for the principal species. Banak may often contain varying amounts of baboen (*V. surinamensis*). Small quantities of *V. sebifera* Aubl., locally known in Surinam as Hoogland baboen or pientrie and *V. melinonii* (R. Ben.) A. C. Smith, also known as Hoogland baboen, may also be used. Both species are reported to be very closely related to baboen but less preferred in the plywood industry (*231*).

Virola surinamensis is known by the following names: dalli in British Guiana; guinguamadou, yamamadou in French Guiana; baboen, banak, moonba in Surinam; cajuca, wild nutmeg in Trinidad; cuajo, camaticaro in Venezuela; becuiba, ucuúba in Brazil; muscadier à grive and nutlet in French West Indies.

Distribution and habitat.—Banak (*Virola koschnyi*) ranges from British Honduras and Guatemala to Panama. Baboen (*V. surinamensis*) grows in some of the southern West Indies from Guadeloupe to Grenada and Trinidad and Tobago, and on the continent in the Guianas, Venezuela, and the Amazon region of northern Brazil. Other closely related species of limited commercial value in the Caribbean area include the following: *V. guatemalensis* (Hemsl.) Warb., growing in extreme southern Mexico, Guatemala, Honduras, Costa Rica, and Panama; and *V. sebifera*, which ranges from Nicaragua through northern South America as far as Peru, Bolivia, and southern Brazil (*99*, *190*).

Both baboen and banak are moisture-loving trees. Baboen is very common in the swamp and marsh forests of Surinam, though somewhat less abundant in the latter (*231*). It is a frequent to locally common tree throughout British Guiana in the riparian, mora, and marsh forests (*82*), and is extremely abundant in the low inundable islands of the Amazon estuary of Brazil, where it represents the majority of the larger trees (*248*). Baboen occurs in Trinidad as a rare to occasional tree in all forest types except the swampy areas, where it sometimes approaches being "locally frequent" (*165*).

Banak is reported to grow on all types of soils in Guatemala (*191*). According to Lamb (*150*), it is a frequent tree on sandy soils in the Karst country and in the eastern valleys of the Central Mountains of British Honduras, and attains a concentration of 5 (trees) per acre with ⅓ over 6 feet in girth in the best cohune forest in the Stann Creek district.

The tree.—Baboen and banak are heavily buttressed, flat-crowned trees of the upper canopy. They are medium to large trees, attaining under favorable conditions heights up to 140 feet and diameters of 5 feet, but usually they are much shorter and only 2 to 3 feet in diameter (*165*, *248*, *191*). The boles are generally cylindrical and, according to Fanshawe (*82*), clear of limbs for 60 to 80 feet in British Guiana. In British Honduras, banak is reported to have clear cylindrical boles for more than two-thirds of the total height, often some 70 feet or more (*150*).

The seeds of all species of *Virola* are rich in an oil used for making candles and soap. Large quantities of the oil are used by industries in the Para district of Brazil, and considerable amounts are exported for similar uses in other countries. Cut or wounded trees exude a blood-red watery latex which is similar to the kino of commerce but apparently has not become an export item.

The wood.—The woods of banak and baboen are very similar in appearance and physical properties. Both woods resemble some of the light-colored mahoganies for which they are being substituted in ever-increasing amounts. The freshly cut heartwood and sapwood are indistinguishable; both have the same cream to tan color. The heartwood darkens on exposure and drying, becoming a pinkish, golden brown, or deep reddish brown, and can be distinguished from the lighter colored sapwood. The wood has straight grain, medium to coarse texture, and low luster. Growth rings are not distinguishable. Seasoned wood has no characteristic odor or taste.

Weight.—The specific gravity based on green volume and ovendry weight is reported by Yale University (*248*) to be 0.42 for baboen and 0.44 for banak. The specific gravity of air-dry wood (12 percent moisture content), based on volume and weight in that condition, averages about 0.51 for baboen and 0.53 for banak. On this basis, baboen weights about 32 and banak 33 pounds per cubic foot when air-dry. The weight of green wood of both species is about 51 pounds per cubic foot (*15*, *265*, *241*).

Seasoning.—Care is required to prevent fungal growth and severe staining during seasoning, which requires early piling for air-seasoning or kiln-drying after conversion. Studies at Yale University (*248*) found the wood was easy to season with only slight warping and casehardening occurring during rapid drying. Other reports (*150*, *265*, *222*) describe the timber as having a strong tendency to cup and for material over 2 inches thick to retain its moisture despite rapid surface drying. This condition, plus a high shrinkage ratio and a strong tendency to split radially, is said to necessitate careful handling during seasoning to avoid excessive distortion, deep checking, and splitting. Kiln Schedule 4 of the Forest Products Research Laboratory in England is recommended (*222*).

Shrinkage.—Both baboen and banak undergo unusually high shrinkage during seasoning—including an exceedingly large tangential shrinkage. Baboen shrinkage values from green to ovendry of 5.3 percent radially, 12.4 tangentially, and 17.6 volumetrically (*248*) are considerably above corresponding values of 4.0, 7.1, and 12.3, respec-

tively, for American whitewood and 3.5, 4.8, and 7.7 percent, respectively, for Honduras mahogany (*160*). Banak has very comparable shrinkage values of 3.0 percent radially and 9.0 percent tangentially from green to air-dry (12 percent moisture content) (*222*), which would amount to approximately 4.8 and 13.4 percent, respectively, when converted to a green to ovendry basis. The abnormally high ratio of tangential to radial shrinkage of both woods is a major factor in the tendency for distortion during seasoning.

Mechanical properties.—Mechanical tests have been conducted on baboen (*Virola surinamensis*) from Brazil at Yale University (*248*) and on banak (*Virola koschnyi*) from Central America by the Forest Products Research Laboratory in London (*15*). On the basis of these independent tests, banak is slightly stronger than baboen. The very slight superiority of banak is more or less in proportion to the difference in weight, although baboen is considerably stiffer and slightly superior to banak in static bending and work to maximum load (shock).

In the air-dry condition, both banak and baboen are somewhat superior to yellow-poplar or American whitewood (*Liriodendron tulipifera*) in bending strength and gradually applied loads but somewhat inferior to that species in shock loads and crushing strength. Both woods are superior to Honduras mahogany (*Swietenia macrophylla*) in stiffness and shock resistance, but except for banak's superiority in shear, they are below mahogany in the other strength properties tested. However, both woods are strong enough to use as substitutes for mahogany plywood.

Working properties.—Banak and baboen work easily and very satisfactorily. The Forest Products Research Laboratory in London summarized the working qualities of the lumber as follows: "It cuts easily with hand and power saws and a good surface is obtained with jack and smoothing planes, both along and across the grain. Good clear holes are readily obtained with brad, awl, gimlet, center bit, and twist drill, without tendency to split. Nails and screws can be driven into the woods easily without splitting it and hold fairly well. It cuts with facility in a mortising machine and works easily with gouge and chisel. The wood turns satisfactorily, though the fibers tear slightly, and a good finish is obtainable. It absorbs glue well, can be stained without difficulty to resemble mahogany fairly well and gives satisfactory results in polishing and varnishing. It holds its place when manufactured, does not warp or check, and is free from many knots and other defects" (*111*).

Recent tests at the U.S. Forest Products Laboratory, using ¾-inch clear lumber of *Virola* spp., showed the wood to have very good planing and sanding properties but generally below the average of 14 other tropical hardwoods tested in other machining properties (*68*). However, most of the exported material is used as plywood, which nearly 200 furniture and millwork plants are using in Puerto Rico without any noticeable machining difficulties. The wood is reported to give some difficulty in veneer and plywood production, but this seems to have been overcome, judging from the quality of plywood received in the export markets.

Durability.—Both baboen and banak are not resistant to decay, are very susceptible to attack by termites and other insects, and have little resistance to marine borers (*82*). Wolcott (*263*) rates the resistance of baboen to termite attack at 31, compared to 33 for balsa. Graveyard tests in England (*206*), and durability tests at Yale University (*248*) and the Forest Products Laboratory in Madison (*199*) found the timber to be nondurable. The tests at Madison were both with posts set in soil and with pure laboratory cultures of white-rot and brown-rot fungi; those at Yale were of the latter only. These results verify many other similar reports based on experience and observation. Graveyard tests in Trinidad showed baboen to be very susceptible to both subterranean termites and decay (*39*).

Logs are subject to severe damage by pinhole borers (ambrosia), which can be controlled to some extent by rapid extraction and conversion or by storage of logs under water. Damage by sapstain and wood-destroying fungi may also be serious during shipment of logs. Two insecticides, Tensol and OBD, have recently given almost complete protection for 6 weeks when sprayed on logs immediately after felling (*35*). Seasoned lumber is reported to be subject to attack by powder-post beetles.

Preservation.—The timbers are easily impregnated with preservatives by either the open-tank or pressure systems. Most of the insect, decay, and sap-stain difficulties are presently being controlled in baboen by the use of chemicals in the open-tank method at the time of manufacture. Several waterborne preservatives have been successfully used for this purpose in British Guiana (*50*).

Uses.—Baboen and banak are used mostly for plywood, but are suitable in lumber form for many uses requiring a light, easily worked, nondurable timber. In some areas of the Caribbean, these woods are rapidly replacing mahogany plywood in the manufacture of furniture, millwork, cabinet work, and for paneling and other decorative uses. Plywood is exported to the United States, Central America, northern South America, and throughout the West Indies.

The timbers are also used in Surinam for the manufacture of boxes, crates, cigarboxes, coffins, matches, and matchboxes. Baboen is used for heavy-duty battery separators but is not suitable for car batteries because of the mechanical failure of the thin sheets. The timbers have good lasting qualities below water level and are ac-

cordingly used in Surinam for foundation boarding below water level. In British Guiana, the timber is used for matchboxes, coffins, and inside boarding. Other uses for which the timbers are considered suitable in British Guiana are general carpentry, concrete forms, slack cooperage, and core stock in veneer.

Banak was imported into the United States in the early "thirties" under the name of bastard mahogany as a substitute for cedar in the manufacture of cigarboxes (*226*). The same species was also imported from Guatemala and British Honduras for use in veneer as early as 1926, and possibly earlier (*191*). Baboen was found unsuitable for shingles in Trinidad because of the wooliness that occurred during cutting (*204*).

Supply.—Baboen or banak plywood and lumber are available from British Honduras, Surinam, British Guiana, and possibly French Guiana.

BAGASSE

Bagassa guianensis, Bagassa tiliaefolia

Nomenclature.—*Bagassa guianensis* Aubl. and *B. tiliaefolia* (Desv.) R. Ben. are sold under the trade name bagasse in the Guianas and as tatajuba in Brazil. *B. guianensis* appears to be the best known of the two species and provides most of the information presented in this report. (Mulberry family, Moraceae.)

The wood is also known locally as cow-wood in British Guiana, bagasse blanc and bagasse jaune in French Guiana, and gele bagasse in Surinam. Other well-known members of the family Moraceae are the iroko of West Africa, the fig trees of the tropics, mulberry and Osage-orange of the United States, and satine, fustic, and letterwood of Central and South America (*190*).

Distribution and habitat.—*Bagassa guianensis* occurs infrequently in the Guianas and Brazilian Amazon region, while *B. tiliaefolia* is reported to occur only in British and French Guiana as scattered trees in the low upland forests. In British Guiana, *B. tiliaefolia* is fairly numerous in the near interior and Rupunumi district, but rare in the rain and seasonal forest (*82*).

The tree.—Bagasse is a large, well-formed, unbuttressed canopy tree with a flat, unbrella-shaped crown. The trees are generally 20 to 24 inches in diameter, reaching 36 inches on occasion, and 90 to 100 feet in height. The bole is cylindrical and 60 to 70 feet high. The bark is fibrous and when cut yields large quantities of a sweet, sticky latex. The tree produces edible fruits about the size of an orange, which are astringent but possess a pleasing flavor (*82*).

The wood.—The heartwood is yellow when first cut, often with darker streaks, becoming a lustrous golden brown to russet after seasoning and exposure. The sapwood is narrow, sharply demarcated from the heartwood, and pale yellow to yellowish white. The grain is medium to moderately coarse and usually interlocked, presenting a rather broad striped figure on the radial surface. Growth layers are indistinct. Odor and taste are not evident in seasoned wood (*71, 82, 143*).

Weight.—Bagasse is a hard, heavy wood. The specific gravity of air-dry wood at 12 percent moisture content generally averages about 0.80. The specific gravity based on green volume and ovendry weight averages about 0.68 (0.62 to 0.71). Weight per cubic foot averages 67 pounds in the green condition and 50 pounds when air-dry (12 percent mosture content) (*71, 82*).

Seasoning.—Bagasse seasons at a moderate rate with only moderate checking and very little tendency to warp. It is sometimes classed as moderately difficult to season because of slowness in drying. This seems to be an unjust criticism of a timber which seasons slowly but with very little degrade.

Shrinkage.—Bagasse undergoes exceptionally low shrinkage for a wood of its density. Its volumetric shrinkage of 10.2 percent from green to ovendry is only two-thirds of the rate for white oak and only slightly more than that for black locust, which is noted for its dimensional stability. The shrinkage rates of 5.2 percent radially and 6.6 percent tangentially are usually close, indicating that bagasse should season with a minimum of warping and cupping. A low longitudinal shrinkage of 0.09 percent may also be considered a desirable factor that often accompanies favorable seasoning qualities. Shrinkage from green to air-dry would be about half the above values.

Mechanical properties.—The strength properties of bagasse in the green condition exceed those of any well-known timber in the United States. Tests of *Bagassa guianensis* at Yale University (*71, 249*) show that although only slightly heavier than hickory, bagasse exceeds that species in all properties for which comparable data are available, except work to maximum load in static bending. The margin of difference is particularly prominent in elastic resilience, stiffness, and crushing strength. Bagasse is superior to white oak in the green condition in all strength properties except tension across the grain and cleavage; it also exceeds teak in most strength properties (*160, 105*) by a considerable margin.

In the air-dry condition, bagasse compares favorably with shagbark hickory in all static-bending properties except work to maximum load. In this property, which is a measure of shock resistance, hickory is nearly twice as strong. Bagasse also exceeds oak in the air-dry condition in all properties except work to maximum load (shock resistance), shear tension across the grain, and cleavage resistance.

Working properties.—Bagasse is easy to saw; difficult to split radially; it takes a high lustrous

finish and holds its place well after manufacture. It lends itself well to natural bends for boat and ship members. However, the wood is similar to hickory in hardness and requires more energy to machine than less dense woods (*189*).

Durability.—The heartwood is reported to be very durable in resistance to both white-rot and brown-rot fungi and is slightly resistant to damage by marine borers. Tests with small specimens of bagasse submerged in the ocean at Harbor Island, N.C., showed no evidence of attack by marine borers during the first 10 months, but fairly heavy attack after 15 months. All test specimens were riddled at the end of 23 months and removed from the test (*58*, *249*). Weathering characteristics are considered poor; numerous checks appear when the wood is exposed without a surface covering (*55*).

Uses.—The wood is used locally for general building purposes, heavy construction, carpentry, furniture, and marine and boat construction. It is probably suitable for insulator pins, planking, decking and framing in boatbuilding, and for furniture and cabinetwork. Because of its high resilience, it may also be suitable for some types of sporting equipment.

Supply.—The supply of bagasse is not large, but French Guiana and British Guiana should be able to fill a reasonably large export demand.

BALATA

Manilkara bidentata

Nomenclature.—Balata is presently known botanically as *Manilkara bidentata* (A. DC.) Chev. but has at different times been classified as *Manilkara balata* auth., *M. darienensis* (Pittier) Standl., and *M. nitida* (Sessé & Moc.) Dubard, and as *Mimusops bidentata* A. DC., *M. balata* auth., *M. balata* var. *cruegeri* Pierre, *M. globosa* Gaertn. f., *M. riedeleana* Pierre, and *M. nitida* (Sessé & Moc.) Urban. (Sapodilla family, Sapotaceae.)

The timber is known by the names of bulletwood and balata in British Guiana; balata; balata rouge, and abeille in French Guiana; in Surinam as balata, bolletrie, and paardevleeschout; and in Brazil as massaranduba and maparajuba. It is called purgo in Venezuela, quinilla and pamashto in Peru, níspero in Panama, and ausubo in Puerto Rico.

Several other closely related species of *Manilkara* that occur in Central America and northern South America and in the West Indies are often confused with *M. bidentata.* According to Record and Hess (*190*), at least five other species grow in the lower Amazon region of Brazil, all large or very large trees known as massaranduba or maparajuba. The best of these for durable construction is *M. huberi* (Ducke) Standl., one of the species known as cow-tree or milk-tree. Another species, *M. jaimiqui* (C. Wright) Dubard (*Mimusops emarginata* (L.) Britton, *Achras emarginata* (L.) Little), called wild-dilly and wild sapodilla, occurs in Cuba, Hispaniola, Puerto Rico, the Bahamas, and the Florida Keys. The tree is seldom more than 12 inches in diameter and has no commercial importance.

Distribution and habitat.—Balata is native to the West Indies, Central America, and northern South America. It is widely distributed through the Guianas and the West Indies, Trinidad, Guadeloupe, Martinique, St. Vincent, Dominican Republic, Puerto Rico, Grenada, St. Lucia, Dominica, and other smaller islands in the Caribbean. The tree is also common in northern Brazil, Peru, Venezuela, and Panama (*18*).

The tree occurs in many forest types but is best adapted in the rain forests. It is not an exacting species as to soil or topography, though it is more common on the hills and seldom plentiful on pure sands. It occurs on most geological formations on soils varying from clays to sands, including rocky soils, providing there is sufficient soil moisture (*231*, *165*). In Trinidad, it occasionally occurs in pure stands but is more often an occasional to locally common tree in the rain, marsh, and seasonal forests (*164*).

The tree.—Balata is commonly a large, well-formed tree reaching heights of 100 to 150 feet and diameters of 2 to 4 feet and occasionally up to 6 feet or more. Buttresses are usually lacking but the tree is often basally swollen (*82*).

The wood.—Balata wood is extremely heavy and hard. The heartwood is light red to rose red when freshly cut, becoming light to dark reddish brown upon seasoning. The sapwood is whitish or pale brown; it is distinct but not sharply demarcated from the heartwood. The wood has a fine uniform texture without pronounced figure. The grain is usually straight but sometimes interlocked. Growth layers (not necessarily annual rings) are not distinct. The wood sometimes has a characteristic odor when green, but neither odor nor taste after seasoning (*71*, *82*, *231*, *143*).

Weight.—The specific gravity of balata in the air-dry condition averaged 0.89 in unpublished tests at the Tropical Research Center in Puerto Rico. According to tests at Yale University (*71*), the specific gravity based on green volume and ovendry weight averages about 0.85 (0.77 to 0.91). Weight per cubic foot averages 76 pounds in the green condition and around 64 pounds when air-dry (*82*, *231*, *50*, *175*).

Seasoning.—Balata is generally reported to be a difficult wood to season, tending to develop severe checking, warp, and casehardening (*231*, *153*). However, when it is piled in a manner to assure a slow rate of seasoning, degrade is kept

to a minimum. Still, 1-inch lumber air-seasoned to 19 percent moisture content in 4 months under cover in Puerto Rico; a small amount of degrade occurred in the form of very slight cup, twist and crook, and slight bow, without apparent surface checking.

Shrinkage.—Shrinkage rates for balata from green to ovendry are slightly above the average for other tropical American woods of similar density, but are only slightly greater than those for white oak of the United States. Balata undergoes a shrinkage of 16.9 percent in volume, 6.3 percent on the radial plane, and 9.4 percent tangentially, compared to 15.8, 5.3, and 9.0 percent, respectively, for white oak. Longitudinal shrinkage of 0.23 percent compares favorable with the rate for other dense woods (*71*). Shrinkage rates from green to air-dry (15 percent moisture content) would amount to approximately half these values.

The wood reaches a moisture content of 11.1 percent in a relative humidity of 40 percent, 15.1 percent in a relative humidity of 70 percent, and 27.3 percent in a relative humidity of 100 percent. Balata reacts more slowly to atmospheric changes than many other timbers of similar and even lower density, because it is extremely impermeable to moisture. However, as it gains or loses moisture it undergoes comparatively large dimensional changes (*50*, *198*).

Mechanical properties.—Balata is a very hard, strong, tough wood. Tests of material from Puerto Rico, British Honduras, and Surinam at Yale University showed that balata is generally comparable to greenheart in mechanical properties in both the green and air-dry condition. It is equal or superior to greenheart in bending strength, shock resistance, hardness, shear, and in across-the-grain properties of compression and tension. Balata is slightly weaker than greenheart in compression parallel to the grain (crushing strength) and in elastic resilience in bending, and quite inferior in stiffness. The wood is decidedly superior to white oak in all mechanical properties tested except cleavage resistance in which is it roughly two-thirds as strong as white oak (*71*).

Working properties.—Balata is a moderately easy wood to work despite its high density. It machines and finishes to a very smooth surface and, similar to white oak, it is rated as excellent in steam bending properties. Gluing balata requires special care to acquire a good bond because of its resistance to the absorption of moisture (*240*, *57*, *71*). It is reported to work more easily when green than when dry (*153*). The wood takes a fine polish and has the appearance of walnut when finished.

Durability.—The wood has the reputation of being very resistant to decay and insects. Independent tests of durability of *Manilkera bidentata* in contact with the ground, conducted in Trinidad (*39*), British Guiana (*50*, *82*), St. Lucia (*153*), and Surinam (*175*), showed the wood to be very resistant to decay. In pure culture tests at Yale University, the wood was found to be durable to very durable in resistance to a white-rot fungus and very durable to a brown-rot fungus. Wolcott (*263*) rates the wood on the basis of tests as only moderately resistant to dry-wood termites, comparable to Honduras mahogany. Other observers rate it as highly resistant to subterranean termites (*39*).

The timber has very low resistance to attack by marine borers on the basis of tests in the United States and Hawaii (*76*). Specimens of *Manilkara bidentata* from British Guiana were heavily attacked by *Bankia* within 6 months at Kure Beach, N.C. (*71*). The timber weathers very severely, developing severe surface checking when not protected by paint (*55*).

Uses.—The many good characteristics of balata fit it admirably for a sizeable number of special uses. Its excellent steam-bending properties make it suitable for boat frames and other bent work. Its fine texture, density, and very good finishing properties suit it for use as shuttles, loom harnesses, and certain other textile items. However, practical tests indicate the wood has insufficient resilience to replace sugar maple (*Acer saccharum*) for drop-forge hammer bars or as a substitute for hickory (*Carya*) picker sticks in textile looms.

Balata is used extensively for billiard cues, violin bows, turnings of all types, and furniture. Its strength, high wear resistance, and excellent durability adapt the timber for use as sheathing, boat frames, mill rollers, and keel shoes. The wood has given good service as beaters, agitator bars, and jordan and bed plate filling in paper mills. In two tests under normal working conditions, balata showed no appreciable wear as beater filling, where oak (*Quercus*) had failed completely.

The wood is used for many additional purposes including utility poles, fence posts, heavy construction, ax and tool handles, railway ties, heavy beams, marine and bridge construction, flooring, foundations and, to a great extent, for all types of carpentry and joinery (*50*, *71*, *154*, *51*).

Manilkara bidentata and other woods of the genus have been shipped into the United States for many years, but were not considered of particular interest until 1936 when massaranduba became available as a result of clearing for the Ford Rubber plantations in Brazil. It is reported to give good service as flooring in industrial plants and machine shops and in bench tops, stair treads, and truck bodies.

Supply.—The timber is available from British Guiana, Surinam, French Guiana, and Trinidad and possibly other Caribbean islands.

BALSA

Ochroma pyramidale

Balsa is the lightest commercial wood in use today. In addition to being light and soft, balsa possesses an unusually high degree of buoyancy and is very efficient insulation against heat and sound; where these properties are essential, the wood is adaptable to a great number of special uses.

Nomenclature.—For all practical purposes, balsa may be considered as composed of variations or forms of a single species, *Ochroma pyramidale* (Cav.) Urban. A synonym, *O. lagopus* Sw., is in frequent use. Several specific names have been applied according to country of origin. The wood is known the world over as balsa, or balsa wood, and occasionally as corkwood in the lumber trade. The name balsa, meaning "raft" in Spanish, developed when the early Spanish colonists first observed Indians using the wood in the construction of rafts.

Balsa is called guano in Puerto Rico and Honduras, lanero in Cuba; doun-tree and dun in Jamaica; bois flot in Haiti, Jamaica, St. Vincent, and Trinidad; polak in British Honduras and Nicaragua; patte de lièvre in Martinique; balsa, lano, and palo de lana in Venezuela; enea, piú, and pung in Costa Rica; lana and puero in Panama; topa in Peru; tami in Bolivia; and various other names through its range. (Bombax family, Bombacaceae.)

Distribution and habitat.—The balsa tree is widely distributed in tropical America. Its natural range extends throughout the West Indies from Cuba to Trinidad and on the continent from southern Mexico through Central America into Brazil, Bolivia, Peru, Ecuador, and Venezuela. In Central America, the tree grows in British Honduras, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama. Occasional trees are planted as far north as southern Florida. According to World Timbers (*118*), "It is, however, estimated that 90 percent of the world's supply of balsa is grown in Ecuador, where the rich soil and high temperature and rainfall form ideal conditions."

The tree does not occur uniformly throughout its extensive range, particularly in the higher altitudes or where the soil is excessively wet or dry. It is usually found at lower elevations from sea level to 3,200 feet, especially on bottom-land soil along streams. Although found as scattered trees in the tropical forests, balsa generally occurs as a second-growth tree in natural openings or after the original forest has been removed by fire or floods, or in clearings resulting from cultivation.

The tree.—Balsa is a rapid-growing, short-lived tree, often attaining a height of 70 feet and a diameter of 1 ½ to 2 feet in 7 years; on the best sites, it may reach 80 feet and a diameter of 2½ feet in 5 years. After 8 years of life, some trees develop a pink heartwood that is much inferior to the sapwood. In 12 to 15 years when the trees reach maturity, they are 2½ to 4 feet in diameter and 60 to 90 feet high. After this age they deteriorate rapidly, growth slows, the heartwood becomes waterlogged and doty, and the new growth is hard and heavy.

At maturity, on the average tropical American site, balsa trees usually measure 40 to 60 feet in height and from 1 to 3 feet in diameter. The largest trees occur in open places within the forests after clearings or in abandoned fields along water courses where the soil, light, and drainage are ideal. Balsa makes its best growth in loamy soils in perfectly drained areas. The quality—in balsa the lightness of the wood—is almost entirely dependent on the rapidity of growth, which is best on fertile, well-drained, open sites. Pure stands often occur on burned-over areas (*190*, *45*, *233*, *118*). Trees growing on other less favorable sites produce wood of greater density and of little commercial value. Large balsa plantations have been successfully established in Costa Rica and with variable results in other tropical areas; plantations in India have not been entirely successful, while those in Java have made tremendous growth (*45*, *233*, *157*).

Logging.—Felled trees are cut into 10- to 18-foot lengths with good trees yielding an average of two logs after the branchy parts are eliminated. The logs are then hauled by oxen to the river and submerged to prevent severe stain, decay, and excessive splitting from over-rapid drying. They are later formed into rafts and floated downriver to the sawmill.

Weight.—Balsa varies greatly in weight. The specific gravity may vary from as low as 0.05 to 0.41 based on ovendry weight and air-dry volume. Second-growth balsa in an air-dry condition (12 percent moisture content) has been found to vary in the same stem from 7½ pounds per cubic foot at the center of the log to 21½ pounds per cubic foot near the outer edge. However, wood cut by the mills for export generally ranges from 0.12 to 0.20 in specific gravity based on air-dry weight and volume. Weight per cubic foot varies from 8 to 14 pounds with an average of 10 pounds in the trade. The extremely light weight and buoyancy of balsa is due to its thin cell walls and relatively large cell cavities, which vary inversely with its weight. Balsa wood of slow growth may weigh up to 25 pounds per cubic foot air-dry compared to 15 pounds for cork and 25 pounds for eastern white pine of the United States (*45*, *265*, *241*).

Seasoning.—The wood is reported to be so extremely difficult to air-season from the green condition that kiln-drying is recommended as the best method of seasoning. Even in kiln-drying there is danger of splitting, warping, casehardening, and a tendency to "toast" the wood (*265*). Balsa is somewhat variable in its seasoning characteristics, largely because of differences in density

and moisture content. The Forest Products Research Laboratory in England indicates different schedules might be desirable for timber of different densities but, except for timber of the heavy weight class, their Kiln Schedule 7 should prove suitable (*222*).

Balsa is often end-racked for air-seasoning. Stock 4½ inches thick has been air-seasoned by this method in Ecuador to below 20 percent moisture content in 14 to 21 days (*45*). According to other reports, this rapid seasoning may have been accompanied by excessive degrade.

One-inch lumber has been air-seasoned under cover in Puerto Rico to 17 percent moisture content in 4½ months drying time in stickered piles. Moderately heavy degrade occurred in the form of slight to moderate cupping, slight bow and twist, and very slight surface checking and crook.

Shrinkage.—The timber is reported by most sources to shrink considerably during seasoning. Average shrinkage values for balsa from Puerto Rico weighing 17 pounds per cubic foot air-dry amounted to 1.3 percent radially, 4.7 percent tangentially, and 0.11 percent longitudinally from green to 15 percent moisture content. Volumetric shrinkage averaged 6.1 percent. Shrinkage from green to ovendry averaged 3.0 percent radially, 7.6 percent tangentially, 0.47 percent longitudinally, and 10.8 percent in volume.

Balsa is a stable wood in use; changes in atmospheric conditions cause only minor shrinkage or swelling. Wood in equilibrium with a 60-percent relative humidity will increase 1.7 percent tangentially and 0.5 percent radially when brought into equilibrium with a relative humidity of 90 percent. This amounts to a movement (swelling) of $^{13}/_{64}$ and $^{1}/_{16}$ inch per foot, respectively. The wood comes to an equilibrium moisture content of 20 percent in a 90-percent relative humidity and 11.5 percent in a 60-percent relative humidity (*108*).

Green, freshly cut balsa generally contains from 200 to 400 percent moisture. Soaked specimens have been recorded at 792 percent moisture (*156*). To overcome this tendency to soak up water, balsa is often given water proofing treatments with paraffin, commercial water repellents, water-repellent preservatives, varnish, or glossy paint.

Mechanical properties.—The strength of balsa varies directly with its density or dry weight. Tests at the Forest Products Laboratory (*251*) show that the modulus of rupture (maximum bending strength) at 12 percent moisture content varies from 1,100 pounds per square inch for wood weighing about 5½ pounds per cubic foot to 4,300 pounds per square inch for wood weighing 17 pounds per cubic foot. The maximum crushing strength parallel to the grain varies from 500 to 2,800 pounds per square inch for the same range in moisture content and weight. In comparison, spruce weighing 25 pounds per cubic foot has a modulus of rupture in bending of 10,000 pounds per square inch and a maximum crushing strength of 5,700 pounds per square inch at 12 percent moisture content.

In comparison with Scotch pine or Baltic redwood (*Pinus sylvestris*), balsa has about half the strength in bending and stiffness and about 70 percent the strength in compression parallel to the grain (*265*). It is reported to be 40 percent weaker in bending and 20 percent less stiff than obeche (*Triplochiton scleroxylon*) (*105*). According to the Forest Products Research Laboratory in London, the heartwood of balsa has only half the strength of the sapwood.

Working properties.—Balsa is very easy to work with sharp, thin-edged power or hand tools and has practically no dulling effect on cutting edges. Dull or thick-edged tools tend to cause the wood to crumble and to give a woolly finish in planing. It takes nails and screws readily but is too soft to hold them well. Fortunately, the wood glues satisfactorily; gluing is the most efficient method for fastening or holding the wood in use (*265*, *105*). The timber can be stained and polished fairly well but absorbs much of the material used in the processes. Saw type E of thin gage is recommended by the Forest Products Research Laboratory in London (*105*, *237*).

Durability.—Balsa has very little resistance to decay; 2- by 2-inch timbers decayed in 2½ years in the ground at Princes Risborough, England (*206*). The wood is very susceptible to termite attack according to tests by Wolcott in Puerto Rico (*263*), and obviously is susceptible to severe marine borer attack. Logs and green lumber are readily attacked by pinhole borers, and if conversion is delayed the logs may become very heavily damaged.

Preservation.—The heartwood is resistant to preservative treatment, but a limited amount of preservative can be injected into the vessels quite easily by either pressure or nonpressure methods. However, the cell walls are difficult to impregnate and pressure treatment often causes them to collapse. Treatment of sapwood is reported to be feasible with either pressure or nonpressure methods (*105*).

Uses.—Balsa is used for many specific purposes related to its weight, resilience, buoyancy, and high insulating properties against heat and sound. Some of the more important are listed below (*118*, *45*):

Heat insulation—Packing cases for perishable foods, cold storage rooms, aircraft cabins, roof insulation, railway storage cars, refrigerators, water coolers, lining of pith helments, packing for armor plate in battleships.

Buoyancy—Rafts, lifebelts, floats for fishing nets and mines, water sports equipment, bouys, hydroplane floats.

Sound and vibration insulation—Lining for telephone booths, broadcast studios, aircraft, phonograph booths, subflooring; pads for heavy

machinery and other equipment with moving parts.

Lightness—Aircraft streamlining, model airplanes and other toys, display models, surgical splints, theatrical and film sets and accessories.

Resilience—Protective packing for glass, ceramics, delicate instruments, furniture.

The silky floss or doun brone with the seeds is used for the same purposes as kapok from the related ceiba tree (*Ceiba pentandra* (L.) Gaertn.) and is preferred to kapok in some areas (*150*).

Supply.—British Honduras, Trinidad, and possibly some of the West Indies islands are in a position to supply balsa to the trade in the Caribbean area. The Ecuadorian supply has diminished but still provides the bulk of the commercial-grade balsa in international trade.

BAROMALLI

Catostemma commune, Catostemma fragrans

Baromalli is the preferred trade name of the wood from two and possibly other species of *Catostemma*. The wood, although similar to oak (*Quercus*) and of good quality, is seldom sawed locally and is virtually unknown to the export market.

Nomenclature.—The principal species marketed as baromalli are *Catostemma commune* Sandw. and *C. fragrans* Benth., formerly identified as *Guenetia macrosperma* Sagot. Two other species, *C. alstonii* Sandw. from British Guiana and *C. sclerophyllum* Ducke of Brazil, appear to be less common but may occasionally be marketed under the trade name of baromalli. This report is restricted to the first two species but may apply to other members of the small genus. (Bombax family, Bombacaceae.)

The wood is locally known as baromalli, baramanni, or baramalli in British Guiana and as flambeau rouge in French Guiana.

Distribution and habitat.—In British Guiana both *Catostemma fragrans* and *C. commune* are of frequent to common occurrence in the rain, seasonal, and wallaba forests, with *C. commune* becoming common to locally abundant in the heavy forests. *C. fragrans* is found in both British and French Guiana, while *C. commune* apparently is confined to British Guiana (*82*).

The tree.—The trees are commonly unbuttressed with a long, slender cylindrical trunk of very low taper and excellent form. *Catostemma fragrans* grows to 48 inches in diameter and 150 feet in height on the best sites, but is generally 24 to 36 inches in diameter with clear boles 70 to 90 feet long. *C. commune* is the smaller of the two trees, reaching a maximum of 40 inches in diameter and 100 feet in height on the best sites. However, the usual merchantable tree is about 24 inches in diameter and 60 to 70 feet in height (*82*).

The wood.—Baromalli is a soft, light to medium-weight wood of plain appearance. The heartwood, a dull yellowish-brown to pinkish-brown color, is distinct but not sharply demarcated from the lighter yellowish-brown sapwood, which is often discolored by sap-stain fungi. The heartwood is sometimes described as having an oatmeal color. The grain is straight and the texture coarse. Growth rings are not distinct. Rays are visible as heavy white lines on the cross section, as diamond-shaped spots on tangential surfaces, and conspicuous and large on the radial surface, being darker than the background.

An unusual feature of this wood is the presence of "galls" of included bast appearing as resin streaks of varying lengths on the longitudinal surfaces and as concentric arcs on the end-grain. Quartersawed surfaces generally show a distinctive "silver-grain" figure suggesting silky oak but lacking the luster of that timber. The wood has no distinctive odor or taste (*183*, *142*).

Weight.—Baromalli weighs about 70 pounds per cubic foot in the green condition and ranges from 35 to 40 pounds per cubic foot (averaging about 37) when air-dry (12 percent moisture content) (*15*). Specific gravity based on air-dry weight and volume averages about 0.60. Specific gravity based on green volume and ovendry weight is reported at 0.45 by Kynoch and Norton for *Catostemma fragrans* and at 0.60 by Yale University, based on tests on one log of *Catostemma* sp. from British Guiana (*250*).

Seasoning.—Baromalli seasons rather slowly, without excessive degrade. Some end splitting, surface checking, and opening up of previous defects may occur during seasoning, but degrade from these causes or by distortion is not serious. Although the timber has a rather high shrinkage rate, the proportion of tangential to radial shrinkage is within allowable limits and should not cause excessive warping or cupping. Kiln Schedule 4, developed by the Forest Products Research Laboratory, is recommended (*222*).

Shrinkage.—Baromalli undergoes relatively heavy shrinkage during seasoning compared to other timbers of similar density. The values reported in two independent tests give comparable shrinkage values for the timbers. Kynoch and Norton (*149*) report shrinkage values of 5.4 percent radially, 11.7 percent tangentially, and 17.1 percent volumetrically from green to ovendry for *Catostemma fragrans*. Wangaard, (*250*) reporting on similar tests of wood from one log of *Catostemma* sp. from British Guiana, lists shrinkage values of 5.2 percent radially, 11.1 percent tangentially, and 17.5 percent volumetrically from green to ovendry. The corresponding movement of the wood from atmospheric changes is also excessive.

The wood reaches an equilibrium moisture content of 23.5 percent in 90-percent humidity and 13 percent moisture content in 60-percent humidity.

A tangential movement (swelling or shrinking) of 4.0 percent or ½ inch per foot and a radial change of 2.5 percent or 5/16 inch per foot take place between these equilibrium moisture contents, based on the dimensions at 60-percent humidity (*108*). This places baromalli among the timbers with large movement values, and eliminates its use where good stability is required.

Mechanical properties.—Tests of *Catostemma fragrans* in the green condition by Kynoch and Norton (*149*) showed that the wood compares favorably with black ash (*Fraxinus nigra*) of similar density from the United States. Baromalli exceeded the latter species in all properties tested except compression perpendicular to the grain (crushing strength) and work to maximum load (shock bending), and fell only slightly below black ash in end hardness, shear, and cleavage. The high moisture content of the green baromalli when tested (154.5 percent) may be a factor in these deficiencies. Black ash is not one of the strongest woods of the United States but is above average strength for its weight. On the basis of this comparison, baromalli can be considered to have average strength characteristics in the green condition.

Results of tests by the Forest Products Research Laboratory in London (*15*), using air-dry wood of *Catostemma commune* from British Guiana, showed it to be inferior to black ash in shear, cleavage, hardness, and nodules of elasticity (stiffness). It was somewhat superior to black ash in modulus of rupture (bending strength) and work to maximum load (shock bending). The ashes are noted for their ability to withstand suddenly applied loads as in the handles of striking tools. From this comparison, baromalli should be considered a rather good wood for similar use.

Working properties.—Baromalli works easily with machine or hand tools. The timber has only a moderate blunting effect, although the numerous bands of resin in the wood ducts may cause chipping of the planing and moulding knives. Compared to maho (*Sterculia pruriens*), baromalli cuts somewhat less easily and gives a more fibrous finish. This tendency for the finish to be fibrous or fuzzy can usually be overcome with sharp cutting edges. Machine-finished surfaces lack luster and are harsh to the touch. The wood requires a considerable amount of filler but can be stained and polished satisfactorily, although not to a high luster. It takes glue well and can be nailed without splitting (*118*).

Durability.—The heartwood is not durable in contact with the ground, according to service tests in British Guiana (*32*) and laboratory tests in England (*107*). Wolcott (*263*) rates the heartwood as very susceptible to attack by the dry-wood termite of the West Indies. Other sources list dry sapwood as susceptible to attack by *Lyctus* (powder-post) beetles.

Preservation.—Baromalli is reported as easily impregnated with preservatives by either pressure or open-tank processes.

Uses.—Baromalli is reported suitable for both dry and wet cooperage, interior work, box shock, paper pulp, utility plywood, and light construction. Good quality molasses barrels were made of baromalli at Barbados for a short period when imported barrels were not available. The results of mechanical tests indicate this wood may be suitable for tool handles and certain sports equipment. It is also considered a prospective timber for inexpensive furniture.

Supply.—Baromalli is one of the most plentiful trees in British Guiana, occurring at the rate of from 186 to a maximum of 722 trees, 16 inches and over, per 1,000 acres in the seven districts surveyed in that country. It is available in sufficient supply to merit large scale exploitation for domestic and export markets. Its volume and availability in French Guiana are not known.

BETHABARA

Tabebuia serratifolia

Bethabara is a member of the lapacho group of the genus *Tabebuia*. The timbers in this group are noted for their great strength and durability and are characterized by the presence of an abundance of a yellowish powder (lapachol compound) in the vessels. This powder has the appearance of sulfur but turns deep red in alkaline solutions (*190*).

Nomenclature.—*Tabebuia serratifolia* (Vahl) Nicholson (*Tecoma serratifolia* G. Don) is also known in the export trade as tabebuia, arcwood, noibwood, and sometimes erroneously as Surinam greenheart and bastard lignumvitae, names commonly and more properly used for other woods. It is called yellow poui in Trinidad and St. Vincent; hakia and ironwood in British Guiana; groenhart and wassiba in Surinam; ébène verte in French Guiana; pau d'arco, ipê, and ipê tabaco in Brazil. The name ipê tabaco originates from the peculiar irritating effects of the dust when inhaled during sawing or planing operations (*132*). (Trumpet-creeper family, Bignoniaceae.)

Distribution and habitat.—Bethabara grows in Trinidad, Grenada, and St. Vincent of the Lesser Antilles (*50*), and on the continent from Mexico through Central America and into South America to southern Brazil, including Colombia, Bolivia, Peru, Paraguay, Venezuela, and the Guianas.

The tree occurs on a variety of sites from the tops and sides of ridges to river banks and low ridges in the rain forests but avoids low inundated areas. It occurs as an occasional tree in the rain and marsh forests of Surinam and as a rare to occasional tree in the rain, wallaba, and seasonal forests of British Guiana (*231, 82*). In Trinidad the tree is found on several sites but seldom occurs

on flats or in valleys (*165*). On some areas, it is reported to grow in pure stands.

The tree.—Bethabara is a canopy tree, either unbuttressed or with low buttresses, frequently attaining a height of 100 to 125 feet and a diameter of 2 to 3 feet. In some parts of its range, trees may grow to 6 feet in diameter and 140 to 150 feet tall. Clear cylindrical boles 50 to 60 feet long are common (*82*). The tree is of medium height in many areas, but becomes one of the tallest trees in the upland forests of the Amazon. According to one report (*248*), trees with trunks that will square 30 inches of heartwood are available. Bethabara is deciduous during the dry season at which time it is covered with masses of bright yellow flowers, making it a magnificent sight. The bark is thin and smooth on young trees, becoming fissured on very large trees (*165*).

The wood.—The heartwood is yellowish green when first cut, but upon drying turns to a light to dark olive brown with lighter or darker streaks. The olive-brown color is apparently the result of the presence of the yellow powder in the pores. The sapwood is distinct, 1½ to 3½ inches wide, and cream colored when fresh but becoming white or grayish white when dry (*248*). The texture is fine; the grain is straight to occasionally irregular; and the luster is low to medium (*143*). The wood is cold to the touch and often appears oily; very fine ripple marks show on the tangential surface of the wood. Pores in the heartwood, which appear as fine yellow dots, are filled with a yellowish powder (lapachol). On longitudinal surfaces, these pores appear as yellow lines. The fibers are interlaced and in tiers much like those in persimmon and true mahogany. Narrow darker zones of fibers where the pores are less numerous designate distinct but not sharply defined growth layers.

Weight.—Bethabara is classed as an extremely heavy wood. In tests at Yale University, it had a specific gravity of 0.92 (0.86–0.96) based on green volume and ovendry weight and 1.10 based on air-dry weight and volume. The weight per cubic foot averaged 75 pounds when green and 69 pounds when air-dry at 12 percent moisture content (*248*). Tests of *Tabebuia* sp. (lapacho) at the Forest Products Research Laboratory in England showed an average air-dry weight of 58 pounds per cubic foot at 12 percent moisture content and 67 pounds per cubic foot when green at 32 percent moisture content. However, the material tested may have included the closely associated *Tabebuia ipe* (Mart.) Standl. of Brazil and Argentina, along with the *T. serratifolia*. The specific gravity of air-dry wood averaged 0.93, based on air-dry weight and volume, in the English tests. Other sources report weights of 60 to 80 pounds per cubic foot air-dry.

Seasoning.—Bethabara is considered an easy timber to season. Despite its relatively high density, it dries rapidly with slight warping, cupping, twisting, end checking, and surface checking occuring, as well as some casehardening (*248*). Some surface checking and extension of original shakes, as well as slight cupping, may occur during normal kiln-drying operations, but very little degrade will occur if the wood is kiln-dried slowly from the green state. Horn (*132*) also reports the ipê tabaco of Brazil is apt to check and split badly in the form of large timbers, while boards warp considerably unless dried very slowly. Kiln Schedule 5 of the Forest Products Research Laboratory, Princes Risborough, is recommended (*222*).

Shrinkage.—Bethabara undergoes moderately low shrinkage in relation to its high density, being better than white oak and Demerara greenheart in this characteristic. Shrinkage from green to ovendry amounts to 6.6 percent radially, 8.0 percent tangentially, and 13.2 percent volumetrically (*248*). Shrinkage from green to air-dry (12 percent moisture content) would be approximately half these values. The very low ratio of tangential to radial shrinkage indicates this wood should normally dry with only minor distortion.

The wood is very stable in response to atmospheric changes for a wood of its high density. The change or movement from equilibrium in a 90-percent relative humidity to equilibrium in a 60-percent relative humidity amounts to 3/16 inch per foot tangentially and 1/8 inch per foot radially, or about 1.5 and 1.0 percent, respectively (*108*).

Mechanical properties.—This wood is exceptionally tough, strong, and hard. When green, it is considerably stronger than Demerara greenheart in static bending, elastic resistance, hardness, bearing strength, and shear, and at least comparable to greenheart in all other respects except stiffness (*248*). The wood also compares very favorably with the American hickories because of its unusual properties of high strength, stiffness, hardness, and shock resistance. Upon air-drying, the wood increases slightly in most strength properties but not comparable to that commonly found in hardwoods of the temperate zone; yet it still compares most favorably in this state with greenheart and hickory.

Working properties.—Bethabara is moderately difficult to work, especially with handtools, and has a blunting effect on cutting edges. Ripsaws are subject to some heating when cutting thick material; fine dust escaping from the gullets packs between the saw blade and cut surfaces. This difficulty is partially overcome by using a fairly wide tooth-pitch and increased rate of feed if practicable, or as an alternative a reduced spindle speed. Using swage-set saws somewhat thicker than the standard gage is also advisable. The teeth of crosscut saws tend to vibrate or chatter, and charring may occur during boring.

Flat-sawed material planes to a good finish but reduction of the cutting angle to at least 15 degrees is recommended to eliminate chipping of quarter-

sawed stock. The wood finishes satisfactorily in other operations except for some difficulty encountered when interlocked grain is present. The fine yellow dust rising during most operations is a nuisance and at times is reported to cause mild dermatitis. The timber stains and polishes well and requires little grain-filler. Preboring is required before nailing to prevent splitting and the bending of nails.

Durability.—The timber is very resistant to decay in contact with the ground (*175*, *218*, *82*) and is considered one of the two most durable woods in Trinidad (*39*). Pure culture tests at Yale University (*248*) showed Bethabara as very resistant to both a brown-rot and white-rot fungus. Similar tests at the U.S. Forest Products Laboratory (*199*), using "Guayacan" (*Tabebuia* sp.) also indicated the wood was very resistant to both a white-rot and brown-rot fungus. However, soil tests of "Guayacan" in the northern (Madison, Wis.) and southern (Saucier, Miss.) sections of the United States indicated the wood's resistance to decay varies from resistant to very resistant. Tabebuia woods are reported by Horn (*133*) to last 10 to 12 years in poorly drained soil in Brazil, while those placed in well-drained soil lasted 18 to 20 years.

The timber is rated very resistant to subterranean termites by Brooks (*39*) and as resistant to the dry-wood termite of the West Indies by Wolcott (*263*), who rates bethabara at 72 in resistance as compared to 59 for Honduras mahogany. According to Edmondson, bethabara was found to have low resistance to marine borers in Hawaiian waters, despite its hardness and density (*76*). In similar tests at Wrightsville, N.C. (*58*), this species was heavily attacked by marine borers in a 12-month period. The results in this test agree with those by Edmondson in Hawaii. The silica content has been reported at 0.01 percent by Amos (*14*).

Preservation.—The wood is extremely resistant to impregnation with preservatives by either pressure or nonpressure methods.

Uses.—Bethabara is particularly well adapted for uses which take advantage of its strength, toughness, resilience, and very high resistance to insects and decay. It is suitable for use as railway sleepers, bridge construction, turnery, vehicles, cabinetwork, and carpentry, while some of its highest specialty uses are for tool handles, walking sticks, fishing rods, and archery bows. Figured logs have been cut into veneer in both England and the United States (*135*).

Locally, the wood is also used extensively for fence posts, house poles, and building framing. It is also a good timber for naval construction and dock work above water and for general sporting goods items. In Brazil it finds wide use as factory flooring, machinery parts, mill rollers in sugar mills, and parts for vehicles and carts.

Supply.—The timber is present in exportable quantities in the three Guianas, Trinidad, St. Vincent, and possibly other Caribbean areas.

BOIS GRIS

Licania ternatensis

Nomenclature.—Many species of *Licania* grow in the American tropics but only *Licania ternatensis* Hook. f. is of commercial importance in the West Indies. Both the tree and timber are known as bois de masse in St. Lucia, bois gris in Grenada, Martinique, and Guadeloupe, and bois gris casse or casse in Trinidad. Other local names for the wood in the Caribbean area include bois diable, bois de fer, resolu, and breaknail. Several additional species are discussed under kauta. (Rose family, Rosaceae.)

Distribution and habitat.—Bois gris is rather widely distributed in the southern West Indies. It is recorded from Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, and Trinidad. The tree is very common in the rain forests of St. Lucia but of limited distribution in Trinidad (*18*, *165*, *50*).

The tree.—Bois gris is a fairly large evergreen tree reaching a height of 100 feet and a diameter of 2 to 3 feet. It has a characteristic long, clean straight stem, free of buttresses but sometimes fluted. The thin bark is light colored, smooth, and has numerous grayish-white lenticular warts (*154*).

The wood.—The heartwood of bois gris is dark reddish brown, fairly close grained, and extremely hard and tough. The sapwood is white and equally hard and tough. All species of *Licania* tested have been found to have a high silica content (*14*) and presumably bois gris is no exception, although no specific information is available for this species.

Weight.—The timber is reported to weigh from 65 to 75 pounds per cubic foot with a specific gravity of 1.04 to 1.20, based on air-dry volume and weight (*165*, *218*, *50*). This weight range is comparable to other species of *Licania*, all reported to be hard, heavy woods.

Seasoning.—Specific information concerning the seasoning characteristic of bois gris is lacking, but other species of *Licania* tested at Yale varied from easy to moderately difficult to air-season. In these tests, seasoning took place at a fast to moderate rate according to species, with some warping, checking, and casehardening. (See section on Marish, Kauta, and Kautaballi.) On the basis of this information for other closely related species of *Licania*, bois gris is probably moderately difficult to air-season.

Shrinkage.—Shrinkage values for other species of *Licania* are relatively high, approximating greenheart in this characteristic but falling below some hardwoods of much lower density from the

United States. In general, the species tested at Yale University (*248*) were comparable to white oak in tangential and volumetric shrinkage but somewhat lower in radial shrinkage. Bois gris may have similar shrinkage values.

Mechanical properties.—There are no published results of strength tests on bois gris, but information is available from the tests at Yale University (*248*) on three closely related species: *Licania buxifolia* Sandw. of British Guiana, *L. macrophylla* Benth. of Brazil and Surinam, and *Licania* sp. of Surinam. These species were, in general, all very comparable to greenheart in most strength properties. They were found to be decidedly superior to shagbark hickory (*Carya ovata*) and white oak (*Quercus alba*) of the United States in all strength properties except shock resistance, compression parallel to the grain, and shear in comparison with hickory; and shock resistance, shear, and cleavage in comparison with oak. Species of *Licania*, like many very hard, heavy, close-grained woods, are notably deficient in shear, tension across the grain, and cleavage resistance, but in all other respects they are very strong woods.

Working properties.—Machining characteristics of bois gris are poor because of the wood's great density and high silica content. Bois gris is extremely difficult to saw and quickly dulls cutting edges. The government of St. Lucia reports on its use as follows: "Given a trial on the machines a few times after which it was decided not to use this wood as it was too hard for economical handling on the saws. Probably a good wood for turnery" (*153*).

Durability.—The woods of this genus are said to be low in resistance to decay (*190*, *134*, *175*). However, the three species tested at Yale University ranged from very resistant to moderately resistant to both a white-rot and brown-rot fungus (*248*). Members of the genus *Licania* are noted for their high silica content and resistance to marine borers (*14*). A closely related species, *Licania densiflora*, the marishballi of British Guiana, showed considerable resistance to marine borer attack in Hawaiian waters (*76*). *L. buxifolia*, another closely related species, also showed extremely high resistance to teredo attack in tests at Wrightsville, N.C. (*58*). On the basis of these tests and other similar reports (*134*), bois gris should be rated as having considerable resistance to marine borer attack. Wolcott (*263*) rates the wood of marishballi, *L. densiflora*, as resistant to the dry-wood termite of the West Indies. Bois gris may be comparable to that wood in this resistance.

Uses.—The probable but unproved high marine borer resistance of untreated bois gris timbers suggests it should serve its highest use for piling and other marine construction. Other species of the genus are used for house framing and paving blocks (*82*, *227*). It is used in St. Lucia for interior posts and beams and as a charcoal wood (*154*); in Martinique and Guadeloupe for marine and river work (*218*, *50*).

Supply.—Bois gris is reported as very plentiful in the forests of St. Lucia (*153*, *154*) and may occur in sizable volumes on other West Indies islands. St. Lucia could probably supply the timber in piling sizes.

BROADLEAF

Terminalia latifolia

Nomenclature.—Broadleaf, *Terminalia latifolia* Sw., is second to Central American cedar, *Cedrela odorata*, the most important timber species of Jamaica. In addition to broadleaf, the timber is widely known as amandier and amandier bois. Several other species of *Terminalia* grow in the Caribbean region, of which *T. amazonia* (J. F. Gmel.) Exell is the most widely distributed and of greatest commercial importance. This timber, commonly called nargusta, is described later under that name. (Combretum family, Combretaceae.)

Distribution and habitat.—Broadleaf is a very common tree on the damp glade sites of the limestone districts in Jamaica. It is most frequent at elevations of 1,000 to 2,000 feet where rainfall is 60 inches or more; it is seldom found at lower elevations (*229*, *230*). The tree is also reported from Guadeloupe (*50*).

The tree.—A tall tree, broadleaf grows up to 100 feet in height and 3 feet or more in diameter. The trunk is straight, well formed, and usually clear of branches for about 50 feet (*190*).

The wood.—The wood is light buff to gray, soft, straight grained, medium hard, and splits rather easily.

Weight.—Stehlé (*218*) gives the specific gravity of air-dry wood at 0.65. On this basis, air-dry wood weighs 41 pounds per cubic foot as compared to 44 pounds for red oak of the United States.

Seasoning.—No data available. See section on nargusta, *Terminalia amazonia*.

Shrinkage.—No data available. See section on nargusta, *Terminalia amazonia*.

Mechanical properties.—No information is available on the general strength properties of broadleaf except that the wood is moderately heavy, stringy, rather hard, and splits easily (*218*, *229*).

Working properties.—The wood is reported to work easily and as a result is in great demand in Jamaica.

Durability.—Broadleaf is not very durable in contact with the ground but is durable when used above the ground or in interior work (*50*, *229*, *230*). No specific information is available regard-

ing the timber's resistance to termites and marine borers. However, other species of *Terminalia* vary from resistant to very susceptible to attack by dry-wood termites, and are generally not considered resistant to marine borers (*263*).

Uses.—The most important uses for broadleaf in Jamaica are in building boards, shingles, and barrel staves. It is also used for flooring, rafters, lath, window frames, and doors. The bark is used in Jamaican tanneries but has a relatively low tannin content (*230*, *48*, *50*).

Supply.—Broadleaf is one of the most plentiful timbers in Jamaica but is not available for export, for present supplies hardly equal the local demand.

BULLHOOF

Drypetes brownii

Nomenclature.—Bullhoof and male bullhoof or bullhoof macho are the most common names for the wood of *Drypetes brownii* Standl., of the spurge family (Euphorbiaceae.) Two other species, *Celtis schippii* Standl. and *Ampelocera hottlei* Standl., known as female bullhoof and belonging to the elm family (Ulmaceae), are at times sold in mixture with bullhoof. The justification for the combination is not clear since *A. hottlei* is reported to contain an abundance of calcium carbonate and, consequently, is valued principally for round or axed beams, while *C. schippii* is a moderately soft, light, nonsiliceous or slightly siliceous wood recommended for boxmaking, utility plywood, and tool handles (*150*).

The genus *Drypetes* contains more than ten species in the American tropics and numerous others in the Old World. *D. glauca* Vahl is called bois café in French West Indies and varital in Puerto Rico (*218*). *D. variabilis* Uitt. in British Guiana is known as shibadan (*82*). The following discussion is restricted to bullhoof or male bullhoof (*D. brownii*) unless otherwise indicated.

Distribution and habitat.—*Drypetes brownii* is recorded from the Yucatan area of southern Mexico to southern British Honduras and Guatemala. In British Honduras, bullhoof trees (*Drypetes*, *Celtis*, and *Ampelocera*) are reported as rather frequent and widespread, with up to 30 trees per acre on limestone soil in the rolling country of the northwest district (*150*).

The tree.—Bullhoof is a medium-sized canopy tree of the high forest, attaining a height of 120 feet and a diameter of 30 inches. The boles are straight, cylindrical, and generally clear of branches for 50 to 60 feet above the low buttresses. The bark is thin, smooth to finely fissured, and greenish gray in color.

The wood.—Freshly cut heartwood is a pale yellowish brown, turning a light reddish brown on exposure. A dark brown core up to 10 inches in diameter is often present in the heart of old trees. Growth rings are marked by darker colored tissue, which show as brown streaks on the longitudinal surfaces. The grain is usually straight, and the texture is fine and uniform. Pores are barely visible to the naked eye. The rays are fine and barely visible on the cross section, inconspicuous on the radial plane, and invisible on the tangential surfaces. Parenchyma is abundant, forming a fine, close reticulation with the rays; but they are visible only under magnification.

Weight.—Air-dry wood has an average specific gravity of about 0.74 and weighs in the neighborhood of 46 pounds per cubic foot.

Seasoning.—The wood seasons without excessive splitting, checking, or distortion. It is classed as only moderately difficult to season.

Shrinkage.—Shrinkage values for bullhoof are not recorded, but the wood is reported to have a moderate rate of shrinkage.

Mechanical properties.—Detailed strength tests have not been conducted on bullhoof. Lamb (*150*) reports the timber is strong and tough and has strength properties in keeping with its weight, which are probably about the same as those of English oak. It is considered to be a moderately hard wood, perhaps 10 percent harder than English oak, and to have a moderately high resistance to splitting. Record and Hess (*190*) describe the timbers of the genus *Drypetes* as hard, heavy, tough, and strong.

Working properties.—Bullhoof is only moderately difficult to work with hand and machine tools, resembling English oak. Bullhoof saws cleanly but with some difficulty because of its hardness. A smooth finish is obtained in planing without any tendency to roughened grain. It can be drilled and recessed easily with clean unchipped holes and turns readily to a smooth finish with about the same resistance to working as English oak. Nailing necessitates preboring nail holes to prevent splitting and bending of the nails.

Durability.—The timber is considered moderately resistant to decay in contact with the ground and moderately resistant to insect attack. No information is available on its resistance to marine borers.

Uses.—In British Honduras, bullhoof is widely used in the round form for rafters, as axed squares for beams and sills in the construction of native houses, and for shafts in agricultural instruments. Except for some splitting and checking, bullhoof has given good service as railway ties in the government railway in the Stann Creek area of that country (*86*). The wood seems suitable for many uses where a strong, tough, heavy wood is required as in both light and heavy construction. Because of its light color, close texture, and good turning qualities, the wood may be suitable for utility grade plywood (*190*, *150*).

Supply.—British Honduras can supply bullhoof for the export market.

BUSTIC

Dipholis salicifolia, Dipholis spp.

Nomenclature.—Several species of *Dipholis* provide the bustic or bulletwoods of general use in Jamaica and other areas in the Caribbean. In Jamaica the following species are recognized: mountain bully, *Dipholis montana* (Sw.) Griseb.; red or cherry bullet, *D. nigra* (Sw.) Griseb.; white bully or black bullet, *D. salicifolia* (L.) A. DC.; and *D. pallens* Pierre & Urban and *D. octosepala* Urban (*229*). The first two species are apparently the most common in Jamaica (*230*), while *D. salicifolia* is the best known species throughout the range of the genus (*190*). (Sapodilla family, Sapotaceae.)

The timber is commonly known as bustic, willow bustic, or cassada in Florida and the British West Indies, and as almendro, carolina, cuya, jubilla, jubilla colorada, and sangre de doncella in Cuba. In British Honduras and Mexico, it is called cháchiga, mijico, txitxya, or sac-chum (*217*). Wood of *Dipholis* spp. is known as caya colorada, caya rubia, and caya de loma in Dominican Republic; acomât rouge, bois d'Inde, sapotiller marron in Haiti; sanguinaria, almendrón, tabloncillo, and varital in Puerto Rico; and as níspero amarillo and tempisque in Costa Rica. Another Cuban species, *D. jubilla* Ekman, is known locally as cuaba, jucuma colorada, juba, and jubilla (*207*). *D. stevensonii* Standl. is a large tree of the Mopan region of British Honduras, where it is called faisán or zapote faisán. Another British Honduran species, *D. durifolia* Standl., is a small tree of the higher elevations.

Distribution and habitat.—The several species of *Dipholis* have a combined range including southern Florida, West Indies, southern Mexico, and Central America. The best known species, *D. salicifolia*, is native nearly throughout this range. The trees occur on a variety of sites from sea level to the higher elevations. The five species growing in Jamaica are reported to be distributed throughout the country in areas of moderate to heavy rainfall below 3,500 feet elevation (*229*). However, *D. salicifolia* is found in dry locations on the southern coast of Puerto Rico and on the nearby arid islands of Mona and Guanica.

The tree.—The trees vary in size according to geographic location, site, and species. *Dipholis salicifolia* is a slender tree usually less than 50 feet tall and about 20 inches in diameter, while *D. stevensonii* is reported to reach large dimensions in British Honduras (*190*). One of the characteristics of the genus is the presence in the bark of a latex, called chicle faisan. It is used in some countries as chicle in chewing gum.

The wood.—The heartwood of *Dipholis* spp. is brownish to reddish brown, with gradual transition to the sapwood. It is of medium luster and has no distinctive odor but a somewhat bitter taste. The texture is medium fine and the grain fairly straight. It is a very hard and heavy wood (*190*, *184*).

Weight.—The specific gravity of air-dry timber ranges from 0.90 to 1.00, based on air-dry volume and weight. The specific gravity based on green volume and ovendry weight averages about 0.86. Air-dry wood weighs from 56 to 62 pounds per cubic foot (*184*, *218*) and green wood about 77 pounds per cubic foot (*160*).

Seasoning.—No information available.

Shrinkage.—Detailed information concerning shrinkage is lacking. However, the timber is not recommended for cabinetwork in the Dominican Republic as it "cracks badly." This may be an indication that the wood undergoes high or uneven shrinkage, and is somewhat unstable in response to changes in atmospheric conditions (*200*).

Mechanical properties.—Bustic is considered a hard, strong, tough wood in Jamaica, where it is the standard heavy construction timber. Mechanical tests made on *Dipholis salicifolia*, the bustic of southern Florida, verify these observations. The Florida timber was found to be superior to white oak (*Quercus alba*) in all strength properties tested except work to proportional limit and shock in impact bending. It was clearly superior to white oak in static bending, compression parallel to the grain, and compression perpendicular to the grain. Shear and cleavage were not tested.

Working properties.—Bustic is not difficult to work and finishes smoothly (*190*, *184*).

Durability.—The timber is generally considered fair to good in durability when in contact with the ground (*184*, *229*, *50*). *Dipholis salicifolia* is reported to be unsurpassed in the Dominican Republic for shore work, where it resists inclemency of salt water very well (*200*). This would indicate the timber may have considerable resistance to attack by marine borers, although the wood does not contain silica. On the basis of long-term observations, the Government of Jamaica reports red and white bulletwood are durable in contact with the ground (*229*).

Uses.—Bulletwood or bustic is used extensively in Jamaica and elsewhere in the Caribbean for heavy construction and other jobs including house framing, bridge runners, telephone poles, flooring, railway ties, and similar uses. It is also used in Jamaica for fence posts and for carts and wagon parts. Under some conditions, the timber may be suitable for cabinet or furniture work, particularly where a heavy, hard, strong, durable wood is required. However, the user should consider the report from the Dominican Republic concerning its tendency to develop cracks after seasoning.

Supply.—Limited supplies may become available in Jamaica and other islands of the West Indies and possibly in Central America.

CENTRAL AMERICAN CEDAR

Cedrela mexicana, Cedrela odorata, Cedrela guianensis

Central American cedar is one of the most important timbers for domestic use in tropical America. At one time it was an important export timber to the United States and Europe. The wood is suitable for almost every purpose where lumber is needed in the tropics. But it has been utilized principally in the United States for cigarboxes, a use which has now declined to a fraction of the former volume. Cedar has almost all the desirable properties required of a first-class wood and virtually none of the troublesome or detracting characteristics plaguing many other woods; the one exception is the tendency for some material to exude a gum that discolors the wood surface.

Nomenclature.—Three species of *Cedrela*[2] are of primary commercial importance in the Caribbean: *Cedrela mexicana* M. J. Roem., *C. odorata* L., and *C. guianensis* A. Juss. The species are not easily distinguished; there is no fundamental difference in the woods of the three species. Various other species occur in tropical America. Record and Hess (*190*) offer the following: "So far as the woods of *Cedrela* are concerned, they might well be of a single species, for although they exhibit considerable range in their properties, the differences observed could all be attributed to the age and condition of growth of individual trees." (Mahogany family, Meliaceae).

Because of their fragrance, *Cedrela* trees are generally known as cedar or Spanish cedar in the English speaking countries, and as cedro to most Latin Americans. In some Caribbean countries, the name of Central American cedar is preferred to separate these three species from others growing in South America and also from the species of the genus *Toona* of Asia and Australia, which are so similar that some botanists merge them with *Cedrela*. The timber is also known as cigarbox cedar, Honduras cedar, or Mexican cedar in the trade (*195*). In South America, it is also commonly known as South American cedar. West Indian cedar is another trade name.

The timber is commonly called cedar in British Honduras and Jamaica; cedro hembra and cedro español in Puerto Rico; acajou rouge in Guadeloupe and Martinique; acajou in Dominica and Trinidad; red cedar in St. Lucia, St. Vincent, Grenada, and British Guiana; cedar in Surinam; acajou cèdre in French Guiana; cedro amarillo and cedro amargo in Venezuela; cedro amargo, cedro dulce, and cedro colorado in Costa Rica and Panama; cedro hembra and cedro macho in Cuba; and cèdre or cèdre espagnol in Haiti. It has many other local names throughout its extensive range.

Distribution and habitat.—Central American cedar grows throughout the West Indies and on the continent from Mexico through Central America and into northern South America, including Brazil, Peru, and Venezuela. This timber, or one of several other cedars growing in South America, occurs in every country south of the United States except Chile. *Cedrela mexicana*, native from Mexico to Brazil, does not occur naturally in the West Indies except in Trinidad, but has been widely planted and naturalized, especially in Cuba and Puerto Rico. *C. guianensis* is presumably confined to the Guianas, while *C. odorata* is native apparently through the West Indies and has been planted widely in tropical America.

In some areas there may be two forms of a single species; one form is located along streams or on sheltered moist sites and provides light-colored wood of relatively low density; the other form occurs on well-drained hillside forests or on drier sites and produces denser, more deeply colored wood (*145*, *127*, *2*).

The trees generally make their best growth on rich, well-drained humid sites, but under certain circumstances compete favorably on drier hillside sites. However, the trees are ordinarily somewhat exacting as to site requirements and are especially intolerant of water-logged locations (*54*). Cedar is often planted as an ornamental and shade tree throughout the American tropics (*230*).

The tree.—Under favorable conditions, Central American cedar grows to a height of 90 to 130 feet and a diameter of 2 to 4 feet. Trees commonly have clear boles 50 to 80 feet above the buttresses, which often extend 4 to 12 feet up the tree. Larger trees are often found, ranging up to 6 or even 10 feet or more in diameter. The bark is thin, smooth and grayish in color on young trees and often fairly thick and unevenly fissured on older trees. This bark has a characteristic aroma and astringent taste on trees of all sizes (*82*, *145*, *54*, *71*, *30*).

The wood.—The wood of young trees, especially those of very rapid growth in the open, is less fragrant, lighter in color, softer, but somewhat tougher than that of older trees or more slowly grown forest trees. The more slowly grown, dense, pungent-odored timber is preferred and commands a greater price in the local market.

The heartwood is pinkish to reddish brown when freshly cut, becoming red or dark reddish brown, occasionally with a purplish tinge, after exposure. The darker wood, as mentioned above, comes from the drier exposures. The sapwood is whitish grey or pinkish in color. In general, Central American cedar resembles the lighter grades of Honduras mahogany (*195*).

The texture is generally medium but the darker colored woods may have a coarser texture than

[2] C. Earle Smith, Jr. (A Revision of *Cedrela* (Meliaceae). Fieldiana: Botany 29: 295–341, illus. 1960) has combined *Cedrela mexicana* and *C. guianensis* as synonyms of *C. odorata*.

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the lighter woods. The grain is usually straight but on occasions is interlocked and sometimes highly figured in buttresses and butts. The wood, which may be slightly to decidedly ring porous, has a characteristic growth-ring pattern visible on the tangential surface (*24*). Some wood shows gum streaks. The luster is medium to high but generally least apparent in the lighter colored timbers. Most wood has an odor similar to that of several species of coniferous "cedar" growing in the United States. Some specimens also have a distinctive bitter taste.

These two distinct types of wood are recognized in some areas of British Guiana as: (1) The darker variety, more straight-grained, with a coarser texture and more volatile oil; and (2) the lighter variety, not so straight-grained as the darker, with a finer texture and less volatile oil (*127*, *141*, *30*, *143*, *265*).

Weight.—Timber weight varies considerably, depending on the location, site, age of tree, and rapidity of growth. Specific gravity, based on ovendry weight and green volume, is reported from 0.34 to 0.45, averaging about 0.40. Specific gravity, based on air-dry volume and weight, ranges from a low of 0.42 to a high of 0.64, averaging about 0.48 at 12 percent moisture content. Green wood weighs about 44 pounds per cubic foot and air-dry wood about 30 pounds per cubic foot at 12 to 15 percent moisture content (*231*, *82*, *145*, *135*, *30*).

Seasoning.—Central American cedar is generally an easy wood to season, either by air-drying or in the kiln. The timber seasons at a rapid rate with only very minor warping and only slight surface checking and end splitting, but it has a tendency under some conditions for knots to split rather badly (*30*, *145*, *241*). The wood is sometimes compared to white pine (*Pinus strobus*) in seasoning behavior (*71*). One-inch boards are reported to air-dry in 3 to 6 months in Trinidad (*165*), 3 to 4 months in Dominica (*50*), and 4 months in Puerto Rico.

In kiln-drying, some individual pieces may at times distort or collapse quite appreciably but may be controlled by lower kiln temperatures (*222*). Kiln Schedule 6 of the Forest Products Research Laboratory in England is recommended (*222*). The U.S. Forest Products Laboratory schedule that appears most appropriate for 4/4 cedar stock is numbered T8–C3 (*238*, *145*). The Indonesian Forest Research Institute has also developed a satisfactory kiln schedule for *Cedrela mexicana* grown in Indonesia (*172*).

Shrinkage.—During seasoning, the wood undergoes relatively low and remarkably uniform shrinkage. Tests made at Yale University with *Cedrela huberi* Ducke from Brazil showed average shrinkage values from green to ovendry of 3.9 percent radially, 5.9 percent tangentially, 0.16 percent longitudinally, and 8.9 percent volumetrically (*71*), as compared to 4.1, 4.9, and 8.9 percent, respectively, for *Cedrela* sp. from Nicaragua (*125*). Slightly higher values have been obtained for *C. odorata* from Puerto Rico.

These values are for shrinkage from green to ovendry, expressed as a percent of the original green volume. Shrinkage from green to air-dry would be approximately half these values. Studies of *Cedrela* spp. by the Forest Products Research Laboratory in England gave shrinkage values of 3.0 percent radially and 4.0 percent tangentially from green to air-dry. The tests in England and the United States are quite comparable when the latter are converted to a green to air-dry basis (*50*). The very low ratio of radial to tangential shrinkage and the normal rate of longitudinal shrinkage are indicative of the good seasoning characteristics of the wood and largely explain why the timber seasons without appreciable warping, checking, or other defect.

The timber is relatively stable to changes in relative humidity, placing it in the class of timbers having small movement values. It reaches a moisture content of 14.5 percent in equilibrium with a relative humidity of 60 percent and a moisture content of 21.5 percent in a relative humidity of 90 percent. It moves (swells or shrinks) 1.0 percent in the radial plane, and 1.5 percent in the tangential plane from the lower to higher moisture content, or vice versa (*108*).

Mechanical properties.—Mechanical properties are available from several sources for either *Cedrela* sp. (species unknown) or for other species than those discussed in this report. However, because of similarity of the wood of all species of *Cedrela*, the data can be safely applied to the species covered here.

Central American cedar is comparable, or only slightly below, Honduras mahogany in all strength properties in both the green and the air-dry condition except hardness, resistance to shear, and compression and tension across the grain (*102*, *249*, *127*). Some difference is noted in strength properties between species and different tests; this can be attributed to the density and other properties of the test specimens that very according to site, location, age, and growth rate as described in the section on the wood and its properties.

Working characteristics.—The wood is easy to work, both with hand and machine tools, and dulls cutting edges very little. It planes to a smooth surface and normally finishes cleanly in all other operations. There is a slight tendency for "woolliness" to develop during machining, but this can be overcome by keeping all knives and saws sharp. The darker wood is said to work more easily than the lighter. Saw type D is recommended by the Forest Products Research Laboratory in England (*105*).

The presence of gum in some logs gives a little trouble in planing and polishing but, in general, the wood stains and polishes beautifully after suitable filling. It has good nail-holding and

screw-holding properties. Tests at Yale University showed one species, *Cedrela tonduzii* C. DC., to have fair bending qualities (*57*). Cedar is very popular in the veneer and plywood industry, for it peels cold, dries exceptionally well, and has good gluing properties (*197*, *195*, *229*, *30*, *102*, *240*).

Durability.—Central American cedar logs are liable to become stained if conversion does not take place soon after felling or if a protective end-coating is not applied. The wood of *Cedrela odorata* is rated moderately durable to durable to decay in "graveyard" tests in British Guiana (*50*) and Surinam (*175*). Other species of *Cedrela* showed a considerable variability in durability in pure culture tests at Yale University but, in general, were moderately durable to durable to both a white-rot and brown-rot fungi (*249*).

The timber is resistant to both subterranean and dry-wood termites but has little resistance to marine borers (*76*) and is occasionally subject to infestation by pinhole borers. Wolcott (*263*) rates this cedar slightly better than Honduras mahogany in resistance to dry-wood termites in Puerto Rico. The timber has excellent weathering properties without the protection of paint (*55*).

Uses.—The wood is eminently suited for uses requiring a soft, lightweight, but strong, straight-grained, easily worked, relatively durable wood of above average beauty. Because of its many good qualities, as well as its beauty, cedar is particularly suitable for such items as patterns, drawing boards, venetian blinds, decking and planking for small boats, musical instruments, wooden novelties, cigarboxes, and doors. It is also preferred for both sliced and rotary-cut veneer, being used both as a face and core veneer for decorative and utility grades of plywood (*197*, *145*).

World Timbers, v. 1 (*118*), describes the use of wood in England as follows: "The main uses in this country are for furniture, interior fittings and boat building. In the latter case it is used both for planking of high-class pleasure boats and also for interior cabin work both in the solid and as a core for veneering. It is also used for panels in railway coaches, especially such as are grooved, as the wood will bend easily without breaking. It still remains the best timber for cigarboxes as it harmonizes with the scent of the tobacco and prevents the working of an insect which attacks tobacco. It is also stated that Cedar keeps the tobacco in the best condition as it permits excess moisture from tobacco to be evaporated and also admits moisture from without when the cigars become too dry. When used as an interior for wardrobes it is an excellent precaution against clothes moth."

The timber is also commonly used in the tropics for furniture, interior construction, panelling, cabinetwork, millwork, light boat parts, canoes, shingles, clothing chests, flooring, and general building material for house construction. The heavier grades are suitable for the same uses as Honduras mahogany.

Supply.—Logs and sawed lumber are available in export quantities from the Guianas, British Honduras, and possibly from a number of the islands in the West Indies. Present quantities are not large but should meet a limited demand. The timber is normally exported to England in the form of both square and round logs up to 40 feet long and 40 inches in diameter. Some sawed lumber is also exported.

COURBARIL

Hymenaea courbaril, Hymenaea davisii

Nomenclature.—The timbers of *Hymenaea courbaril* L. and *H. davisii* Sandw. are most commonly known in the Caribbean trade as courbaril, locust, locus, locuat, or West Indian locust. The British know the timber as West Indian or South American locust and courbaril, while the Spanish-speaking countries often use the names algarrobo or guapinol. Brazilian names are principally jutaby and jatoba. It is called locust in British Guiana, Trinidad, and St. Vincent; locus or rode locus in Surinam; courbaril in French Guiana, Guadeloupe, Dominica, Martinique, and St. Lucia; and algarrobo in Puerto Rico. In Jamaica it is called stinking toe or West Indies locust, caguairan, courbaril, and algarroba de las Antilles. The usual Mexican names are cuapinol, coapinol, and guapinol. Other names include jatay, jetay, jataiba, Brazilian gum-copal tree, and courbaril plum. (Legume family, Leguminosae.)

Distribution and habitat.—The best known species, *Hymenaea courbaril*, is found from southern Mexico, throughout Central America and the West Indies, and into northern South America to northern Brazil, Bolivia, and Peru.

Hymenaea davisii grows only in British Guiana, where it is confined to the country's north-central and northeast districts. It occurs as an occasional tree on sandy or loamy soils within the rain or seasonal forests (*33*, *82*).

Hymenaea courbaril is a tree that prefers open sites, not too humid. It is best adapted on sandy, well-drained soils, making its best development on ridges or slopes and high river banks and generally not present on flat wet areas. In Surinam the tree is rare in the rain forest, but locally frequent on high ridges and river banks in the coastal region. In British Guiana, courbaril is an occasional to locally frequent tree on clay loams or silty clays in the mora and marsh forests; on sandy soils near rivers or streams in the seasonal forests; and on lateritic soils in the rain forests in hilly country. In Jamaica the tree is common on the Liguanea and St. Elizabeth plains (*229*). It does best on ridges in Trinidad and also grows on slopes, but rarely on flats or in the mora forest.

The tree.—Courbaril is a large, nearly evergreen tree growing to 130 feet high and 5 feet in diameter; but normally it is less than 100 feet high and 2 to 4 feet in diameter. The trunk is usually free of branches for 40 to 80 feet, well formed and basally swollen or buttressed in large trees. *Hymenaea davisii* is the taller of the two trees; both have massive spreading branches and heavy umbrella-shaped crowns and are usually dominant or codominant in the stand.

The bark contains an abundance of a pale yellow or reddish translucent gum, known in the trade as South American copal. This gum often accumulates in the ground at the base of the tree and may be found in the soil (fossil gum) in large quantities long after the tree has disappeared. The resin is used for certain cements and varnishes, and is also wrapped in corn husks and sold in cake form as incense for burning in churches. At one time, the bark was stripped from large trees and used for native canoes, capable of holding 25 to 30 men (*71, 33, 118*).

The wood.—Green courbaril heartwood is salmon red to orange brown, becoming russet to reddish brown when seasoned. The sapwood is usually wide, sharply demarcated from the heartwood, and white, gray, or pinkish. The heartwood frequently is marked with dark streaks and may at times show a golden luster.

Grain is usually interlocked, but is occasionally straight; the texture is medium to coarse. Seasoned wood has no distinctive odor or taste. The wood is particularly attractive, resembling sugar maple on the radial surface and having a high lustrous sheen marked with scattered lines of vessels on the tangential surface. Quartersawed wood is particularly attractive due to the exposure of the radial surface on the top surface of the boards.

Weight.—The specific gravity based on ovendry weight and green volume averages 0.70 (0.62 to 0.80) for *Hymenaea courbaril* from Puerto Rico, Honduras, and Surinam, and 0.67 (0.60 to 0.75) for *H. davisii*. The specific gravity, based on air-dry volume and weight for both species, is reported by different sources from 0.75 to 1.05, averaging about 0.84. Weight of green wood of both species averages about 70 pounds per cubic foot when green and about 52 pounds air-dry, which is comparable to black locust (*Robinia pseudoacacia* L.) in the seasoned condition (*71, 33, 144*).

Seasoning.—*Hymenaea courbaril* is considered slightly difficult to air-dry. It seasons at a fast to moderate rate with slight checking, warp, and case-hardening. *H. davisii* is somewhat more difficult to season, drying at a moderate rate with moderate surface checking and slight checking and warp (*249*); but seasoning must be slow if checking is to be kept to a minimum. Some sources compare *H. courbaril* to black walnut (*Juglans nigra* L.) in seasoning characteristics, and *H. davisii* to white oak (*Quercus alba* L.), which is a difficult timber to season. Kiln Schedule 3 of the Forest Products Research Laboratory in England is recommended for kiln-drying and Schedule T3–D1 of the Forest Products Laboratory in the United States also appears suitable for 4/4 stock (*222, 144, 238, 33*).

Shrinkage.—*Hymenaea courbaril* undergoes moderate shrinkage for a wood of its density, comparing favorably with black locust of the United States, which is noted for its low shrinkage in relation to its density. Courbaril shrinks 4.5 percent radially, 8.5 percent tangentially, and 12.7 percent volumetrically from green to ovendry, compared to 4.4, 6.9, and 9.8 percent, respectively, for black locust. It is also considerably better in this respect than either white oak or shagbark hickory (*Carya ovata* (Mill.) K. Koch.), although hickory is not highly regarded for its drying characteristics. Courbaril's longitudinal shrinkage rate of 0.27 percent is normal for timbers with interlocked grain.

Hymenaea davisii undergoes shrinkage rates of 4.1 percent radially, 7.6 percent tangentially, 0.51 percent longitudinally, and 14.8 percent volumetrically from green to ovendry. The relationship between radial and tangential shrinkage of both species is fairly high, indicating that considerable warp and twist could occur as a result of stresses that occur during seasoning. The 0.51 percent longitudinal shrinkage of *H. davisii* is also relatively high for wood with interlocked grain. Shrinkage from green to air-dry (12 percent moisture content) would amount to about half the above values (*71, 144, 238*).

The wood of both species is relatively permeable and absorbs and loses moisture readily. According to Pfeiffer (*175*), *Hymenaea courbaril* does not swell or shrink excessively in response to changes in relative humidity. He found that ovendry wood of this species reached a moisture content of 10.4 percent when placed in heated rooms having a 40-percent relative humidity, 14.0 percent at 70-percent relative humidity (air-dry), and 23.0 percent at 100-percent (maximum) relative humidity. Swelling from ovendry to equilibrium in the 40-, 70-, and 100-percent relative humidity conditions amounted to 6.73, 8.82, and 11.3 percent respectively. These rates are acceptable for wood of courbaril's density.

Mechanical properties.—Courbaril is a very strong, hard, tough wood. In the green condition it is about equal or somewhat below black locust in most properties, but is slightly to considerably superior to that timber in hardness and perpendicular-to-the-grain properties. In comparison with woods of similar density, *Hymenae courbaril* is below average in bending and crushing strength and stiffness, and above average in shock resistance, hardness, compression, cleavage, and tension.

Hymenaea davisii in the green condition is generally higher in strength properties than teak, but falls slightly below teak in elastic resilience, shock resistance, and maximum crushing strength. It is also a somewhat heavier wood than teak.

Both species are generally superior to white oak in the green condition, and retain their superiority in the air-dry condition in all properties except compression perpendicular to the grain in which *Hymenaea davisii* is slightly inferior to white oak (*249*, *71*).

Working properties.—Courbaril is moderately difficult to work, due largely to its high density. It nails badly but has good screw-holding power, takes glue well and turns satisfactorily. The wood finishes smoothly but does not take a high polish. It is comparable to white oak in steam-bending properties and splits rather easily (*57*, *240*, *123*, *66*).

Durability.—Courbaril is generally not considered durable in contact with the ground. However, the high proportion of sapwood in second-growth trees may account for the timber's poor reputation for durability, as sapwood of all species is always lower in decay resistance than heartwood. Recent laboratory tests indicated that the heartwood of *Hymenaea courbaril* was very resistant to a white-rot fungus and very resistant to resistant to a brown-rot fungus, although somewhat variable. Graveyard tests by Pfeiffer indicated that the wood is durable in the ground (*175*).

The wood has little resistance to marine borers as evidenced by tests in Hawaiian and Atlantic waters (*76*, *249*). The silica content of the wood, often associated with high resistance to marine borers, amounts to only 0.02 percent (*14*). *Hymenaea courbaril* is very resistant to termites, rating considerably above both West Indies mahogany and Honduras mahogany in this respect (*263*). The wood checks badly upon exposure to the weather without the protection of paint (*55*) and, consequently, rates relatively low in weathering properties.

Uses.—Courbaril's high shock resistance fits it admirably for use in sporting goods and for tool handles in place of ash. It is also suitable for steam-bent boat parts for which oak is generally used. As flooring and stair treads, it provides a very wear-resistant surface, which takes a fairly good polish. The timber has been recommended for veneer, because the characteristic wide sapwood layer in second-growth timber works well into natural and blond-finish furniture.

Both the sapwood and heartwood are suitable for furniture, cabinetwork, interior trim, and turnery. European manufacturers have recently shown interest in the timber as a piano wood. Other purposes for which courbaril is used include ship planking, tree-nails, gear cogs, wheel rims, general building construction, looms, naves and felloes of wheels, and as wooden parts in sugar mills and other mill machinery. It is also used to some extent for lock gates in areas free from marine borers.

Supply.—Courbaril should be available in quantity from the Guianas and possibly British Honduras and in limited amounts from Trinidad and other West Indies islands.

CRABWOOD

Carapa guianensis

Crabwood is a member of the mahogany family (Meliaceae) and resembles the true mahoganies, sometimes being substituted for them. Crabwood has been sold locally and overseas for many years, often with unfavorable results due to poor conversion and drying practices. However, during the last few years, with better milling and seasoning practices and an increased knowledge of its properties, the timber has gained an international reputation as a wood of high quality and many uses (*126*).

Nomenclature.—Crabwood is the preferred trade name for the timber of *Carapa guianensis* Aubl. It is also known as cedro macho in some parts of the West Indies and in the United States, and principally as andiroba in Brazil (*186*). A few other species of *Carapa* growing in Central and South America are frequently mistaken for *C. guianensis* but lack some of the good qualities of crabwood. Among these are *C. surinamensis* Miq. of Surinam, *C. nicaraguensis* C. DC. (*C. slateri* Standl.) from Costa Rica to western Ecuador. Several other species of this genus are found in tropical Africa, the principal one being *C. procera* DC.

Other common names of this timber are bastard mahogany in British Honduras, krappa in Dutch Guiana, carapa rouge in French Guiana, empire andiroba in British Guiana, crappo in Trinidad, nazasi in Cuba, and varape or carapote in Guadeloupe. The timber also has been called British Guiana mahogany, karaba, karaba-yek, karapa, caraba, para mahogany, Demerara mahogany, robe mahogany, and Brazilian mahogany. Names referring to mahogany are misleading and should not be used.

Distribution and habitat.—Crabwood occurs in the West Indies from Cuba to Trinidad and on the continent from Honduras south through Central America, the Guianas and into Brazil, Colombia, Peru and the overflow delta lands of the Orinoco in Venezuela (*195*). The tree is very abundant in the Amazon flood plains in the States of Para and Amazonas, and in the Guianas (*73*). It occasionally grows in nearly pure stands, often as reefs of 100 or more trees or occasionally up to 200 trees.

Crabwood is a tree of the lowlands, preferring marshy land or land that is periodically inundated, although it tolerates a rather wide range of growing conditions over its extensive range. The tree occurs as a dominant climax species on old sand reefs and sandbanks in marsh and riparian forests of British Guiana. It is a frequent tree throughout British Guiana, but is most abundant in the mora forest on alluvial flats which are periodically inundated. It is also scattered along watercourses on sandy or alluvial soils and occasionally in the climax rain or seasonal forest on well-drained steep hillsides (*82*).

Trees growing in the mangrove swamps along the coast of British Guiana and on frequently inundated river or creek flats are comparatively small and of low quality; likewise, trees growing along steep hillsides are also of inferior quality to those growing on streambanks of sufficient height that they are only occasionally inundated. It is the trees growing on these slightly higher areas that provide the best timber. These conditions are likely effective in other areas, particularly in the Guianas and Amazon regions.

Crabwood is also abundant in the marsh forests in the western half of Surinam but occurs in small numbers in the swamp forests and rain forests of that country (*231*).

In Trindad, where crabwood is considered one of the best native species, the tree is generally not exacting as to soil and site as long as conditions are not too dry (*164*, *161*). The tree is fairly common at high altitudes in Guadeloupe, where it prefers valley beds along rivers. It is confined to the southern part of British Honduras in the Temash-Moho region, where trees in the cohune forest are small, and those growing on the broken ridges or swamps are somewhat larger (*150*).

The tree.—The trees are evergreen, straight, of good form, and commonly 2 to 3 feet in diameter and 80 to 100 feet in height. Under good growing conditions, they sometimes attain diameters up to 6 feet and heights of 170 feet (*118*). The trunks are usually buttressed or basally swollen for 2 to 3 feet above the ground. Boles are clear of branches for 30 to 90 feet, depending on the site, with the shortest trees occurring in the marsh and hillside forests. Trees are smallest in the marshes, somewhat taller on the hillsides, and tallest on the alluvial flats and along watercourses where the species reaches its best development and is most abundant. Nearly pure stands of crabwood occur on these better sites. The trees grow rapidly, and reach felling size in 20 to 25 years in the marsh forests of British Guiana, around 30 to 35 years in the mora forests, and perhaps 40 to 60 years in the hill forests.

The bark has a bitter taste due to an alkaloid called carapina, which is used medicinally for dysentery, diarrhea, rheumatism, eczema, and ulcers. The bark also contains from 1 to 10 percent tannin, which is used occasionally in tanning. A cream-colored, intensely bitter oil of high acidity and very unpleasant smell, called carapa oil, is also derived from the seeds and used by the Indians for many uses. Foremost is its use as an anointment for the skin and hair as a repellent for ticks, sandflies, eyeflies, and other insects. It is also used as an illuminant by the Indians. The oil is used industrially in the manufacture of soap, candles, insecticidal washes, and medicinally for skin diseases, and as a wound dressing for livestock.

The wood.—Crabwood resembles a plain mahogany (*Swietenia*) and some grades of cedar (*Cedrela*) in color, general appearance, and technical properties, but it lacks the high luster and attractive figure present in the better grades of mahogany (*265*). The heartwood is a light salmon or pale pink to reddish brown when freshly cut, becoming reddish brown to brown when dry. The general color is somewhat darker than mahogany because of the accumulated dark-colored gum in the vessels. Wood, above average in density, is notably darker, while coarse-textured wood appears lighter and somewhat mealy on the radial surface. The sapwood is pinkish when freshly cut, turning a pale brown or grayish color, often with brown or black flecks, when dry. It is generally 1 to 2 inches thick and not sharply demarcated from the heartwood.

The wood varies from coarse to fine but is mostly medium in texture. The luster is generally medium but often low on the tangential surface, although luster may be high in the more dense material and often very low in coarse-textured wood. The grain is usually straight, but interlocked grain and occasional fiddleback mottle occurs in larger logs. Ripple marks occur sporadically in the denser tissue. The wood is generally appreciably denser and harder than mahogany, comparing quite favorably with black walnut (*Juglans nigra*). Harrar (*123*) rates crabwood 102 in hardness as compared to 100 for black walnut at 6.4 percent moisture content. Odor and taste are absent in seasoned wood (*143*, *149*).

Irregular growth rings due to bands of marginal parenchyma are visible on the cross section. The pores are open and visible to the naked eye. Rays occasionally are faintly visible on the tangential surface and distinct on the radial surface.

In British Guiana some of the wood from hillsides is darker, heavier, denser, and has interlocked grain, similar to brown silverballi or bullforehead greenheart. Wood from swamplands is softer, lighter in color, more coarse, often woolly, and floats high out of the water (lighter in weight). Wood from the same site and even the same tree may vary in color.

Weight.—The specific gravity, based on oven-dry weight and green volume, averages about 0.56. Air-dry wood has a specific gravity of about 0.64. Air-dry wood weighs about 40 pounds per cubic

foot and green wood about 56 pounds per cubic foot.

Seasoning.—The Forest Products Research Laboratory in England reports that the timber air-seasons and kiln-dries rather slowly with a tendency to split, check, and collapse during the early stages of drying, but without serious bowing or cupping (*222*). They recommend cleating the end of boards after sawing and the use of thin stickers. However, recent tests at Yale University (*249*) indicated that crabwood is only moderately difficult to air-season with only moderate checking and slight warping. In Georgetown, British Guiana, 1-inch lumber dries from 48 to 19 percent moisture content in 25 days and to 14 percent in 62 days under open-sided sheds (*25*). At the Forest Station, Mazaruni, British Guiana, 1-inch lumber dried from 60 to 15 percent moisture content in 6 months.

A low temperature and high humidity during the early stages of kiln-drying is essential to reduce degrade. Kiln Schedule 3 of the Forest Products Research Laboratory in England is recommended (*222*). Fanshawe (*80*) reports that the timber is liable to reabsorb moisture rapidly during rainy weather accompanied by a retarded rate of seasoning. This moisture is lost again more slowly.

Logs check badly in the woods and during shipment abroad and should be converted into lumber as soon as possible after felling. Green lumber is reported to degrade up to 40 percent or more during overseas shipment, but this may be prevented by seasoning before shipment.

Shrinkage.—Crabwood varies considerably in its rate of shrinkage, but compares very well with other species of comparable density. Its shrinkage rates of 3.1 percent radially, 7.6 percent tangentially, and 10.4 percent volumetrically from green to ovendry are comparable to that of other woods of like density. The wood's ratio of tangential to radial shrinkage is relatively high, indicating nonuniform shrinkage in these two directions. However, its longitudinal shrinkage of 0.10 percent is somewhat below the average for other similar woods (*127*).

The stability of crabwood in response to changes in atmospheric conditions is very good in comparison to most other tropical species of similar density.

The Forest Products Research Laboratory in England (*108*), studying the movement of wood (dimensional changes), found that this species reached an equilibrium moisture content of 20 percent in 90-percent relative humidity and 14 percent in 60-percent relative humidity. The corresponding movement between these two moisture contents was 1.5 percent tangentially and 1.3 percent radially compared to 1.3 and 1.0 percent, respectively, for Honduras mahogany. This amounts to $\frac{3}{16}$ inch per foot in the tangential plane and $\frac{5}{32}$ inch per foot in the radial plane, rating crabwood as relatively stable in response to atmospheric changes.

Mechanical properties.—The mechanical properties of crabwood vary according to the density of the wood and to some extent with the source of material because timber from different sources often varies in density. Tests at the Forest Products Reseach Laboratory in England (*105*) showed air-dry wood to be about 30 percent stronger in bending and in resistance to suddenly applied loads, about 40 percent more resistant to splitting, 50 percent stiffer, and about 60 percent harder on the side grain than Honduras mahogany. It was considered equal in strength to black walnut and black cherry.

Tests at Yale University (*127*, *249*) showed considerable variability in strength according to sources. Their results were summarized as follows: "Compared with wood of similar density, andiroba is average in stiffness as measured in compression parallel to the grain, hardness, shear, and cleavage; slightly above average in resistance to crushing, toughness, and tension across the grain; and definitely superior in compression across the grain, stress at proportional limit in compression along the grain, and all static-bending properties." The Yale tests rated crabwood superior to mahogany (*Swietenia macrophylla*) in all properties other than work to maximum load and shear, and superior to yellow birch (*Betula alleghaniensis*) in all properties except work to maximum load.

Working properties.—Crabwood is more difficult to machine than mahogany but can be worked quite easily with machines and hand tools and is superior to Honduras mahogany in some respects. Machining tests at the U.S. Forest Products Laboratory (*68*) with *Carapa nicaraguensis* show that the wood has good machining properties in planing, molding, shaping, turning, mortising, sanding, and boring. Straight-grained material machines smoothly but quartersawed material is apt to pluck when wavy grain is present. When this occurs, considerable sanding is required to obtain a smooth finish.

The Forest Products Research Laboratory in England (*105*) rates crabwood as 25 percent harder to cut than Honduras mahogany and equally more wearing on cutting edges. They recommend a 15-degree knife angle for planing. The wood holds nails well but has a slight tendency to split when nailed. It rates above Honduras mahogany in screw holding, Harrar (*123*) rating it about equal with black cherry and white oak in this respect. It also glues well and takes all finishing treatments very well but requires the use of a filler on the softer variety. The wood assumes a walnut rather than mahogany appearance when treated with oil. Crabwood is not suitable for steam bending but peels well for veneer, although end splitting of the logs causes a certain amount of loss.

Durability.—Crabwood logs are susceptible to pinhole borer damage, and the green lumber is attacked by powder-post (*Lyctus*) beetles (*168*, *134*, *132*). Wolcott (*263*) found the wood very susceptible to damage by dry-wood termites, rating 39 as compared to 59 for Honduras mahogany. The timber is variously reported to be resistant or poorly resistant to decay in the ground. Tests in different locations show varying results, indicating density may be a factor in the durability of this wood.

Soil tests in England (*206*) rated the wood durable in contact with the ground where it lasted 10 to 15 years. Scheffer and Duncan (*199*) report that *Carapa nicaraguensis* from Panama and Central America was moderately resistant in both soil and pure culture tests. Wangaard and Muschler (*249*) found *C. guianensis* very durable to both a white-rot and brown-rot fungus, while soil tests in British Guiana (*50*) showed the timber only slightly resistant. Because of these conflicting reports, crabwood should not normally be used in contact with the ground or where decay is a problem. The wood is comparable to teak in fire resistance and comparable to mahogany in weathering properties; it rates very good in both respects.

Uses.—Crabwood is used in Central and South America for furniture, turnery, shingles, millwork, interior trim, boxes, crates, flooring, masts, and as studding, rafters, sheathing, and other items in house construction (*51*). It is one of the most preferred substitutes for mahogany in furniture and other uses in the areas where it grows. Crabwood has been recommended as a substitute for black walnut and black cherry in the manufacture of furniture, interior finish, and other similar uses. The Forest Products Research Laboratory recommends the timber for furniture, carcassing, chair and table legs, instrument cases, drawer linings, and for general joinery such as shop fittings, display cabinets, cupboards, and moldings. It is generally considered very suitable for interior work in boatbuilding, veneer, and plywood.

Crabwood has been used successfully in Holland as a substitute for oak in veneer manufacture. If prices are held down, this wood is considered an eventual competitor of yellow birch and sugar maple in the United States market. According to M. N. Gallant, Food and Agriculture Organization forestry expert, crabwood is the principal species used in British Guiana for siding in the better class of wooden housing. It has also been designated as one of the eight local woods acceptable for louvres, weather strips, sash frames, and Demerara shutters in the British Guiana Government's housing program.

Crabwood logs 24 to 50 inches in diameter were purchased in large quantities over a considerable period of time by German airplane manufacturers, and were presumably cut into veneer for airplane plywood. The volume of logs and the period of time indicates that the material was acceptable for whatever use it was employed (*96*). Crabwood is also a preferred wood in the manufacture of shoe heels (*74*). For pulping, in combination with 14 other species from Surinam, it makes a fairly good quality wrapping paper. Species were used in the proportion of their occurrence in the forest (*137*).

Supply.—British Honduras, Trinidad, and the three Guianas have crabwood in exportable quantities (*50*). Considerable quantities of logs are rafted from British Guiana to Surinam for conversion.

The timber is plentiful in the Guianas and British Honduras. In British Guiana, crabwood occurs at a density of from 5 trees 16 inches and over per 1,000 acres in the Demerara-Mahaicony area to 543 trees per 1,000 acres in the Cuyuni-Mazaruni area. These averages are based on a ½ to 2 percent sampling of a 3,000 square mile area in the near interior. This timber is also available from Costa Rica where large supplies of lumber and logs are available for export.

DAKAMA

Dimorphandra conjugata

Nomenclature.—Dakama, *Dimorphandra conjugata* (Splitg.) Sandw., is one of about 25 species of *Dimorphandra* growing in Brazil, the Guianas and Amazonian Venezuela. *Mora*, the similar genus, which is sometimes merged with *Dimorphandra*, is described separately in this reference. The tree and timber of *D. conjugata* are commonly called dakama by the Arawak Indians and anjama by the Bush Negroes of Surinam. The general trade name is dakama. (Legume family, Leguminosae.)

Distribution and habitat.—Dakama is found in the northeast and north-central districts of British Guiana, in Surinam, and possibly in French Guiana. In British Guiana and Surinam the tree is locally abundant and dominant on white sandy soils on or near watersheds (*82*).

The tree.—Dakama occurs most often as a small coppice tree or scrub in the open, but in some locations it develops into a large well-formed tree. These trees are commonly 16 to 24 inches in diameter, 90 to 120 feet high, and clear of branches for 60 to 80 feet. Trees up to 40 inches in diameter are found. The tree is unbuttressed and coppices freely (*231*, *82*).

The wood.—The heartwood is dark reddish brown, sometimes with paler streaks showing, and has an oily feel and appearance. The texture is coarse and the grain varies from straight to irregular, but is generally very irregular. Wood parenchyma is abundant and distinct, appearing as diagonal bands on the transverse surface.

Weight.—The specific gravity of air-dry wood (12.0 percent moisture content) averages about 1.06, based on air-dry volume and weight. Air-dry wood weighs about 66 pounds per cubic foot.

Shrinkage and seasoning.—No information is available on shrinkage or seasoning.

Mechanical properties.—There are no available data on the strength properties of dakama. It is generally known as a very hard, heavy, tough wood.

Working properties.—Dakama is reported to be rather difficult to work as could be expected of a wood of its high density, irregular grain, coarse texture, and oily nature, but is reported to finish smoothly.

Durability.—The timber is considered moderately resistant to decay.

Uses.—It is presently recommended as a general construction timber. Many other uses may be developed when more is known about the mechanical and physical properties.

Supplies.—The total supplies of dakama are not large, but the timber is available in relatively large quantities in the districts where it occurs. In British Guiana it is concentrated largely in the Essequibo-Demerara and Demerara-Makaicony areas.

DETERMA

Ocotea rubra

Nomenclature.—*Ocotea rubra* Mez botanically is related to Demerara greenheart, *Ocotea rodiaei* (R. Schomb.) Mez, although the woods are quite different. The laurel family, Lauraceae, contains also many other related species in tropical America.

The timber is commonly marketed as determa, wana, or teteruma in British Guiana; wana, baaka, bewana, wane, and teteroma in Surinam; grignon franc, grignon rouge, and grignon in French Guiana; louro vermelho in Brazil; and laurier or laurier canelle in Trinidad. Red louro is the standard timber name recommended by British Standards Institution (*36*).

Distribution and habitat.—Determa grows in the Guianas, Trinidad, and the lower Amazon region of Brazil. In British Guiana, the tree is of occasional to frequent occurrence on sandy or loamy soils within the rain and seasonal forest (*82*). In Surinam it occurs as an occasional tree in the rain and marsh forest, becoming more plentiful on the Saramacca District on brown sandy soils, and disappearing west of the Wayombo River (*231*). It is apparently found principally on the lowlands within the lower Amazon region in Brazil (*71*).

The tree.—The trees are evergreen, unbuttressed but generally basally swollen. They have erect-spreading, heavy-branched and rounded, compact crowns. Trees grow to 5 feet in diameter and 130 feet high, but are usually 2 to 3 feet in diameter and 90 to 100 feet high. Their cylindrical boles are clear of branches for 40 to 80 feet. Taper is often heavy, especially in trees under 2 feet in diameter (*82*). Timbers are available 40 feet long and squaring 30 inches of heartwood, and spars up to 70 to 80 feet long and 14 inches in diameter at the small end (*190*).

The wood.—The wood does not resemble any of the other Lauraceae. The well-defined sapwood is creamy, gray, or creamy brown and about 1 to 2 inches thick. The heartwood is a deep salmon red when freshly cut, becoming a light reddish brown with a golden sheen resembling Honduras mahogany when seasoned. The color is rather uniform with pink or yellow streaks occurring occasionally (*136*, *71*).

The texture is coarse, uniform, and with numerous tyloses showing as shiny deposits in the vessels. The grain is either straight or roey, which occasionally shows as ribbonlike bands on the quartersawed surface. Consequently, quartersawed lumber is sometimes attractively figured because of the roey grain and the fine but distinct rays. Straight-grained material is characterized by the closely spaced, coarse vessel lines. Green wood has a pungent odor, but dry wood is without distinctive odor or taste. The wood is unusually free of knots and other defects (*213*).

Weight.—Determa is a moderately hard and heavy wood, similar in weight to yellow birch of the United States. The specific gravity of wood from Surinam and British Guiana averaged 0.52 in tests at Yale University (*249*), based on green volume and ovendry weight. The specific gravity of air-dry wood averages about 0.62, based on weight and volume in that condition. Green wood weighs about 59 pounds and air-dry wood about 39 pounds per cubic foot.

Seasoning.—The wood is moderately difficult to air-season and kiln-dry, largely due to the slow diffusion rate of free moisture through the wood and the development of collapse, if the drying rate is greatly accelerated. Thick stock tends to remain moist in the center for a considerable time, thereby causing slight casehardening. In general, the wood air-dries at a moderate rate with slight checking and casehardening and moderate warping. In Georgetown, British Guiana, green 1-inch lumber can be air-seasoned to 21 percent moisture content in 4½ months. Yale University (*70*) reports a 6-month drying period at New Haven, Conn., for 1-inch stock piled during the early part of the year.

The wood kiln-dries at a moderate rate but with a definite tendency to check and develop end splits, although it is successfully kiln-seasoned if a mild kiln schedule is used during the first part of the run (*222*). Stock above 90 percent moisture content requires about 6 to 7 weeks to kiln-dry under a mild schedule. Kiln Schedule 5 of the Forest Products Research Laboratory is recommended (*222*). A successful kiln sched-

ule was also developed at Yale University and is presented in their Technical Report 5 (*70*).

Shrinkage.—Wood from Surinam and British Guiana undergoes an average shrinkage from green to ovendry of 3.7 percent radially, 7.6 percent tangentially, and 10.4 percent volumetrically (*249*). The overall shrinkage is moderate, but the ratio of tangential to radial shrinkage is indicative of a tendency for moderate warp to occur during seasoning. However, the timber has lower shrinkage values than most of the better quality hardwoods of the United States, including sugar maple, shagbark hickory, white ash, white oak, and yellow birch. The longitudinal shrinkage value of 0.26 percent in determa is not out of proportion for woods with interlocked grain. Shrinkage from green to air-dry would amount to approximately half the above values.

Mechanical properties.—Mechanical tests at Yale University (*249*) indicated that the wood is somewhat below average in strength properties for tropical woods of similar density. It about equals white oak in resistance to bending and compression parallel to the grain, but is inferior to oak in other mechanical properties. It compares well with oak under gradually applied loads but fails earlier under suddenly applied bending loads. In comparison to black walnut, it is stronger, stiffer, not as tough, and weaker in cleavage resistance. The timber is softer on the end grain than on the side and has greater tangential than radial resistance to splitting.

Working properties.—Determa works easily and well with both hand and machine tools, being similar to a dense grade of Honduras mahogany in this respect. Saw type D is recommended by the Forest Products Research Laboratory (*124*). However, the use of dull cutting edges should be avoided as they tend to raise the grain. This wood glues easily (*240*) and polishes fairly well, although its coarse texture requires the use of fillers (*136*). Weathering characteristics of the wood are very good; unpainted wood can be exposed to the elements with virtually no checking or warp and only a moderate loss of surface smoothness (*55*). The heartwood is unusually resistant to the absorption of moisture, surpassing teak in this respect (*198*).

Durability.—The heartwood is rated durable to very durable to a white-rot fungus, and though variable it averages durable to a brown-rot fungus (*249*). In graveyard tests in British Guiana, the wood was highly resistant to decay in contact with the ground; 2- by 2-inch square test pieces lasted 8 to 9 years in the ground (*50*).

The timber is rated about as resistant to drywood termites as Honduras mahogany (*Swietenia macrophylla*) but is considerably less so than teak (*263*). It also has some resistance to marine-borer attack as evidenced by tests at Harbor Island, N.C., where heartwood showed only slight attack after 10 months' exposure and moderate attack by teredo and pholads after 15 months' exposure (*58*, *249*). However, after 23 months the test panels were riddled and removed from the tests (*58*). A similar test in Hawaiian waters showed either no infestation or only light attack by teredo over a 13-month period (*76*).

On the basis of these tests, determa is similar to teak but below Demerara greenheart in resistance to marine borers in salt water. The ash of this timber was determined at only 0.19 percent in tests at the Institute of Paper Chemistry (*261*). No silica is detectable microscopically, indicating that the resistance to marine organisms was not associated with a high silica content.

Uses.—Determa is recognized as a wood of good quality in British Guiana and accordingly commands relatively high prices. It is used within its range for furniture of all types: greenhouse sash framing, sugar boxes, interior and exterior construction, boat planking, punt masts, packing boxes, cart and truck bodies, turned articles, cabinetwork, drawing boards, dowel rods, and other uses. Dugout canoes are also made from it because of its large size and resistance to splitting. The government of British Guiana selected determa as one of 18 local timbers acceptable for interior partitions and battens in the housing program.

The wood's natural resistance to moisture absorption should promote its use for boat parts, tanks, vats, tight cooperage, and other similar items. Its resistance to teredo, termites, and decay should also fit the timber for use in heavy durable construction, piling and marine construction, and for uses in contact with the ground where durability is essential. The timber has also been recommended for plywood and veneer. Having good bending qualities, the wood is recommended for bent parts in furniture, boats, and other items (*136*).

Supply.—The supply of determa is not large, but sizable quantities are available for export in the three Guianas.

DUKALI

Parahancornia amapa

Dukali is one of the few tropical American hardwoods suitable to some extent as a substitute for the white pine imported from the United States. The tree also furnishes a bitter latex used in medicines and is a limited source of a gutta percha. It also provides an edible fruit.

Nomenclature.—The wood of *Parahancornia amapa* (Huber) Duke is called dukali in British Guiana; amaapa, mampa, and mappa in Surinam; amapa in Brazil; and naranja podrida in Peru. This genus has about six species, mostly in Brazil. (Dogbane family, Apocynaceae.)

Distribution and habitat.—Dukali occurs infrequently throughout most of the Amazon Basin, including the Guianas. In British Guiana it occurs in small reefs on light soils in seasonal forests, and as a rare tree in the rain forest throughout the near interior.

The wood.—The heartwood is dull white to pale cream or pinkish. It has a moderatly fine texture, straight grain, and is fairly lustrous. The timber is moderately hard and firm and without distinctive odor or taste (*190*, *82*).

Weight.—Air-dry wood is reported to have a specific gravity of 0.60 and to weigh 37 pounds per cubic foot (*82*). The timber is somewhat heavier than white pine (27 pounds) and lighter than pitch pine (44 pounds) (*160*, *50*).

Shrinkage and seasoning.—No information is available on shrinkage and seasoning.

Mechanical properties.—Information on strength properties of dukali is not available, but its uses would suggest that the timber possesses strength properties commensurate with its density, which is between those of white pine and yellow pine of the United States.

Working properties.—The wood is easy to work and finishes smoothly.

Durability.—It is not resistant to decay and is also very susceptible to blue stain and pocket rot. The timber is not likely to have any appreciable resistance to termites or marine borers.

Uses.—In British Guiana, the Forest Department recommends dukali as a substitute for white pine. In that country it is used for general carpentry, interior work, furniture, door and window stock, concrete forms, and matchboxes. It is also recommended for box manufacture and plywood (*82*). Directors of the official housing program in British Guiana have selected dukali as one of eight local timbers acceptable for louvers, weatherstrips, sash frames, and Demerara shutters; and as one of 18 species acceptable for interior partitions and battens.

Supply.—British Guiana is the principal source of the timber, although it may be available in Surinam and French Guiana when an export market develops.

ENCENS

Protium attenuatum

Nomenclature.—*Protium attenuatum* (Rose) Urban is known as encens, gommier, and bois encens, with encens the preferred trade name. (Bursera family, Burseraceae.)

Distribution and habitat.—The tree is apparently restricted to the southern part of the Lesser Antilles in Guadeloupe, Dominica, Martinique, St. Lucia, and St. Vincent (*18*). It is common in St. Lucia, less frequent in Dominica, and uncommon in St. Vincent. The tree is not reported from Grenada.

The tree.—Encens is a straight, nearly unbuttressed evergreen tree generally distributed throughout the rain forests on many different soils and sites. It reaches a maximum height of 80 to 90 feet and a diameter of about 2 feet or more on favorable sites in St. Lucia (*154*).

The wood.—The timber resembles mahogany in superficial appearance due to the relatively soft, fine-textured, pink-colored heartwood. The sapwood is white; the grain is uniform and fine.

Weight.—Air-dry wood is reported to have a specific gravity of 0.52 and to weigh 32 pounds per cubic foot.

Seasoning.—The wood air-seasons to between 17 and 18 percent moisture content in 5 months on St. Lucia without any apparent degrade, and is stable after manufacture (*50*).

Shrinkage.—No information available.

Mechanical properties.—Detailed strength tests are lacking for encens, but limited tests indicate that the wood is fairly elastic though quite fissile (*218*).

Working properties.—Encens works easily and well with all power and hand tools. It planes to a smooth lustrous surface, saws easily across the grain but leaves a rough edge, drills easily, and takes nails without splitting. The wood polishes well and is very attractive when finished, resembling mahogany when well finished (*154*, *153*).

Durability.—Encens succumbs very quickly to insects or decay and is generally rated low in resistance to both (*218*, *154*, *50*, *153*).

Uses.—Because of its easy working properties, light weight, and attractive appearance, encens is used in St. Lucia and other West Indies islands for furniture, cabinetmaking, interior paneling and trim, and other uses where a durable timber is not required. It is also used for boxes and crates. Gum derived from the bark is sometimes used for incense.

Supply.—Encens is available on St. Lucia and possibly other nearby islands in the Lesser Antilles (*154*).

GOMMIER

Dacryodes excelsa

Nomenclature.—*Dacryodes excelsa* Vahl (*D. hexandra* (Hamilt.) Griseb.) is one of the best formed and most extensively used timbers of Puerto Rico, Dominica, St. Lucia, and other West Indies islands. It is best known as gommier throughout its range except in Puerto Rico, where the name is tabonuco. Names in Guadeloupe and Martinique are gommier blanc and gommier montagne. The tree and wood are also known as gommier blanc in Dominica and mountain gommier in Grenada. (Bursera family, Burseraceae.)

Distribution and habitat.—Gommier is confined to Puerto Rico and the Lesser Antilles, gen-

erally occurring in small groups along ridgetops and upper slopes in the rain forests. It is recorded from Puerto Rico, St. Kitts, Montserrat, Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, and Grenada (*18*, *37*).

The tree.—Gommier is a large to very large evergreen tree, reaching its best development in Puerto Rico, where it grows to 120 feet high and a diameter of 3 to 5 feet. Mature trees are more commonly 60 to 80 feet tall and 20 to 30 inches in diameter. The trees are deep rooted, unbuttressed, and able to withstand the numerous hurricanes of the Caribbean area. The bark is smooth, light gray to nearly white, and often scarred at the base of the tree from gashes made to secure a fragrant resin used for candles and torches, and for incense and medicinal purposes. Because of its abundance, size, and straight, well-formed clear bole, gommier was one of the most valuable lumber trees of the original mountain forests in Puerto Rico (*170*).

The wood.—Gommier is variously reported to resemble birch (*Betula*), mahogany, and sometimes yellow-poplar (*Liriodendron tulipifera* L.) in superficial appearance. The heartwood is a uniform pale brown with a purplish cast when first cut; it turns to a pinkish brown when seasoned and a lustrous brown on exposure. The narrow sapwood, an unattractive grayish color, is not clearly demarcated from the heartwood. The texture is fine to medium and uniform. The wood is generally somewhat finer textured than mahogany, which it resembles superficially. Silica is abundant in the wood, particularly in the ray cells (*190*, *252*, *50*). The grain is more or less roey and sometimes interlocked, creating an attractive ribbon stripe. The luster is high and sometimes satiny in appearance. Growth rings are not distinct, and seasoned wood lacks any distinctive odor or taste.

Weight.—The wood is moderately heavy. The specific gravity of air-dry wood, based on weight and volume in the air-dry condition, averages 0.64. Air-dry wood weighs about 40 pounds per cubic foot and green wood, 52 pounds. It is similar to sugar maple and yellow birch in this respect.

Seasoning.—Gommier seasons easily with no appreciable distortion or other defects. It is reported to air-season in the island of Dominica as well as the average softwood (conifer) in 3 to 4 months and in St. Lucia in 5 months with very little degrade (*50*). Experience in Puerto Rico agrees with the report from Dominica.

Shrinkage.—Gommier undergoes a volumetric shrinkage of 10.5 percent, radial shrinkage of 4.1 percent, and tangential shrinkage of 6.4 percent from green to ovendry. It exceeds both West Indies and Honduras mahogany in volumetric shrinkage, which is a disadvantage if the wood is used where wide variations in atmospheric humidity are likely to occur. However, when used within the tropics, this shrinkage is not a limiting factor (*252*, *149*, *160*).

The ratio of radial to tangential shrinkage is relatively low, indicating the wood should season with a minimum of checking and distortion. In this respect, gommier is superior to African mahogany (*Khaya ivorensis*) and Honduras mahogany (*Swietenia macrophylla*) and about equal to yellow birch and West Indies mahogany.

Mechanical properties.—Mechanical tests of tabonuco from Puerto Rico (*252*) rate the wood as moderately hard, tough, and strong. In general, its strength properties are the same as those of Honduras mahogany, and equal or superior to those of yellow birch except in stiffness and resilience. It also compares very favorably with African mahogany and West Indies mahogany in all strength properties.

Working properties.—The timber is easy to work with some tendency to dull saws and other cutting edges, because of the accumulated silica in the wood. When sharp cutting edges are maintained, the wood finishes smoothly and takes glue and all finishes effectively. It is a good wood for turning and holding nails (*153*, *50*).

Durability.—Gommier is generally considered in Puerto Rico and elsewhere as only slightly resistant to decay (*190*, *170*). This is substantiated by graveyard tests in St. Lucia (*50*), where the wood was destroyed after 3 years in both wet and dry locations. Wolcott (*263*) rates the timber as very susceptible to attack by the dry-wood termite of the West Indies. Gommier has failed quickly in Puerto Rico when used in waters infested with marine borers.

Preservation.—The timber is reported as difficult to impregnate with preservatives under both pressure and nonpressure methods (*194*, *252*).

Uses.—Gommier is used in Puerto Rico principally for furniture and cabinetmaking in the urban areas and for general construction and carpentry in the rural areas (*252*). In St. Lucia and Dominica it is used for crates, shingles, small boat building and furniture (*154*). The wood has sufficient strength and attractiveness to merit its use in place of yellow birch, mahogany, and other cabinet woods. In Puerto Rico it is often stained a dark mahogany color and sold as "mahogany." Rails and posts of "mahogany" beds are frequently made of gommier, stained dark to hide its identity. This is the result of gommier's reputation of being very susceptible to termite attack in comparison to mahogany's known resistance to termites (*231*, *263*). The wood is considered by Wellwood (*252*) and others as suitable for veneer.

Supply.—The timber is only of local importance; no exportable volumes are available at present. St. Lucia and other islands may have surpluses at some future date for the tree reproduces well and is fairly immune to disease, insect attack, and hurricane damage.

DEMERARA GREENHEART

Ocotea rodiaei

Demerara greenheart is an excellent timber for many uses, but is most highly regarded for marine construction because of its high resistance to marine borers and very high resistance to fungi and termites. The timber's resistance to destructive agencies is further supported by exceptionally high strength properties, qualifying it for numerous uses where durability, strength, and good wearing qualities are essential. Other woods are occasionally called greenheart and used as substitutes, but none have proved as satisfactory as true Demerara greenheart. Nearly all the commercial supply comes from British Guiana, where it is one of the most plentiful timbers (*241*).

Nomenclature.—The timber of *Ocotea rodiaei* (R. Schomb.) Mez (*Nectandra rodiaei* R. Schomb.) is generally known throughout the American tropics, Europe, and the United States as Demerara greenheart, or more often as just greenheart. The name Demerara greenheart is preferred to distinguish it from other woods sold on the market as greenheart.

The principal vernacular names used in British Guiana are bibiru and sipiri, rora, kwatuk sipu, and bibiju. In Surinam and the Netherlands, it is called beeberoe, sipiroe, and groenhartbloom; and in Germany, gruenholz, gruenherzbaum, and bibirubaum. In the trade, the wood is often separated into black, brown, yellow, and white greenheart, although wood of different colors is reported to have the same physical and mechanical properties. (Laurel family, Lauraceae.)

Distribution and habitat.—Demerara greenheart occurs principally in British Guiana and in lesser amounts in Surinam on the upper Maratakka River and in Venezuela on the upper Cuyuni River. It has also been reported from the Maroni Region of western French Guiana and from northern Brazil (*44*, *26*).

The distribution of the tree is very limited in Surinam and Venezuela. In British Guiana it ranges widely over 20,000 square miles of the near interior from the Corentyne River to the Waini River, with isolated patches farther west. Commercial distribution in northern British Guiana is within the area drained by the Pomeroom, Cuyuni, Mazaruni, Essequibo, Demerara, and Berbice Rivers, exclusive of the coastlands (*44*). The best remaining stands are in the Bartica Triangle, the Kartabo Triangle, the Cuyuni-Supenaam-Pomeroon area, and the Upper Demerara River (*26*). This area of 2,360 square miles is estimated to contain more than 300,000,000 cubic feet of sound, merchantable timber.

Greenheart avoids the drier sites, but will grow under conditions of physiological drought as in the mora and wallaba forests. The tree is found frequently on all types of soil and reaches its best development on light, sandy soils in a mesophytic habitat, but seldom occurs at elevations greater than 500 feet above sea level. It grows mostly on slopes leading down to streams and in damp sites near streams. It also grows in true swamps between streams, where the tree size, quality, and volume per acre are not quite as good as on the slopes (*26*, *44*, *190*).

The tree.—The tree is evergreen, usually dominant or co-dominant; it grows to a maximum of 40 inches in diameter and 130 feet in height, but normally only 16 to 24 inches in diameter and about 100 feet in height. Boles are generally cylindrical, straight, and 50 to 75 feet long. Taper is moderate, amounting to about 1 inch in 16 feet. Crowns are conical or oval or sometimes irregularly open, small, heavy, and a dark glossy green in color. The bark is flaky and cream colored. Trees are generally basally swollen or have low buttresses.

Many of the standing mature trees are defective. There is more defectiveness on rocky sites where the tree is not as well adapted as on the moist sites. On the average, 80 to 85 percent of all trees have some defect, particularly in the butt portion (*26*).

The wood.—The pale yellow or greenish sapwood of Demerara greenheart is 1 to 2 inches thick in small trees and about 3 inches thick in mature trees. The sapwood is not easily defined from the heartwood, which varies in color from yellowish green, greenish yellow, or light olive through golden yellow, dark olive, or yellowish brown to very dark brown, blackish, or black.

Figured (bull-forehead) wood has a curly grain and golden or black bands running across the width of the boards. The wood of logs with rotten or defective hearts has a distinctive yellow color. The wood is straight grained to roey, fine in texture, uniform, lustrous, and cold to the touch. Freshly cut wood is strongly aromatic but becomes odorless and tasteless when dry. The wood is usually free of knots and other defects (*190*, *143*, *135*, *105*).

Weight.—The timber is exceedingly heavy, weighing about 75 to 80 pounds per cubic foot in the green condition (50 percent moisture content) and about 65 pounds when air-dry (12 percent moisture content). The specific gravity of air-dry wood averages about 1.04, based on air-dry volume and weight, and about 0.88, based on green volume and ovendry weight (*26*, *190*, *105*, *149*).

Seasoning.—The timber is moderately difficult to air-season and somewhat more difficult to kiln-dry in comparison to other timbers. With mild drying conditions under cover in England, the timber air-dries very slowly with a marked tendency to check and with some end splitting. However, warping is not serious, and the total amount of degrade is not excessive.

One-inch boards are reported to air-season to 18 percent moisture content in 1 year in England, with 2-inch boards requiring 2 years to reach the same moisture content. According to the British Guiana Forest Department, 1-inch boards season to 17 percent moisture content in 3 months and to 15 percent moisture content in 5 months at the Mazaruni Station in that country. One-inch boards are reported to season to 15 percent moisture content at Georgetown, British Guiana, in 3 months.

Kiln-seasoning is extremely slow with considerable degrade, particularly in the thicker sizes. Distortion is not excessive, but checking and splitting tend to be severe during kiln-seasoning. In general, timber over 1-inch thickness should be air-seasoned prior to kiln-drying. Kiln Schedule 2 of Forest Products Research Laboratory is recommended (*105*, *222*, *26*, *118*, *237*).

Shrinkage.—Shrinkage rates for Demerara greenheart are relatively low for a wood of its great density. The Forest Products Research Laboratory reports (*222*, *105*) shrinkage values from green to air-dry (12 percent moisture content) of 3.0 percent in the radial plane and 4.5 percent in the tangential plane, or 3/8 and 9/16 inch per foot, respectively. This compares favorably with results at Duke University (*123*) showing 3.4 percent radial and 4.2 percent tangential shrinkage from green to the air-dry condition.

Shrinkage from green to ovendry, which generally averages about twice that from green to air-dry, was reported by Kynoch and Norton (*149*) at 8.2 percent radially, 9.6 percent tangentially, and 16.8 percent volumetrically. This compares favorably with shrinkage rates for yellow birch of 7.2, 9.2, and 16.7 percent, respectively. Volumetric shrinkage is equal to that of yellow birch, which is of much lower density. The low and very favorable ratio of tangential to radial shrinkage may account for the absence during seasoning of any appreciable amount of cup, bow, or twist.

The timber does not react readily to changes in atmospheric conditions but in time undergoes a moderate rate of movement when subjected to changed atmospheric conditions. It will reach an equilibrium moisture content of 11 percent in a relative humidity of 60 percent, and a moisture content of 16 percent in a 90-percent relative humidity. This change is accompanied by a movement (swelling or shrinkage) of 2.0 percent tangentially and 1.6 percent radially, or 1/4 and 3/16 inch per foot, respectively (*108*).

Mechanical properties.—The strength properties of Demerara greenheart are exceptionally high, even for a wood of its great density; it is considered one of the strongest woods in the American tropics. In general, the timber is exceptionally hard, heavy, tough, strong, and elastic but inclined to splinter when fractured. It is only 40 to 50 percent heavier than English oak but 100 percent harder, 140 percent stronger in bending and compression along the grain, and 120 percent stiffer in bending under gradually applied loads. Greenheart is 25 percent stiffer than black locust (*Robinia pseudoacacia* L.), the strongest and stiffest commercial hardwood of North America. Demerara greenheart is twice as strong in resistance to shock as oak, but somewhat inferior to hickory in this respect. Its cleavage strength is about the same as that of oak radially and 70 percent better tangentially than that of oak, which is not particularly outstanding because of its cleavable character. Greenheart is one of the best timbers for resisting tensile and compressive strains. The wood is flexible in narrow strips and has a high coefficient of friction that gives it a nonslip tractive property when wet or even when coated with a film of oil or grease (*16*, *149*, *24*, *26*, *105*, *265*, *135*).

Working properties.—The wood is moderately difficult to work with either hand or machine tools because of its exceedingly high density and hardness. It resists cutting about like a tough grade of English oak. The timber dulls cutting edges rather quickly but finishes to a fine smooth lustrous surface. If cutting edges become dull, there is a tendency for surfaces to become slightly roughened. Because of the low cleavage resistance of the wood, cross-grained or end-grain material must be machined carefully to avoid the breaking-off of chips and splinters at the exit of the tool. The timber turns easily and takes a high finish with wax, oil, or French polish without the need of a filler. Gluing gives fairly good results. It is a moderately good bending wood but does not take nails well, requiring prebored holes to avoid splitting and nail bending.

Tests at Duke University (*123*) on the screw-holding capacity of greenheart show that it is intermediate to courbaril (*Hymenaea courbaril*) and purpleheart (*Peltogyne pubescens*) in the force required to extract No. 6 and No. 10 screws, giving the wood a rating of "good" in screw-holding capacity.

Bandsaws with four teeth per inch and circular saws with the following specifications are recommended for ripping Demerara greenheart: Diameter, 26 inches with rim speed of 10,000 feet per minute; pitch 0.048 × diameter; hook of 15° for green wood and 10° for seasoned material; depth of gullet 0.4 × pitch; width of tooth 0.3 × pitch. A pig-type tooth is recommended for crosscutting (*26*). The timber is reported to be somewhat troublesome when sawed on band mills in the Guianas, as it dulls saws rapidly and logs tend to spring during sawing. These difficulties are not as prevalent in circular mills or frame saws, and are largely overcome in an efficient bandsaw operation.

The acid content of the wood is very low, calculated at 0.48 percent of acetic acid in air-dry

wood, which represents a very low corrosive effect on nails, spikes, and metal fastenings.

Durability.—The sapwood of greenheart, as in all other timbers, is not durable to insects, fungi, or marine borers. The heartwood is very resistant to all types of wood-destroying fungi. The timber was given a rating of "very highly resistant" in graveyard tests in British Guiana (*50*, *206*). Similar tests in England gave comparable results. The heartwood of Demerara greenheart has been subjected to the action of 24 different wood-destroying fungi at the Forest Products Research Laboratory, and was found to be highly resistant to all of them and, in most tests, practically immune to damage. The high resistance was attributed to the presence of tyloses in the pores and certain alkaloids in the wood (*51*).

The timber is reported by many sources as highly resistant to marine organisms in temperate salt or brackish waters and in tropical salt waters, but not in tropical fresh or brackish waters (*76*, *26*). The high resistance to marine organisms is not in this timber the result of a high silica content (considered by some as the principal component present in woods resistant to teredine borers), for the wood has only 0.01 percent or less silica as compared to as much as 2.43 in some samples of manbarklak.

Demerara greenheart's resistance to marine borer attack is generally attributed to the presence of toxic alkaloid, biberine, or nectandrine (*14*). Recent tests of greenheart and 36 other timbers at Wrightville, N.C. (*58*), indicate 11 of the 37 timbers tested were superior to greenheart in resistance to marine borers under the conditions prevailing at this location. These timbers listed in their order of resistance are as follows:

Rating in order of resistance	*Species*	*Name*
1	*Licania macrophylla*	marish
2	*Parinari rodolphii*	parinary
3	*Parinari campestris*	burada
4	*Eschweilera subglandulosa*	manbarklak
5	*Vouacapoua americana*	wacapou
6	*Licania buxifolia*	marish
7	*Eschweilera odora*	manbarklak
8	*Lecythis paraensis*	sapucaia
9	*Hymenolobium excelsum*	angelim
10	*Lecythis usitata*	----
11	*Eschweilera blanchetiana*	----
12	*Ocotea rodiaei*	greenheart

Greenheart and other timbers vary in their resistance to marine borers from one locality to another, largely because of the presence of different wood-destroying organisms and other local conditions (*14*).

The wood is almost immune to attacks by dry-wood termites, pinhole borers, and other wood-destroying insects. Wolcott (*263*) rates the wood very resistant to dry-wood termites—91 in termite resistance in comparison to 80 for West Indies mahogany and 59 for Honduras mahogany. It has very good weathering characteristics and excellent wearability under heavy use. And because of its high fire resistance (very slow burning), Lloyds rate the wood A–1 for ship construction, second only to teak. The American Bureau of Shipping has also approved greenheart for use in shipbuilding because of its fire resistance.

Preservation.—This wood is nearly impermeable to preservatives by either open-tank or pressure methods, but fortunately has enough natural durability to nearly eliminate the need for preservative treatment. Only slight end penetration and virtually no lateral penetration is achieved with either open-tank or pressure treatment (*265*, *105*).

Uses.—Demerara greenheart is obtainable in square, hewn logs or timbers from 70 to 85 feet long and 24 to 30 inches square, even though specifications normally call for a minimum square of from 11 to 18 inches and lengths of 30 to 50 feet. These sizes represent timber free from sapwood. Round piling is also available in lengths up to 80 feet, although the average is 40 to 60 feet with a 12- to 18-inch butt diameter and 6- to 12-inch top diameter.

Taper in hewn logs does not normally exceed 1 inch in a 40-foot log or 2 inches in 60 feet. Logs squared to maximum dimensions seldom vary more than 1 to 1½ inches on adjacent faces. Figured logs, those with a crenated form called "bull-forehead" greenheart, are fairly common but are generally not logged because they are difficult to square. Then too, even though the figure usually occurs only in the outer part of the log, it may at times be continuous throughout (*26*).

The most important use for Demerara greenheart is in marine and ship construction. In marine construction, it is used for revetments, docks, locks, fenders, braces, decking, groins, gates, piers, piling, jetties, and wharves; and in ship construction, for keelsons, beams, engine bearers, planking, gangways, fenders, stern posts, and sheathing for whaling ships.

The timber has been used in the Panama Canal since its initial construction for gates, dredges, and dry docks. It has long been a favorite material for lock gates, piling, and other marine construction in Europe, particularly in England and Holland. It has also been used for these purposes for many years in Mexico, India, South America, and the United States. Greenheart enjoys an almost exclusive position for round or hewn piling owing to the long lengths that can be supplied. The only serious Caribbean competitor is angelique. Hewn angelique piling is considered by some people to be superior to greenheart piling.

Greenheart is particularly well fitted for use where a heavy, hard, straight-grained, very strong, and durable wood is required, as in heavy construction, bridges, trestles, flooring, shipping platforms, and other uses where resistance to wear is required. Because of its great strength and stiffness, the wood has been in demand for

many years in the manufacture of fishing rods in the United States. It is also used for walking sticks, billiard cue butts, belaying pins, mortars, and in textile mills for picker sticks.

In British Guiana the timber is employed in many more uses where a strong durable wood is required, including crossarms, paving blocks, boardwalks, axles, wheel spokes, mining timbers, box culverts, fence posts, and for many uses in general building construction. The Forest Products Research Laboratory in England recommends the timber as excellent for all heavy types of factory and warehouse flooring because of its smooth, long-wearing qualities (*109*).

Supply.—Most of the commercial supply is obtained from British Guiana, where the Government control of cutting and the extent of the forests will assure a steady supply of the timber for many years ahead. The current government policy of managing stands of this species on a sustained yield basis will permit recutting every 80 to 100 years.

The volume of commercial timber in the accessible forest area in British Guiana is estimated at 1,600,000,000 cubic feet—about 12 billion board feet or more of sawed lumber (*109*). (See section on Distribution and Habitat.) In 1954 about 1,427,000 cubic feet of the round, hewn, and sawed timber of all dimensions was shipped from that country, principally to the United Kingdom, British West Indies, Europe, and the United States.

GRONFOELOE

Qualea rosea, Qualea coerula, Qualea albiflora

Nomenclature.—Three species of the genus *Qualea*, namely *Q. rosea* Aubl., *Q. coerula* Aubl., and *Q. albiflora* Warm. (*Q. glaberrima* Ducke), are often marketed individually or in mixture in Surinam and French Guiana under the trade name of gronfoeloe. In Surinam the timber is also called meniridan, menirislin, woto-kwarie, berg gronfoeloe, and jakopi. Other names in French Guiana are cèdre gris, grignon fou, and grignon indien (*50*, *231*, *175*). In Brazil the timber of *Qualea* is known as mandioquiera and at times as quaruba, although the latter name is usually applied to species of the genus *Vochysia*. The name manio was derived from mandioquiera and accepted in 1946 as the standard name on the British market (*36*). The German trade know the timber as Brazilian okume or aburaq. The principal Venezuelan name for *Qualea* timber is florecillo. Other common trade names used in the Guianas are wiswishvalie and wassie-wassie kwarie (*190*). *Q. rosea* is commonly known as berg kwarie or mountain gronfoeloe in Surinam and laba-laba in Brazil. (Vochysia family, Vochysiaceae).

The three species providing gronfoeloe occur in the Guianas and in the states of Para, Maranhao, and Amazonas in Brazil, where they are of rather common occurrence in the primeval forests on the higher, noninundated sites. *Qualea coerula* is a frequent tree in the marsh forests of Surinam, especially in the eastern part of the country, while *Q. rosea* and *Q. albiflora* are rare to locally frequent in the rain forests. *Q. rosea* is a common tree in French Guiana constituting one-eighth of the trees in some parts of the country (*231*, *118*, *190*). *Q. albiflora* is found also in British Guiana.

The tree.—The trees are generally tall, sometimes attaining a height of 200 feet, with long clear boles and often of very large diameter. In French Guiana, *Qualea rosea* is a well-formed tree up to 150 feet tall, averaging 2 feet in diameter, and free of branches for 60 to 70 feet (*23*). There is a lack of information in the literature concerning the dimensions and growth habits in the rest of the tree's range.

The wood.—The cream-colored sapwood of gronfoeloe is 1¼ to 2¼ inches thick, and except for *Qualea rosea* is rather clearly separated from the heartwood. Freshly cut heartwood is a pinkish brown; upon drying it turns a light reddish brown with a definite coppery or golden look. Superficially, the wood resembles Spanish cedar (*Cedrela*) and quaruba or yemeri (*Vochysia*).

Growth rings are not distinct, but show as concentric bands made visible by differences in color density of the groundmass that show up on the tangential surface as conspicuous parabolic figures. The luster is high but without the characteristic subluster so well developed in many high-grade cabinet woods. The texture is medium to coarse and the grain straight to sometimes interlocked. When interlocked grain is present, a mild wavy figure is apparent on the tangential surface. No distinctive odor or taste is evident in seasoned wood (*127*, *231*).

Weight.—Gronfoeloe is a moderately heavy wood, with little difference in the density of the three species covered in this report. The specific gravity, based on ovendry weight and green volume, is reported at 0.49 for *Qualea albiflora* and 0.53 for *Q. rosea*. Specific gravity, based on the weight and volume of air-dry wood at 12 percent moisture content, is reported at 0.59 for *Q. albiflora*, 0.58 for *Q. coerula*, and 0.62 for *Q. rosea*. Air-dry wood weighs 37, 36, and 39 pounds respectively for the species in the order listed. Green wood averages from 60 to 79 pounds per cubic foot (*231*, *249*, *127*, *250*).

On the basis of these various gravity determinations, gronfoeloe averages about 0.50 in specific gravity based on green volume and ovendry weight, and 0.60 based on air-dry volume and weight (with wood averaging about 37 pounds per cubic foot when air-dry and 70 pounds when green).

Seasoning.—The wood is moderately difficult to air-season and kiln-dry. It seasons rapidly but with some warping in the form of crook and twist

and slight end and surface checking. *Qualea rosea* is somewhat more difficult to season than the other species while *Qualea albiflora* dries without any appreciable degrade. Slight stain may develop during the early stages of air-drying, but is easily controlled if the green lumber is submerged or sprayed with a fungicide prior to piling. Kiln Schedule 4 has been suggested by the Forest Products Research Laboratory in England for kiln-drying gronfoeloe (*104*, *127*, *118*, *231*).

Shrinkage.—Gronfoeloe undergoes moderate shrinkage during seasoning with a somewhat high ratio of tangential to radial shrinkage and a volumetric shrinkage that is moderate for a wood of its density. The timber is similar to yellow birch in tangential shrinkage and much lower in both radial and volumetric shrinkage, but lacks the favorable ratio of tangential to radial shrinkage shown by yellow birch. Summarized below is the shrinkage from green to ovendry, expressed as a percent of the green volume, of gronfoeloe and yellow birch. Normal shrinkage from green to air-dry would be approximately half these values.

	Green to ovendry			
	Radial (*percent*)	*Tangential* (*percent*)	*Longitudinal* (*percent*)	*Volumetric* (*percent*)
Gronfoeloe:				
Qualea albiflora (*127*)	4. 0	7. 7	0. 14	12. 7
Qualea coerula (*231*)	3. 7	7. 9	------	-------
Qualea rosea (*250*)	4. 4	8. 4	. 08	11. 4
Yellow birch:				
Betula alleghaniensis	7. 2	9. 2	------	16. 7

Movement, swelling or shrinkage, of gronfoeloe in response to changes in atmospheric conditions is moderate for a wood of its density. *Qualea albiflora*, most representative of the timber, swells 6.12 percent from ovendry to equilibrium in a 40-percent relative humidity, 9.25 percent in a 70-percent relative humidity, and 15.15 percent in a 100-percent relative humidity (based on the original ovendry volume). It reaches a moisture content of 10.5, 15.6, and 28.7 percent, respectively, at these three humidity conditions, which is considered normal for a wood of gronfoeloe's density (*175*, *50*).

Mechanical properties.—Tests at Yale University (*249*, *250*) of *Qualea albiflora* and *Qualea rosea* in the green condition showed that gronfoeloe is similar to or exceeds yellow birch (*Betula alleghaniensis*) in all mechanical properties except work to maximum load, although yellow birch is an appreciably heavier wood. In the green condition, gronfoeloe is noticeably above average for woods of similar density in stiffness, elastic resilience, crushing strength, and tension and compression across the grain. It is average for a wood of its weight in static bending, strength, shock resistance, hardness, shear, and cleavage.

Gronfoeloe increases in most strength properties upon air-drying, but decreases in cleavage resistance and tensile strength across the grain. After seasoning, gronfoeloe loses most of its superiority over yellow birch, in which condition it has half the shock resistance of yellow birch and is generally somewhat inferior to that species in most other strength properties. It is superior to white ash in static-bending properties and in compression parallel to the grain, but inferior to that wood in hardness, compression, and tension perpendicular to the grain, shear, and cleavage.

These strength determinations of gronfoeloe at Yale University are substantiated in tests by Pfeiffer (*175*), the Agricultural University of Wageningen in Holland (*231*), and the Forest Products Research Laboratory in England (*15*).

Working properties.—Gronfoeloe has moderately good working properties, saws and planes well, glues satisfactorily, but requires care in polishing. However, it dulls saws and cutting edges rather quickly because of the accumulation of silica in the parenchyma and ray cells. Chipped or torn grain is likely to occur when roey grain is present, and fuzzy surfaces and tearing are apt to occur in boring.

Durability.—The wood is somewhat variable in decay resistance but in general is moderately durable. *Qualea albiflora* was rated durable in its resistance to a white-rot fungus but only moderately durable to nondurable to a brown-rot fungus in pure culture tests at Yale University (*127*). *Q. rosea* was found very durable to a white-rot organism and durable to moderately durable to a brown-rot fungus. It is reported as moderately resistant to resistant to decay in Surinam (*175*). Observations in England at the Forest Products Research Laboratory indicated that the timber is not suited for general use in continuously damp conditions.

Qualea albiflora is moderately resistant to damage by the dry-wood termite of the West Indies (*218*), rating 42 as compared to 80 for West Indies mahogany and 59 for Honduras mahogany. The resistance of the timber to damage by marine borers is not clear. However, its extensive use in Holland for piling, specifically in nonteredo areas, would indicate that the timber has little resistance to marine borers despite the considerable accumulation of silica in the parenchyma and ray cells. However, specific tests of this timber may show it as considerably resistant to damage by marine organisms.

The weathering characteristics are rated as only fair; severe surface checking develops when unpainted wood is exposed to the weather.

Uses.—Gronfoeloe is used locally for such purposes as joinery, flooring, interior trim, furniture, and millwork. In Holland it is used as a substitute for oak in marine piling and sheeting in teredo-free areas. If it can be successfully peeled or sliced, it should be very suitable for veneer and

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plywood for use in furniture, paneling, or general utility. It has been used in Germany for veneer, indicating that the wood can be veneered. Logs of either gronfoeloe or related species from Brazil have been used in superstructures of bridges. The wood has also been found suitable for packing cases, outside and inside sheathing, rafters, and implements. Generally, it is found suitable for outside construction.

Supply.—Surinam and French Guiana can supply gronfoeloe in export volumes.

GUMBO-LIMBO

Bursera simaruba

Gumbo-limbo is the most widespread and commercially important of the several species of *Bursera* growing in the Caribbean area. Many others are distributed in tropical America. Several are prized principally for the high percentage of fragrant oil in the wood and fruit and to some extent for their resins. Record and Hess (*190*) indicate that the following species are of commercial importance in Mexico in addition to *Bursera simaruba* (L.) Sarg., which is discussed here: *B. tecomaca* (DC.) Standl., *B. glabrifolia* (H. B. K.) Engl., *B. penicillata* (Sessé & Moc.) Engl., *B. copallifera* (Sessé & Moc.) Bullock, and *B. jorullensis* (H. B. K.) Engl. (Bursera family, Burseraceae.)

Nomenclature.—The timber of *Bursera simaruba* is commonly marketed under the trade name of West Indian birch. Other local names used in the Caribbean area for the tree or timber are as follows: Red gombo, red gombolimbo, limbo, and chaca in British Honduras; mastic, incense tree, turpentine tree, red birch in Jamaica; naked Indian, peeling bark, gommier in Trinidad; almácigo in Puerto Rico; gumbo-limbo in Florida; almácigo, aceitero in Cuba; gommier in Haiti; almácigo, almácigo blanco in Dominican Republic; archipén, gommier, chibou in French West Indies; chaca in Mexico.

Distribution and habitat.—The tree occurs commonly in southern Florida, throughout the West Indies, and on the continent from southern Mexico, Central America, and into northern South America. It is reported from all the larger islands in the Greater and Lesser Antilles, and it probably occurs on most of the smaller islands (*18*).

The tree is not exacting as to site and moisture conditions, growing on a variety of sites from xerophytic to mesophytic forests but reaching its best development in lowland forests. It occurs in some sites as pure or nearly pure forests, and in others as an occasional to very frequent tree. It grows well in the dry coastal plains and foothills in Jamaica and in rocky, barren limestone soils in other parts of the island. In British Honduras, where it is rather common, up to 23 trees per acre are found along broken ridges on the northern plain.

The tree.—Size varies according to site and geographic location. In general, it is a slender unbuttressed tree of short to medium height. It can be readilly recognized by its characteristic smooth, shiny, copper-colored bark, which peels off in thin shreds like some of the birches (*Betula*) though the trees are not related. The smooth, green inner bark exudes a reddish aromatic resin that hardens upon exposure. Forest grown trees are usually tall and slender with a fairly straight bole; in the open the trees are generally short and often crooked.

In British Honduras, trees attain heights of 80 to 90 feet and diameters of 30 inches; but they are more commonly 60 feet in height and 14 to 18 inches in diameter (*82*). In Jamaica, trees are commonly 50 feet in height and up to 3 feet in diameter (*229*). On some of the drier sites, particularly on the dry slopes in the West Indies, short crooked trees are most common (*165*, *162*).

The wood.—Heartwood is white, yellowish, or light brown, soft and light in weight, but firm and tough. Sapwood is not differentiated from the heartwood. The texture is fine to medium and the grain fairly straight. The wood, without distinctive taste or odor, is of moderate luster. Both the heartwood and sapwood are often discolored to a gray by sap-stain fungi. The inner parts of the growth rings are whitish and the other parts are pale brown, giving a ribbon stripe figure on longitudinal surfaces similar to that on white pine or spruce (*82*, *143*).

Weight.—Tests of gumbo-limbo wood from Florida at the Forest Products Laboratory in Madison (*160*) showed a specific gravity of 0.34, based on air-dry weight and volume (12 percent moisture content), and a weight of 21 pounds per cubic foot air-dry and 38 pounds per cubic foot when green. The specific gravity based on green volume and ovendry weight averaged 0.30. Timber from British Honduras is reported to range from 0.30 to 0.40 in specific gravity, based on air-dry weight and volume, and to weigh from 19 to 30 pounds per cubic foot when air-dry (*231*).

Seasoning.—The timber seasons very well with only slight checking or warping, but will become discolored from sap-stain fungi and sometimes decay unless the wet, green boards are allowed to dry immediately after conversion. This can be most economically and effectively controlled by dipping or spraying with a fungicide or by kiln-drying imediately after sawing. Also, logs are very susceptible to sap-stain fungi, which may penetrate as far as a foot from both ends of the log in a one-week period; when it does, a heavy hyphal growth shows on both exposed surfaces. The high moisture content is principally responsible for this condition. However, it can also be controlled by spraying the logs with a fungicide immediately after felling (*82*, *197*, *65*).

Shrinkage.—Shrinkage of *Bursera simaruba* from green to ovendry is very moderate, amounting to 2.3 percent radially, 3.6 percent tangentially, and 8.6 percent volumetrically. The low ratio of tangential to radial shrinkage indicates the inherent capacity of this timber to dry without appreciable checking or warping. Shrinkage from green to air-dry is roughly half the above figures. Compared to the heavier yellow birch and paper birch of the United States, gumbo-limbo has one-third as much radial shrinkage, two-fifths the tangential shrinkage, and about one-half the volumetric shrinkage of these species (*160*).

Mechanical properties.—The tests at the Forest Products Laboratory (*160*) showed gumbo-limbo rated considerably below the pines, spruces, and firs in all mechanical properties tested except in resistance to splitting (cleavage), in which gumbo-limbo compared favorably to the others. However, the tests were conducted on five logs from southern Florida, and these may not be representative of timber from other sources.

Working properties.—The timber works easily with all types of tools and machines. It saws cleanly, planes to a smooth finish, drills cleanly with some tearing at the exit side, and turns readily on the lathe. The wood takes all stains and polishes well and holds nails firmly without splitting (*191*, *82*).

Gumbo-limbo logs peel well on the rotary lathe without preliminary heating or bark removal, although some logs produce wooly-surfaced veneers. The yield of acceptable face veneers is estimated at 30 to 40 percent by a large producer in Mexico. The veneer usually has numerous pin knots and some mineral streaks, although veneer cut from some logs has a bird's-eye figure similar to that of sugar maple. The veneer resembles Canadian paper birch (*Betula papyrifera* Marsh.) in color and design; when made into plywood it has the same appearance as yellow birch (*B. alleghaniensis* Britton). One difficulty in using *B. simaruba* is the frequent crookedness of the logs and their susceptibility to sap-stain discoloration (*197*).

Durability.—The wood is not durable in contact with the ground, and when green, is susceptible to pinhole borer attack. Seasoned lumber is attacked by *Lyctus* beetles and is very susceptible to termite damage (*263*.) Generally, without preservative treatment, gumbo-limbo is not a suitable wood for outside or exposed use in the tropics.

Uses.—Gumbo-limbo is suitable, in general, for the same uses as pine or other light-weight conifers; but it lacks the strength of these woods and, consequently, should not be used where strength is needed. The timber is used for matchsticks, boxes, crates, flooring, house construction, and general carpentry. The wood appears to have suitable characteristics for use as a pattern wood, although it seems rather soft for its present uses as flooring. In Mexico, it has been used successfully for white plywood under the trade name "Mexican white birch" and is well regarded there for plywood core material as a substitute for cedar. Parts of small trees and limbs of large trees are used extensively for live posts, and when set in the soil take root and eventually develop a green crown (*192*).

The aromatic red resin is used to mend crockery, as a crude varnish, and as an insect repellent. A decoction of the bark and leaves is used at times as a tonic.

Supply.—The timber is presently available in quantities for export in British Honduras and possibly Trinidad, Jamaica, Haiti, and Cuba.

HAIARI

Alexa imperatricis, Alexa leiopetala

Two species of *Alexa* are marketed in British Guiana as haiari or haiariballi. The wood is used locally and, although the Forest Department of British Guiana considers haiari available in sufficient volume and of suitable quality for export, it is nearly unknown in the export trade.

Nomenclature.—Species marketed in British Guiana under the trade name haiari and haiariballi are *Alexa imperatricis* (Schomb.) Baill. and *A. leiopetala* Sandw. The former occurs also in Venezuela and Surinam. Another species, *A. wachenheimii* R. Ben., is found from British to French Guiana but is not utilized at present. *A. bauhiniaeflora* Ducke, a small tree or shrub growing in Brazil, is also of no commercial importance. (Legume family, Leguminosae.)

Distribution and habitat.—According to D. B. Fanshawe (*82*), *Alexa leiopetala* is frequent in the wallaba and heavy forest on white or light sands in the north-central and northeast districts of British Guiana, while *A. imperatricis* is often dominant in the heavy forests on light-colored sands of the northwest and upper Mozaruni district and the Pakaraima Mountains. *A. wachenheimii*, which may be marketed with the above species at some future date, is found in the upper Essequibo district of British Guiana and in parts of French Guiana.

The tree.—The trees are unbuttressed, cylindrical, well formed with small oval crowns. They grow to 36 inches in diameter and 100 feet high in favorable sites, but are normally 20 to 24 inches in diameter and less than 100 feet high. The main stem or bole is often 70 to 80 feet long, allowing the extraction of logs of almost any desired length.

The wood.—The heartwood of haiari is nearly colorless to brownish yellow but occasionally somewhat darker. The thick sapwood of dingy white color is not readily separated from the heartwood. The luster is medium to low. The wood is generally straight grained, rather coarse textured and odorless and tasteless when dry.

Weight.—Haiari is intermediate in density to western white pine and Douglas-fir of the United States. Air-dry lumber cut in British Guiana averages 0.48 in specific gravity and weighs 30 pounds per cubic foot.

Seasoning.—The logs are reported to split easily after felling, and the lumber is said to have a marked tendency to collapse during seasoning. Close piling for air-seasoning and the use of high humidities and low temperatures during the early stages of kiln-drying are recommended as a means of overcoming the seasoning problems.

Shrinkage.—Information is lacking on shrinkage during seasoning. But studies of the shrinkage and swelling of haiari in response to atmospheric changes show the wood to have large movement values. This wood reaches a moisture content of 20.5 percent in a 90-percent relative humidity, and 12.5 percent in a 60-percent relative humidity, undergoing a movement of 1.8 percent radially and 3.0 percent tangentially, or $^{14}/_{64}$ and $^{23}/_{64}$ inch per foot, respectively, between equilibrium in the two conditions. These high movement values are about double those of Honduras mahogany of $^{8}/_{64}$ and $^{10}/_{64}$ inch per foot, respectively.

Mechanical properties.—Tests have not been made to determine the mechanical properties of haiari, but its medium density would almost certainly exclude it from the group of tropical woods having superior strength properties.

Working properties.—Detailed information concerning the workability of this wood is not available except that it is considered to work easily and finish satisfactorily.

Durability.—According to the British Guiana Forest Department report, haiari timber is highly resistant to decay, but the freshly cut logs are very susceptible to damage by pinhole borers (*82*).

Uses.—Haiari is suitable for interior construction, boxes, crating, general construction, plywood, and other uses requiring a light, easily worked wood of moderate strength. In a region where heavy, hard, strong woods predominate, a wood such as haiari should be readily accepted for many uses to which these other woods are not suited. In many places, it could replace the imported pines and Douglas-fir.

Supplies.—British Guiana is the only country now prepared to export haiari. The timber there is found over rather extensive areas and, although not available in such abundance as greenheart, wallaba, and some other woods, it is in sufficient supply to fill a relatively large export market.

HURA

Hura crepitans

Nomenclature.—Hura is the preferred trade name for the wood of *Hura crepitans* L. It is also widely known as possumwood and as hura-wood or rakudar in the United States. The timber is known as bois du diable in Martinique; sandbox or sandbox tree in Trinidad, Montserrat, and British Guiana; possentrie in Surinam; sablier in French Guiana; and very commonly as jabillo or javillo in the Spanish-speaking islands of the Caribbean. Another name in Puerto Rico is molinillo. The timber is usualy known as assacú in Brazil. British importers generally refer to the wood as hura, hura wood, or possumtree. (Spurge family, Euphorbiaceae.)

The wood of a second species, *Hura polyandra* Baill., may be included in commercial lots. The latter extends from southern Mexico southward through Central America to Costa Rica, where its range overlaps that of the more important species. It is very similar in every way to *H. crepitans*, the two woods being indistinguishable on the basis of superficial characteristics (*118*, *190*).

Distribution and habitat.—Hura occurs naturally in moist to wet sites through the West Indies and from Central America to northern Brazil and Bolivia (*182*, *65*). The tree reaches its best development along the low narrow reefs of the coastal plain near Paramaribo, Surinam, where nearly pure stands average more than 25,000 board feet per acre over an area of 20,000 acres. The tree is also very common in Trinidad, where it tends to form pure stands in moist sandy loam soil with upward of 50 trees or more per acre (*165*). It is also present in commercial quantities in British Guiana and French Guiana (*235*), and is frequently cultivated for shade and decorative purposes throughout the tropics of both hemispheres.

The tree.—Hura is commonly a large, straight, well-formed tree. In favorable locations it commonly attains diameters of 3 to 5 feet and at times even 6 to 9 feet. Trees in the closed forests commonly reach heights of 90 to 130 feet with clear boles from 40 to 75 feet long. Trees up to 200 feet with 100-foot clear boles are reported along the Surinam coast. In open forests the tree may be relatively short with a thick trunk.

The trees are often basally swollen or have small buttresses. The smoothish bark is usually covered with many conical spines. Contained in the bark is a thin, milky latex that is exceptionally irritating to the eyes; it is used by the natives to stupefy fish and as a remedy for elephantiasis and leprosy. The fruits resemble little pumpkins and explode on drying, expelling small waferlike seeds containing an oil used at times to poison animals (*193*, *211*).

The wood.—Hura superficially resembles simarouba but lacks the bitter taste. The wood is light, has a warm soft feel, but is sometimes woolly on the surface (*142*, *92*). Freshly sawed heartwood is cream to light buff, turning pale yellowish brown, pale olive gray, or dark brown upon drying, or sometimes remaining its original

cream color. The innermost heartwood of large logs is often darker than the exterior portions; sapwood is yellowish white, often indistinct from the heartwood but at times sharply demarcated. The grain is straight to interlocked but more often interlocked. The luster is high, the texture fine, and odor and taste are lacking. Indistinct purplish or greenish streaks and a slight ribbon stripe on the radial surface often give the wood an attractive figure.

Weight.—Moderately light in weight, hura has an average specific gravity of 0.38 (0.31 to 0.51), based on ovendry weight and green volume. The specific gravity based on air-dry volume and weight averages about 0.46 (*127*). Air-dry wood weighs about 28 pounds per cubic foot and green wood about 40 pounds per cubic foot.

Seasoning.—The wood is considered moderately difficult to air-season. It will air-dry rather rapidly, which tends to prevent the development of mold and sap-stain fungi but results in variable degrees of warping, sometimes severe. Slight checking also occurs. If the sawed boards were dipped in a fungicide solution and air-dried at a moderate rate, much of this difficulty could be eliminated. Kiln Schedule 5, a low temperature-high humidity schedule used for slow, careful seasoning, is recommended by the Forest Products Research Laboratory in England (222).

Shrinkage.—Volumetric shrinkage of hura or possumwood is low, amounting to 7.3 percent from green to ovendry, which is similar to mahogany's 7.7 percent. The ratio of radial shrinkage (2.7 percent) to tangential shrinkage (4.5 percent) is moderate, indicating rather uniform movement in these directions. Longitudinal shrinkage of 0.48 percent does not exceed the limit of variation expected of wood with interlocked grain (*127*). The wood is relatively stable, undergoing only moderate dimensional movement in response to atmospheric changes (*175*).

Mechanical properties.—Tests at Yale University (*127*, *249*) showed hura to be above average in all static-bending properties except stiffness, when compared with species of like density in the green condition. It is average in resistance to crushing and stiffness as determined by compression along the grain, and in hardness and toughness; above average in compression and tension across the grain, and in shear and cleavage; and below average in stress at proportional limit in compression along the grain.

Upon air-drying, hura increases moderately in all properties except cleavage and tension across the grain, but improvement is generally below that normally found for hardwoods in the United States. The greatest proportional increase occurs in compression parallel to the grain, followed by end hardness, compression across the grain, elastic resilience, shear, side hardness, and stiffness. A strength loss of 20 percent occurs in tension across the grain during seasoning. The wood is similar in density to yellow-poplar (*Liriodendron tulipifera* L.) of the United States but slightly superior in all mechanical properties, except stiffness as determined by bending.

Working properties.—Green wood is somewhat difficult to work because of extreme fuzziness of the cut surface, but it can be readily machined when air-dry. Chipped and torn grain are frequently encountered with wood that has extreme interlocked grain. The wood takes stain well, nails satisfactorily, and glues easily (*231*, *240*, *127*).

Durability.—In pure culture tests at Yale University (*249*), durability was extremely variable but the wood averaged moderately durable to both brown-rot and white-rot fungi. Graveyard tests in Trinidad (*39*) also showed this species to be fairly resistant to decay. But it is very susceptible to damage by the dry-wood termite (*263*) and probably readily damaged by marine borers. Its excellent weathering characteristics are comparable to those of Honduras mahogany. The wood stays free of surface checks and warp and undergoes only slight loss of surface smoothness when exposed unpainted to the weather (*55*). It is reported inferior to Honduras mahogany in resistance to water absorption (*17*).

Preservation.—The wood has a low resistance to impregnation with preservatives, absorbing up to 20 pounds per cubic foot in a hot and cold bath treatment (*204*).

Uses.—Hura or possumwood is used locally for general carpentry, interior construction, boxes, crates, veneers and plywood, and furniture and joinery. In Mexico it is sometimes used as telegraph poles. The wood is recommended for use as core stock, both utility and face veneer, millwork, and for general use in furniture and joinery where a lightweight, easily worked wood is required (*138*). The wood does not wear well and should be avoided where continuous wear will be a problem. The oil from the seed pods is considered suitable for linoleum manufacture and in soapmaking when mixed with other oils (*265*).

Supply.—The Guianas, Trinidad, and possibly Honduras have sufficient volumes for export.

INYAK

Antonia ovata

Nomenclature.—*Antonia ovata* Pohl is the only known species of its genus. The timber is commonly known as inyak or inacú in British Guiana and as hariroroe, thoeraroe, licahout, and other vernacular names in Surinam (*190*, *82*, *180*). (Logania family, Loganiaceae.)

Distribution and habitat.—Inyak grows in the Guianas and Brazil. It is one of the dominant species in the Kanaku Mountains of British Guiana and occurs as a rare to locally frequent tree

in the seasonal forest of the Northeast and Rupununi Districts of that country.

The tree.—*Antonia ovata* is a medium-sized tree, commonly 16 to 20 inches and occasionally up to 24 inches in diameter and 120 feet in height. The boles are of moderately good form and generally clear of branches for 60 to 70 feet above the low buttresses.

The wood.—The heartwood and sapwood are a uniform off white or greyish cream throughout and of medium texture and luster. The grain is irregular and roey. Distinctive odor or taste are not detectable in seasoned wood (*82*, *190*).

Weight.—Inyak is medium weight, ranging from 0.48 to 0.56 in specific gravity, based on air-dry weight and volume. Air-dry wood averages between 30 and 35 pounds per cubic foot (*82*), which is similar to the weight of Douglas-fir (*Pseudotsuga menziesii*) of the United States (*242*).

Seasoning.—No data are available.

Shrinkage.—No data are available.

Mechanical properties.—No data are available.

Working properties.—Inyak is reported to work fairly easily and to finish smoothly.

Durability.—The Forest Department of British Guiana rates inyak as moderately resistant to decay (*50*, *82*).

Uses.—Inyak has been recommended for interior work, boxes and crates, and as a possible timber for utility plywood and core stock (*50*, *82*). It would appear to be suitable for inside sheathing, partitions and battens, millwork, and for temporary forms and protected outside sheathing.

Supply.—British Guiana has inyak in export quantities.

KAUTA, KAUTABALLI, MARISH

Licania spp.

At least nine, probably more, species of the large genus *Licania* are marketed in the Guianas and Brazil under various trade names. The timbers are all similar: They are very hard, heavy, and strong; they are very difficult to work; their high silica content makes them teredo resistant. Because of a natural resistance of *Licania* to marine borers, the woods of this genus are of more than passing interest to the export trade.

Nomenclature.—Marish and kautaballi are in more plentiful supply than kauta in the three Guianas. Marish is often composed of any one or a combination of *Licania buxifolia* Sandw., *L. densiflora* Kleinh., *L. macrophylla* Benth., and *L. micrantha* Miq. It is commonly known as marishballi in British Guiana; anaura in Brazil; anaura, sponsoehoedoe, and kauston in Surinam; and gris-gris, gris-gris coumate, and gris-gris rouge in French Guiana.

Kautaballi, which is usually made up of *Licania venosa* Rusby and *L. majuscula* Sagot, is also known as counterballi and farsha in British Guiana, and gri-gri and bois galuette in French Guiana. Kauta is composed of three species: *L. laxiflora* Fritsch, *L. mollis* Benth., and *L. persaudii* Fanshawe & Maguire. In British Honduras, another species, *L. platypus* (Hemsl.) Fritsch, is marketed under the name of monkey apple, but is of no commercial importance because pine and mahogany are locally available. (Rose family, Rosaceae.)

Distribution and habitat.—The several species of *Licania* included in this report are all from the area of the Guianas and Brazil. One or more of the species making up marish timber occur throughout the Guianas and the lower Amazon region of Brazil; kautaballi is reported from both French and British Guiana and may occur in other areas, while kauta is reported only from British Guiana but may also have more extensive distribution.

Fanshawe states in his Forest Products of British Guiana (*82*) that kauta is frequent to locally common in the rain forest, especially on lateritic soils, and of general distribution except in the northwest district; that kautaballi is dominant in the rain and seasonal forest on sandy soils and is of general distribution; while marish is frequent in the rain forest, of occasional occurrence in the marsh and mora forests, and is of general distribution.

Licania macrophylla is reported to occur frequently in the overflow woodlands of the Amazon and in the upland forests of the lower Amazon region (*23*, *248*). Kautaballi is one of the most common commerical species of British Guiana, exceeded in number of trees only by mora, black kakaralli, baromalli, wallaba, yaruru morabukea, and possibly crabwood. Marish is fairly plentiful, while kauta is relatively scarce.

The tree.—The species providing the timbers described in this report are heavy crowned, unbuttressed canopy trees, generally 16 to 24 inches in diameter and 80 to 110 feet high. The boles are ordinarily cylindrical and 50 to 60 feet long. Although not buttressed, kautaballi is often basally swollen and occasionally has adventitious shoots. Marish, the largest tree of the group, is sometimes found up to 36 inches in diameter (*82*, *50*, *248*).

The wood.—The wood is very dense, hard, heavy, and strong. The heartwood is generally a yellowish brown to brown or dark brown, sometimes with a reddish tinge; the sapwood is usually distinct and tan in color. The wood is straight grained, with fine, close texture, and without characteristic odor or taste. Growth layers are not evident. Most species contain an abundance of silica (see section on Durability) (*82*, *248*, *231*, *50*).

Weight.—Marish weighs from 71 to 75 pounds per cubic foot in the green condition and from 58 to 68 pounds when air-dry, according to studies at Yale University (*248*) of *Licania buxifolia* and *L. macrophylla* from British Guiana, Surinam, and Brazil. The specific gravity of air-dry wood in this study ranged from 0.93 to 1.09. Specific gravity based on green volume and ovendry weight ranged from 0.76 to 0.88. *L. buxifolia* is the heavier of the two species and is represented by the larger number under each condition. The British Guiana Forest Department lists an air-dry weight of 61 pounds per cubic foot and air-dry specific gravity of 0.98 for the species providing the marish timber of that country (*50*).

Both kautaballi and kauta are heavier than marish, which is itself a very heavy wood. Kautaballi is reported to have an average specific gravity of 1.08 to 1.22 (air-dry) and to weigh from 67 to 76 pounds per cubic foot air-dry. Kauta is still somewhat heavier, weighing 70 to 80 pounds per cubic foot air-dry, with a specific gravity of 1.12 to 1.29 in that condition.

Seasoning.—Marish, kauta, and kautaballi are rated easy to moderately difficult to air-season, depending on the species and geographic location. One of the principal species of marish, *Licania buxifolia*, is considered moderately difficult to air-season, drying at a moderate rate with slight warping and checking and very slight casehardening. *L. macrophylla* from Surinam is rated easy to air-season, drying at a fast rate with slight warping and checking and slight casehardening. However, material of the same species from Brazil dries at a slower rate with slightly more warping in the form of crook and twist (*248*).

Shrinkage.—Shrinkage values of marish are relatively high compared to those of other tropical hardwoods of similar density. Shrinkage values for kauta and kautaballi are not available, but presumably they are similar to those for marish. *Licania buxifolia* from British Guiana exceeds greenheart in tangential and volumetric shrinkage but has a slightly lower radial shrinkage. *L. macrophylla* from Surinam undergoes greater tangential shrinkage than greenheart, but shrinks less than that species radially and volumetrically. Both species shrink slightly more in all directions than white oak (*248*).

Mechanical properties.—Mechanical tests have been conducted on *Licania buxifolia* and *L. macrophylla*, which contribute most of the volume of marish timber (*248*). The results can also be safely applied, in general, to both kauta and kautaballi, which are somewhat heavier and likely somewhat stronger in some properties. However, the tests at Yale indicate there is considerable variation in strength properties between the different species of *Licania* and, consequently, all statements concerning strength properties must be of a general nature.

Both species were found to be somewhat below the average in strength for green wood of tropical species of similar density. In the green condition they are generally inferior to greenheart but superior to white oak and hickory in all properties except in shear, cleavage, and shock resistance.

Seasoned wood of *Licania buxifolia* is comparable or superior to greenheart in most strength properties except in shock resistance and tension perpendicular to the grain, while *L. macrophylla* is generally inferior to greenheart in all strength properties tested. Both species are superior to white oak and hickory in bending properties but somewhat below them in tensions across the grain, cleavage, and shear.

Working properties.—Wood of *Licania* is difficult to work owing to high silica content and hardness. The combination of these factors causes a rapid dulling of cutting edges. When sharp cutting edges are maintained, the wood can be machined to a smooth surface in planing, boring, sawing, and other operations.

Durability.—The wood of the genus *Licania* is generally considered to be low in resistance to decay (*82*, *190*, *134*, *175*). However, in recent pure culture tests, marish (*L. macrophylla*) (*231*, *248*) showed a resistance to decay varying from durable to moderately durable when exposed to both a white-rot fungus and brown-rot fungus. Kauta is reported nonresistant to decay and kautaballi slightly resistant by the British Guiana Forest Department (*82*). *L. densiflora* of the marish group is rated as resistant to attack by the drywood termite of the West Indies. Wolcott (*263*) rates this species at 62 in termite resistance, as compared to 80 for West Indies mahogany and 59 for Honduras mahogany. Kauta and kautaballi are likely similar in resistance to termites.

The *Licania* woods are widely known for their resistance to marine borers, presumably because of their high silica content. Three of the four species sold as marish have been tested for teredo resistance. *L. densiflora* from British Guiana was rated as having "considerable resistance" by Edmonson (*76*) on the basis of tests in Hawaiian waters; no infestation or but very slight attack by teredos took place in a 12-month period. *L. buxifolia* from British Guiana was rated as the sixth most resistant wood to damage by marine borers of 37 tropical hardwoods used in exposure tests at Wrightsville, N.C. (*58*). These results earned a rating of extremely high resistance for this species (*248*).

In the Wrightsville tests, *Licania macrophylla* rated as the most highly resistant species of the 37 timbers tested, surpassing greenheart, manbarklak, angelique, and other woods generally considered highly resistant to marine borers (*58*, *248*). These results agree with earlier reports on this species (*134*).

All species of *Licania* apparently accumulate silica. The silica content of several species has been determined by Amos (*14*) as follows: *L. densiflora*, 1.64 percent; *L. macrophylla*, 1.8 percent; *L. mollis*, 1.01 percent; *L. persaudii*, 2.53 percent; and *L. majuscula*, 2.82 percent. Similar tests on *L. buxifolia* and *L. macrophylla* by Yale University showed silica contents of 0.43 and 1.52 percent, respectively. On the basis of silica content, *L. persaudii* and *L. majuscula* should be even more resistant to marine borer damage than the species tested in Hawaii and in the Atlantic.

Uses.—The high marine borer resistance of marish, kauta, and kautaballi indicates that the highest use for these timbers is for piling and marine construction in waters infested with marine borers. The difficulty in working these timbers except with an ax or adz, as well as their high density and only moderate resistance to decay, suggests that their most suitable secondary use would be in heavy construction above ground.

Kauta is used in British Guiana for light-gage railway sleepers, roof shingles, mine timbers, and fuel and charcoal. Marish is used in that country for house framing and paving blocks, and in Surinam for fuel, charcoal, posts, riverbank structures, and substructures of bridges where teredo attacks may occur. In British Guiana, kautaballi is used for house framing, mine logging, shingles, fuel, and charcoal.

Supply.—Kauta, kautaballi, and marish are reported to be available for export from British Guiana and kautaballi from French Guiana. Surinam may also export them if demand develops.

KERETI SILVERBALLI

Ocotea wachenheimii, Ocotea puberula

Nomenclature.—Both *Ocotea wachenheimii* R. Ben. and *O. puberula* Nees are combined in British Guiana under the common trade name of kereti silverballi or sometimes as silverballi. Shipment under the latter name may contain one to several species of the somewhat inferior woods of the white silverballi group, particularly *Ocotea oblonga* (Meissn.) Mez, which is a cheap, soft grade of timber (*82*). Vernacular names applied to this timber in British Guiana include maipaima, mapwirtan, siduabari, and atomahoko; in French Guiana the name cèdre gris is used. The timber is known in the trade as zwart and witte pisie in Surinam and as pisie when sold in combination with other similar species of *Ocotea* and *Nectandra*. (Laurel family, Lauraceae.)

Distribution and habitat.—*Ocotea wachenheimii* is reported from the Guianas and Trinidad. *O. puberula* is reported from British Guiana and other areas, but little is shipped as kereti silverballi (*34*). Unless otherwise specified, the balance of this report is based on *O. wachenheimii*.

In British Guiana the tree occurs in the rain and seasonal forests on both light and heavy soils. It is generally distributed throughout the near interior, especially in the north and central districts. One small area along the left bank of the Courantyne River contains up to 70 cubic feet per acre (500 to 550 board feet) (*82*). In Surinam, *Ocotea wachenheimii* and other species known as pisie are among the most numerous trees in the rain forests and are also fairly well represented in the marsh forests (*231*).

The tree.—Kereti silverballi is a large evergreen of the upper canopy. It is often basally swollen or occasionally has low buttresses. On good sites trees may attain a diameter of 3 feet and heights of 110 feet, but are normally 16 to 20 inches in diameter and 80 to 90 feet high. Clear cylindrical boles 60 to 70 feet long are common in mature trees. The trees have moderately heavy, rounded crowns and erect spreading, light branching. The bark is flaky, cream colored, and faintly aromatic (*82*, *34*).

The wood.—The heartwood is pale yellow brown to creamy yellow or pinkish yellow when seasoned and not easily differentiated from the grayish sapwood. The texture is medium, and the grain straight to interwoven or roey and often ribbon-grained at an oblique angle. The wood is soft but firm with a satiny luster. It is without any distinctive taste but is fragrant like Central American cedar (*Cedrela* spp.) (*82*, *231*, *34*, *50*).

Weight.—The wood is comparable in weight to Douglas-fir and slightly lighter than shortleaf pine and pitch pine of the United States. The specific gravity of air-dry wood from British Guiana and Surinam ranges from 0.48 to 0.56, based on the volume and weight in that condition. Air-dry wood weighs from 30 to 35 pounds per cubic foot (*82*, *231*, *50*, *34*, *242*).

Seasoning.—Kereti silverballi seasons well under cover with little distortion (*82*, *231*).

Shrinkage.—The timber has a moderately high but fairly uniform rate of shrinkage for a wood of its density. Shrinkage of *Ocotea wachenheimii* from green to oven-dry amounts to 3.6 percent radially and 7.2 percent tangentially as compared to 5.0 and 7.8 percent respectively, for Douglas-fir. Shrinkage from green to air-dry (15 percent moisture content) is reported at 1.3 percent radially and 3.6 percent tangentially as compared to 1.8 and 3.6 percent, respectively, for Douglas-fir (*231*, *242*). Data for *O. puberula* are not available.

Mechanical properties.—Tests of the mechanical properties of wood from Surinam at the Agricultural University of Wageningen, Holland, (*231*) show normal strength properties for wood of its density. It is somewhat inferior to white silverballi (*Ocotea canaliculata* (Rich.) Mez) and yellow silverballi (*Aniba ovalifolia* Mez) in bending strength and is reported to fail suddenly under tension. Fanshawe, in his Forest

Products of British Guiana (*82*), refers to kereti silverballi as "the good kind of Kereti" and *O. oblonga* as "the poor kind of Kereti." However, despite their differences, both species are commonly known and marketed as kereti silverballi in the trade (*34*, *50*).

Working properties.—The timber works easily with both hand and power tools and finishes smoothly in all operations. It also glues and takes paint well.

Durability.—Kereti silverballi was rated moderately durable in graveyard tests in Surinam (*175*, *231*) and British Guiana (*36*); the tests in British Guiana lasted 5 to 6 years. Wolcott (*263*) found the heartwood only moderately resistant to attack by the dry-wood termite of the West Indies, rating kereti silverballi at 48 as compared to 55 for the heartwood of Douglas-fir and 59 for Honduras mahogany. Edmondson (*76*) found little resistance to marine borers in Hawaiian waters.

Preservation.—Specific information is not available regarding the timber's resistance to impregnation with preservatives. However, kereti (*Ocotea* sp.) of British Guiana has been successfully treated by nonpressure methods using several proprietary preservatives mixed with water; all have proved effective to date (*50*). Shelltox in an oil carrier has also been effective in preventing fungal stain in dressed lumber used in the British Guiana housing program.

Uses.—Kereti silverballi is used extensively in its range for interior work, ceilings, partitions, paneling, and other applications in building construction and in general carpentry. It is also used in low cost furniture and cabinetwork, turnery, inlay work, and for planking in small boatbuilding.

In British Guiana it has been used for fruit boxes, ladders, coffins, and walking sticks, and is considered suitable for utility grade plywood. The government of British Guiana has designated kereti silverballi as one of the acceptable timbers for interior partitions, battens, sash frames, louvres, weatherstripping, and Demerara shutters in the government housing program. The timber is well suited for uses now occupied by the imported pines and Douglas-fir, principally where durability is not of primary importance.

Supply.—This timber is not too abundant in British Guiana but is available in moderate quantities for export. It may also be available from Surinam and French Guiana.

KOPIE

Goupia glabra

Nomenclature.—Kopie is the usual trade name for timber of *Goupia glabra* Aubl., formerly identified as *G. paraensis* Huber. It is also known locally as kabukalli, goupi, and stinkwood in British Guiana; kopie or copie in Surinam; goupie in French Guiana; sapino in Colombia; and cupiuba or tento in Brazil. (Bittersweet family, Celastraceae.)

Distribution and habitat.—The natural range of kopie includes the Guianas, the hinterlands of Colombia, and the lower Amazon region of Brazil. Found throughout British Guiana, it becomes dominant in the seasonal forest on light sandy soils in flat terrain and is an occasional tree on sandy or loam soils in the rain and lower montane forest (*32*). In Surinam it is widely distributed in the rain and marsh forests, becoming locally frequent on sandy soils (*231*). It is a common tree in the uplands of the lower Amazon and in the hinterlands of Colombia, where it is often a dominant tree on sandy soils in the seasonal and rain forests (*248*).

The tree.—*Goupia glabra* is a large buttressed, semideciduous, canopy tree. It grows to 130 feet in height and 36 inches in diameter, but usually to only 20 to 24 inches. Clear cylindrical to somewhat flattened boles 40 to 80 feet long are common. Short logs squaring 30 inches and logs 60 feet long squaring 12 to 16 inches are fairly common. Freshly cut slash and stumps exude a gelatinous substance with a characteristic fetid odor (*82*, *32*, *181*).

The wood.—Freshly cut heartwood is orange tan to dark russet brown, often with fine blackish streaks. The sapwood is a light pink, brown, or yellowish color, sometimes with yellow dots about 2 inches wide, and distinct from the heartwood. Unseasoned wood has a fetid odor and disagreeable taste that dissipates during drying but is still apparent in seasoned wood. The wood is moderately lustrous; the texture is medium to coarse and uniform; the grain may be straight but is more commonly interlocked and somewhat harsh (*143*, *248*). The British Guiana Forest Department (*32*) differentiates two distinct varieties as (1) "white" variety and (2) "brown" variety as follows:

White variety—Light brown, luster lower, texture coarser, harsher, pores more open, grain more roey, lighter in weight.

Brown variety—Pinkish brown, luster higher, texture finer, smoother, pores smaller, grain straighter, heavier in weight.

Weight.—Kopie is hard and moderately heavy, with a specific gravity of 0.70 (0.62 to 0.75) based on green volume and ovendry weight. The specific gravity of air-dry wood averages about 0.83, comparing closely with courbaril (*Hymenaea courbaril*) (*248*). Green wood weighs about 73 pounds per cubic foot and air-dry around 52 pounds per cubic foot.

Seasoning.—Kopie rates moderately difficult to air-season. The timber dries at a moderate rate with only slight degrade in the form of warp, checking, and casehardening (*248*, *231*, *32*).

Shrinkage.—The timber undergoes moderate shrinkage during seasoning for a wood of its density. Shrinkage from green to oven-dry averages 4.5 percent radially, 8.0 percent tangentially, and 12.6 percent volumetrically. These values are considerably less than those for white oak, although kopie is of greater density. The wood undergoes a normal longitudinal shrinkage of 0.18 percent from green to ovendry. Shrinkage from green to air-dry would amount to about half these values.

For a wood of its density, kopie is relatively stable in response to changes in atmosphere conditions. According to Pfeiffer (*175*), ovendry timber increases 6.86 percent in volume when brought into equilibrium with a 40-percent relative humidity, 9.37 percent in a 70-percent relative humidity, and 13.5 percent in a 100-percent relative humidity. It attains a moisture content of 11.5, 15.9, and 28.1 percent, respectively, in the three conditions of relative humidity.

Mechanical properties.—Kopie is a hard, strong, tough wood. Compared to green woods of like density, it is above average in elastic resilience and tension across the grain; average in stiffness, crushing strength, end hardness, shear, and cleavage; below average in modulus of rupture, side hardness, and bearing strength; and particularly low in shock resistance. It exceeds white oak in the green condition in all properties tested except toughness and shock resistance.

Kopie improves moderately in most strength properties during air-drying, but in every property in far less proportions than domestic United States hardwoods. In general, it is below the average expected for wood of its density in every property, the greatest deficiency being in shock resistance. In comparison with air-dry white oak, kopie is inferior in shock resistance, shear, bearing strength, and cleavage resistance (*248*).

Working properties.—The wood is moderately difficult to work. Smooth surfaces are obtained in sawing, boring, and turning, but it is difficult to plane, especially cross-grained material. Torn and chipped surfaces are common in planing because of the interlocked grain, and later require considerable sanding to smooth. The wood takes nails well and polishes smoothly, but the coarser material requires a filler to obtain a smooth finish. Although kopie can be sliced for veneer, it is not attractive in this form (*265*, *32*, *248*).

Durability.—Kopie appears to vary in decay resistance, but is generally reported very resistant to decay below ground (*32*). The heartwood of this species was rated durable to very durable when exposed to a pure culture of a white-rot fungus and very durable to moderately durable to a brown-rot fungus (*248*). However, it was rated only moderately resistant to decay in graveyard tests in British Guiana (*50*), and Horn (*133*) reports that kopie crossties had to be removed after 13 months in the dry zone of Johannesburg, South Africa.

Heartwood of kopie resists dry-wood termites, rating only very slightly below West Indies mahogany and considerably above Honduras mahogany (*263*). The wood has little resistance to teredo damage in salt water. In tests in Hawaiian waters (*76*), kopie was severely damaged in 6 to 9 months. In the Atlantic at Wrightsville, N.C. (*58*), damage was severe within one year. This may be attributed in part to the wood's low silica content averaging 0.046 percent. Woods with a high degree of resistance to marine borers usually have 0.5 percent or more silica content (*248*), though there are exceptions.

Uses.—Kopie is considered a good wood in the Guianas for durable heavy building construction, marine construction in areas not contaminated with teredo, land communications materials, agricultural and industrial uses, and joinery and furniture. In building construction it becomes foundations, sills, joists, framing, flooring, siding, posts, steps, paneling, parquet flooring, and rustic building material. In marine construction it is used in piling, decking, groins, revetments, and sluice gates. This wood is employed in land communications for railway ties, paving blocks, crossarms, sign posts, bridge runners, bridge decking, freight wagons, and truck bodies. In the agricultural and industrial fields, it is made into fences, gates, mining timbers, mill foundations, and beds (*32*, *143*, *82*, *135*).

Kopie is the principal utility timber of Surinam, where it is valued for boat knees and common furniture, in addition to the uses cited above (*231*). It has been designated as acceptable for flooring, siding, interior partitions, and battens in the British Guiana Government's housing program. Natives in the savannas of that country prefer kopie above all other wood for dugout canoes because of its resistance to splitting in the sun (*53*).

Supply.—Kopie is available in exportable quantities in Surinam, British Guiana, and French Guiana. In 1951 the merchantable volume in British Guiana was estimated at 2,190,000 tons or 109,500,000 cubic feet. It is also one of the most common trees in Surinam.

KUROKAI

Protium crenatum*, *Protium decandrum*, *Protium sagotianum*, *Protium schomburgkianum

Nomenclature.—The genus *Protium*, containing some 90 species, is of pantropical distribution but is most abundant in the Amazon Basin and British Guiana. Kurokai is the preferred trade name in British Guiana for the timber of three species, *P. crenatum* Sandw., *P. decandrum* March., and *P. sagotianum* March., of which the

first named is the most abundant (*82*). Because of the close similarity of the woods, timber of the three species is marketed separately or in combination as kurokai, and occasionally as porokai without distinction between species. Another common name in many areas is "incense-tree." A fourth species, *P. schomburgkianum* Engl., also called kurokai, is sometimes included with the other species but is of very limited importance. (Bursera family, Burseraceae.)

The wood is known as copal or incienso in Cuba and elimi in Brazil. Several species of *Protium* are often combined with *Trattinickia* spp. and marketed under the name tingimonie in Surinam, although the *Protium* woods appear to be the better of the two genera (*231*).

Distribution and habitat.—Kurokai occurs frequently in the marsh forests and most types of rain forest throughout British Guiana, where it is one of the more abundant trees (*82*). It is also indigenous to other tropical American areas but not in volumes equal to those in British Guiana.

The tree.—All four species are fairly tall trees, growing to 90 feet high and 28 inches in diameter. On the average site, trees are usually 16 to 20 inches in diameter. The boles are slender, sometimes fluted, often 60 feet long, and generally have short buttresses 3 feet or less in height. The tree crowns are heavy and round. The bark contains large quantities of a whitish or yellowish fragrant oleoresin used in native medicine and as incense in churches.

The wood.—Kurokai is a moderately strong, hard, heavy wood resembling yellow birch (*Betula alleghaniensis*) in superficial appearance. The pale buff-colored sapwood is sharply demarcated from the pinkish-brown heartwood, characterized by irregularly spaced darker brown lines. The texture is uniform and fairly coarse; the grain is straight to interlocked and irregular; and the luster is rather high. The pores are large enough to be easily seen on all sections because of the surrounding light-colored soft tissues, which sometime extend as short lines joining several vessels together. Rays are fine and numerous but not visible to the eye. Growth rings are not easily seen though they may be differentiated by narrow zones of denser tissue. These zones or lines are somewhat irregularly distributed and mark the cessation of growth in various seasons (*152, 9, 193*).

Weight.—The wood is comparable in weight to Honduras and West Indian mahogany. Air-dry wood of *Protium decandrum* averages 0.53 in specific gravity, and weighs about 40 pounds per cubic foot. Green wood weighs about 56 pounds per cubic foot (*16*). *P. schomburgkianum* is somewhat lighter, air-dry wood averaging 0.53 in specific gravity and weighing 33 pounds air-dry and 56 pounds green (*149*).

Seasoning.—Seasoning defects develop unless care is taken to prevent too rapid initial drying, indicating that kurokai is moderately difficult to air-dry.

Shrinkage.—Shrinkage values are not available for the three principal species of kurokai. However, shrinkage values from green to ovendry based on the original green dimensions for *Protium schomburgkianum* are as follows: Radial, 4.2 percent; tangential, 6.8 percent; and volumetric, 10.7 percent (*149*). These values are all within the limits for successful seasoning without serious degrade; they compare favorably with the values of 3.8, 5.1, and 8.6 percent, respectively, for Honduras mahogany and are considerably below shrinkage rates for other hardwoods of similar density. The low ratio of tangential to radial shrinkage indicates uniformity in drying, which contradicts the general impression that the timber is subject to considerable degrade during seasoning.

Mechanical properties.—Tests of mechanical properties have been made on *Protium schomburgkianum* from British Guiana by Kynoch and Norton (*149*). Green wood is somewhat superior to Honduras mahogany in bending properties except in total work in bending in which mahogany is appreciably stronger. The wood is also inferior to mahogany in compression perpendicular to the grain, side hardness, cleavage, and tension perpendicular to the grain, but is about equal to mahogany in other strength properties.

Working properties.—Conversion of logs is rather difficult; resin accumulates and clogs the saw teeth. This could be partially overcome by debarking logs prior to conversion, for the bark is the principal source of resin. Dry lumber saws and planes to a smooth surface except for the tendency of raised grain to occur around the pores when inclined grain is present. When this occurs, considerable sanding is required for a first-class finish. The grain needs careful filling before polishing, but when finished is difficult to separate from the white type of crabwood (*Carapa guianensis*) (*9, 152, 82*).

Durability.—Kurokai varies from moderately resistant to nonresistant to decay in contact with the ground (*50*), and is very susceptible to termite damage. The Government of Jamaica reports kurokai is durable only for interior use, according to local experience over a long period of time (*50*). Wolcott (*263*) rates *Protium decandrum* at 32 in resistance to dry-wood termites as compared to 59 for Honduras mahogany.

The timber has no appreciable resistance to marine borers. However, the wood of *Protium crenatum* contains a fairly large amount of silica within its fibers and *P. sagotianum* has silica in both the fibers and rays. Silica is absent from both *P. schomburgkianum* and *P. decandrum*. On the basis of silica content, the first two species

may have some resistance to damage by marine borers.

Uses.—Kurokai is preferred over crabwood for furniture by some people in British Guiana. The Forest Department of that country recommends the timber for masts, spars, house framing, and plywood. It has also been designated as an acceptable wood for interior partitions and battens in the housing program of that country. In Surinam the wood is considered suitable for interior paneling, millwork, carriage bodies, and furniture.

The reasonable good strength properties, moderate shrinkage values, and attractive color and grain suggest the use of the wood in decorative plywood and veneer for paneling, furniture, and general cabinetwork, and use of the lumber in furniture and other interior work. Kurokai's low resistance to insects and decay suggests the timber would be most suitable where it will not be exposed to the weather or in contact with the ground.

Supply.—British Guiana is reported to have kurokai available for export.

KWARIE

Vochysia guianensis, Vochysia tomentosa

Nomenclature.—Two species of the genus *Vochysia*, namely *V. guianensis* Aubl. and *V. tomentosa* DC., are konwn in the trade as kwarie. In Surinam the timber is also known locally as rode kwari, wiswis kwari, or wane kwari. It is known in French Guiana as grignon fou and in British Guiana as iteballi. Another closely related species, *V. hondurensis* Sprague of southern Mexico and Central America, is described later under its usual trade name of yemeri. Two other species of *Vochysia* commonly associated with kwarie are *V. densiflora* Spruce, the appel kwarie of Surinam, and *V. tetraphylla* (G. F. W. Mey.) DC., known as wane kwarie in Surinam and iteballi in British Guiana. Kwarie timber is generally used for the same purposes as that of the related genus *Qualea*, with which it is often confused. *Qualea* is described in this reference under the name gronfoeloe. (Vochysia family, Vochysiaceae.)

Distribution and habitat.—Kwarie is found in the Guianas and lower Amazon on silt soils adjacent to waterways and on sandy soils. The tree makes its best growth along the coastal plain. It also comes in on abandoned farmland on the poorer soils but rarely occurs on very swampy sites or on limestone or marl areas (*127*). In Surinam it is a frequent tree in the rain forest on well-drained soils.

The tree.—The trees are unbuttressed, medium to fairly large in size and range from good to poor in form. The usual mature tree in British Guiana is about 24 inches in diameter, 100 to 110 feet high and clear of limbs for 70 feet, although trees up to 36 inches in diameter are reported (*82*).

The wood.—The wood is reported to be very similar to yemeri (*Vochysia hondurensis*), which is described in detail in the discussion of that timber.

Weight.—Kwarie is generally reported to be somewhat heavier than yemeri but varies in weight by location and conditions of growth. Specific gravity of air-dry wood of *Vochysia guianensis* is reported at 0.62 by the Surinam Forest Service (*231*), 0.56 by the French Tropical Research Center (*50*), and 0.45 by Yale University (*127*). The air-dry specific gravity of *V. tomentosa* is reported at 0.43 by the Surinam Forest Service.

On the basis of these data, the wood of *Vochysia guianensis* averages about 34 pounds per cubic foot when air-dry, and that of *V. tomentosa* about 27 pounds per cubic foot. Green wood of both species weighs about 67 pounds per cubic foot (*127*).

Seasoning.—Kwarie lumber is rated moderately difficult to air-season and kiln-dry. The timber dries at a moderate to slow rate with slight surface checking, casehardening, and warp. Further information on seasoning will be found in the section on yemeri.

Shrinkage.—*Vochysia guianensis* undergoes considerable shrinkage during seasoning, quite a bit more than yemeri. *V. tomentosa* also has high shrinkage values for a wood of its density. Shrinkage values for *V. guianensis* from green to ovendry are reported by Yale University at 4.8 percent radially, 8.2 percent tangentially, 0.07 percent longitudinally, and 15.4 percent volumetrically. These results are comparable to the shrinkage values determined by Pfeiffer (*231*) of 3.9 percent radially and 10.8 percent tangentially. Shrinkage values for *V. tomentosa* from green to ovendry of 2.5 percent radially and 8.8 percent tangentially are lower than those for *V. guianensis*, partially so because of difference in density. Shrinkage from green to air-dry generally amounts to about half the green to ovendry values.

The high ratio of tangential to radial shrinkage for both species, but particularly of *Vochysia tomentosa*, may cause most of the seasoning distortion. The low radial shrinkage indicates the possible advantage in using quartersawed material when stability is required.

Mechanical properties.—Mechanical properties of *Vochysia guianensis* are good to very good for a wood of its density. It is very similar in most strength properties to yemeri (see yemeri for description). The wood of *V. guianensis* is, in general, very comparable to Scotch pine or Baltic red deal (*Pinus sylvestris*) and yellow-poplar (*Liriodendron tulipifera*) but is generally inferior to white oak (*Quercus alba*). Wood of the less dense *V. tomentosa* was reported somewhat inferior to *V. guianensis* in all mechanical proper-

ties tested at the Agricultural University of Wageningen in Holland (*231*, *127*, *249*).

Working properties.—Kwarie works readily but possesses rather poor machining properties. Consult the section on yemeri for a more complete summary of these properties.

Durability.—Other species of *Vochysia* are known for their variability in decay resistance, and kwarie appears to be similar in this respect. The heartwood has little resistance to decay in contact with the soil according to studies of Surinam timber (*175*, *231*). However, pure culture tests indicate the wood is very durable to a white-rot fungus, although somewhat variable in this respect, and moderately durable to a brown-rot fungus (*249*). Other species of *Vochysia* that are without silica are resistant to susceptible to damage by the dry-wood termite of the West Indies (*263*) and have little resistance to marine borers in Hawaiian waters (*76*).

Preservation.—The wood offers little resistance to preservative treatment, being similar to yemeri in this characteristic (*231*).

Uses.—Kwarie is used and recommended for the same purposes as yemeri. It is recommended for boxes and crates, general carpentry, inexpensive furniture, interior trim, and plywood.

Supply.—Export supplies are available from British Guiana, French Guiana, and Surinam.

LIGNUMVITAE

Guaiacum officinale, Guaiacum sanctum

Lignumvitae is not only one of the hardest and heaviest woods known to commerce, but is also unique for its self-lubricating properties due to the unusual resin content of the wood. These properties of strength and self-lubrication make this wood particularly well adapted for underwater bearings. In this use it has three to four times the service life of brass and babbit-metal bearings. The wood has been exported for nearly 450 years. First, its resin, called "guaiac" or "guaiaci resin," was used as a curative in Europe. Later, the wood was used principally to make self-lubricating bearings or bushing blocks to line the stern tubes of propeller shafts on steamships. For centuries, it has remained in great demand despite its relative scarcity, small size, and accompanying high prices.

Nomenclature.—The woods of *Guaiacum officinale* L. and *G. sanctum* L. are principally known in commerce as lignumvitae, but are also called guayacán in Spanish, bois de gaïac in French, and wayaca and pokhout in Dutch. These woods are also known as guaiacum-wood in England, gaïac in French West Indies, guayacán in Puerto Rico, guayacán negro, palo santo, guayacán in Cuba; ironwood in Florida, United States; vera, bera, gaïac, gaïac franc, gaïac mâle in Haiti; lignumvitae in Jamaica; guayacán in Dominican Republic; and palo santo, guayacán in Venezuela. The wood of *G. sanctum* is often identified separately from *G. officinale* by calling it "bastard" lignumvitae, vera, bera, guayacán blanco, gaïac femelle, or guayacancillo, and referring to the latter as "genuine" lignumvitae. However, dealers more commonly identify the wood as to its country of origin. (Caltrop family, Zygophyllaceae.)

Distribution and habitat.—The combined range of the two species of lignumvitae covered here is from southern Florida and the Bahama Islands through Jamaica, Cuba, Hispaniola, Puerto Rico, and the Lesser Antilles to Martinique, and on the continent from Mexico southward through Central America to Colombia and Venezuela on the north coast of South America. Both species have been planted elsewhere, but it is doubtful if either is indigenous to Trinidad and the nearby Gulf islands (*165*).

The tree is largely confined to dry, exposed sites where it is often the predominant species in areas of low rainfall, and where the soil is very dry at least part of the year. It does well on shallow soils, particularly in limestone areas, but also thrives in well-drained low areas, low foothills subject to hot dry winds and in rocky limestone regions (Cuba, Dominican Republic, Nicaragua) at altitudes of 1,500 to 2,000 feet (*41*, *229*).

The tree.—Lignumvitae is a small, slow-growing evergreen tree, normally 20 to 30 feet high and about 12 inches in diameter, although some trees grow to 30 inches. Clear boles in excess of 10 to 12 feet are uncommon. Bolts or logs 2 to 10 feet long and from 3 inches to 18 or 20 inches in diameter are marketed. Larger logs were once fairly common in Cuba, Jamaica, and Hispaniola but are no longer available there in quantity (*105*, *230*, *190*). The largest logs are probably available now in Central America. Logs of *Guaiacum officinale* are reported to be somewhat larger and to have a greater proportion of heartwood than those of *G. sanctum*. Logs of different species are readily identified by their bark; the bark of *Guaiacum officinale* is thin, smooth, with irregular-shaped glossy flakes of varying size and depth similar to sycamore (*Platanus*), while the bark of *G. sanctum* is rough (*118*).

One other species, *Guaiacum coulteri* A. Gray, occurs in Mexico as a shrub or small tree, growing to 25 or 35 feet tall and 16 to 28 inches in diameter. *G. guatemalense* Planch. of Nicaragua is synonymous with *G. sanctum*, although occasionally reported as a separate species.

The wood.—Lignumvitae is an extremely hard and heavy wood. The heartwood is a dark greenish brown to almost black and readily distinguished from the narrow pale yellow or cream-colored sapwood. Heartwood becomes even darker after exposure. The wood is very fine and uniform in texture with a heavily interlocked grain. It has a characteristic oily feel due to the resin (guaiac content) that constitutes about one-

fourth of the air-dry weight. Heating the wood to a temperature of 100° centigrade causes the resin to ooze out with an accompanying lessening of the period of its self-lubricating properties. A slight scent is evident when the wood is warmed or rubbed. It is occasionally figured by color changes or a fine ripple marking from the interlocked, irregular grain (*265*, *230*, *229*).

The heartwood of *Guaiacum sanctum* contains less resin than *G. officinale*, although the amount of resin in both species varies considerably between different localities. Wood from trees growing in the hotter, drier locations is thought to be more resinous than that from more humid, cooler sites.

Weight.—Lignumvitae is one of the heaviest woods in the trade. The specific gravity of air-dry wood ranges from 1.20 to 1.36, averaging about 1.28 at 15 percent moisture content (*105*, *50*). The weight of air-dry wood varies from 75 to 85 pounds per cubic foot and averages about 80 pounds at 15 percent moisture content.

Seasoning.—Lignumvitae is difficult to season because of its refractory tendencies, and considerable care is required to avoid shakes and splitting during seasoning (*222*, *265*). Logs left exposed to the tropical sun are also very liable to develop checks and ring shakes at the ends (*105*). End coating logs at the time of logging with an asphalt, bituminous, or plastic roof coating would probably eliminate most of this difficulty. End coating the sawed material and piling it so that it will air-dry slowly would also help to reduce defect during drying. Kiln Schedule 2 of the Forest Products Research Laboratory in England (*222*) is suggested for kiln-drying the wood.

Shrinkage.—Shrinkage data are lacking for lignumvitae. However, its refractory nature indicates a considerable difference between radial and tangential shrinkage. The very interlocked grain would also indicate a comparatively high rate of longitudinal shrinkage.

Mechanical properties.—Limited tests of seasoned timber at the Forest Products Research Laboratory in England indicated lignumvitae is 3 to 4 times as hard as English oak. Record states that *Guaiacum sanctum* ranked first in hardness over 405 woods tested and was far above any of the common woods of the United States in this property (*188*). According to the Forest Products Research Laboratory in England, straight-grained wood has a resistance to splitting in a radial plane about double that of English oak, but splits very easily on the tangential plane at loads of about 30 to 40 percent of those for English oak (*105*). However, most material is not straight-grained but severely interlocked and irregular, and to split it would require much greater loads than those needed for straight-grained material.

Working properties.—Lignumvitae is a very difficult wood to work with hand tools (*237*, *24*). It is also difficult to saw and machine with power tools, tending to ride over the cutters in planing. A cutting angle of 15 degrees or less is recommended in planing to prevent raised or chipped grain on quartersawed surfaces when interlocked grain is present. Increased pressure is also required on pressure bars and shoes to hold material firmly during the planing. The dulling effect on cutting edges is not unduly severe because of the oily nature of the wood. In sawing, a narrow tooth-pitch and limited hook are necessary to prevent severe vibration. Saw type F is recommended by the Forest Products Research Laboratory (*105*). In most other operations a good finish is possible; the wood turns and shapes very well. It takes a high polish (*237*), but on account of its oily nature requires special surface treatment for satisfactory gluing (*240*).

Durability.—The heartwood is very resistant to decay and is one of the few woods exceptionally resistant to termite and teredo attack; it also resists acid (*265*). Wolcott (*263*) considers the heartwood of lignumvitae more resistant to termites than West Indies mahogany, rating it at 100 as compared to 80 for that wood. The sapwood is moderately resistant to termites, rating equal to the sapwood of West Indies mahogany and the heartwood of Honduras mahogany. However, damage to green logs by longhorn beetles has been recorded on several occasions, although no record is available as to whether sapwood or heartwood was damaged.

Lignumvitae is generally reported to be highly resistant to marine borers in Caribbean waters. Calvert (*49*) reports of observing a post of lignumvitae in the West Indies that had been submerged for several hundred years. Lignumvitae has also proved resistant to marine borers in tests at Aukland, New Zealand, in which untreated wood of this species was undamaged after 7 years' exposure (*122*).

Uses.—The principal use for lignumvitae is in bearings and bushing blocks for propeller shafts of ships, pulley sheaves, dead eyes, and as a replacement for metal bearings in roller mills in steel and tube works. It is reported to last 3 to 7 years as unlubricated bearings in ships and from 50 to 70 years as pulley sheaves.

The extreme hardness and interwoven grain of lignumvitae withstands the tremendous pressures applied by the screw-shafts of the largest vessels with the resin content serving as a lubricant. Brush (*41*) reports that bearings for large steamships are made of a series of strips built up of lignumvitae blocks. The strips are assembled in a way that the shaft bears on the end grain of each block. Bearings for smaller vessels are sometimes bored from one solid piece of wood.

Because of its hardness, wearing qualities, and self-lubrication, the wood is useful for bandsaw guides and awning rollers, furniture casters, and similar uses. It is also used for mallet heads because of its hardness and resistance to splitting;

then too it is made into parts that come in contact with acid or alkaline solutions that would soon destroy most metals. In steel and tube mills lignumvitae is used to replace brass and babbit metal for bearings; the initial cost of the lignumvitae bearings is less than for metal, and the useful life several times longer with no lubrication required. It is particularly useful where bearings are submerged or in constant contact with water as in turbines and papermill machinery.

The wood is also used to a limited extent for gunstock stencils and chisel blocks, masthead trucks, bowling balls, cable dressers, brush backs, rulers, batons, pestles, and packing between saws in machine saw-frames, and for various turned novelties. "Gum guaiac" for the drug trade is extracted from the wood or sawdust, or collected in the form of exudations from the living trees. The resin is obtained by heating the pieces of wood and collecting the resin as it emerges, by heating sawdust and chips in water, or by extracting the gum with alcohol or ether. Most of the "gum guaiac" is used in proprietary preparations (*265*, *143*, *12*).

Supply.—Haiti, Cuba, Jamaica, British Honduras, and the Dominican Republic are the principal sources of lignumvitae. As recently as 1951, Haiti exported fairly large quantities of the wood. There may be other sources in the West Indies, Central America, and northern South America where sizable quantities might be obtained for export.

MAGNOLIA

Talauma dodecapetala

Of the several species of *Talauma* in tropical America, *T. dodecapetala* (Lam.) Urban (*T. plumierii* (Sw.) DC.) is the only one in the Lesser Antilles. The tree serves a dual purpose in some islands where its majestic appearance, white flowers, and excellent form make it an attractive ornamental and an equally important source of timber (*190*, *193*). Stehlé (*220*) considers the wood superior to that of all other timbers of the Caribbean Archipelago.

Nomenclature.—The tree is known locally as magnolia, for its leaves, flowers, and wood closely resemble those of the related genus *Magnolia*. It is also called pin, bois pin, pomme pin, and bois pin marron in the various islands of the Caribbean, including the British Islands of Dominica and St. Lucia. These names result from the resemblance of the fruit to that of the pine trees. In Guadeloupe and Martinique it is also known as cachiman de montagne and bois cachiman (*93*). (Magnolia family, Magnoliaceae.)

Distribution and habitat.—Magnolia is endemic to the hydrophytic forests of five of the largest islands of the Lesser Antilles, namely Guadeloupe, Dominica, Martinique, St. Lucia, and St. Vincent. Two related species, laurel sabino (*Magnolia splendens* Urban) and jagüilla (*M. portoricensis* Bello) are confined to Puerto Rico, where laurel sabino is considered one of the most valuable trees.

Magnolia is not an exacting species as to soil and is generally one of the most common and generally distributed species in the humid, many-storied forests between 1,400 and 2,500 feet elevation (*220*). The tree develops best in deep rich soils in valleys and on level sites at middle elevations in hot, humid climates. It is never found on ridges or slopes or as a dominant species. It is reported to be in plentiful supply in St. Lucia (*153*).

The tree.—The tree is straight, erect, and well formed, with a large round, well-developed crown in dominant trees. Long buttresses are common. On favorable locations the tree may attain a height of 130 feet or more and diameters to 36 inches. Clear boles 40 to 60 feet long are common. Magnificent specimens are said to be present in almost all valleys in the central forests of the islands where it occurs. The bark of old trees is rough and uniformly white with shallow longitudinal fissures. The magnolialike flowers are large, white, and sweet scented (*220*, *93*).

The wood.—The wood resembles yellow-poplar (*Liriodendron tulipifera*) in structure but not in color. The sapwood is white to light yellow and sharply differentiated from the dull dark brown or black heartwood, which is often streaked with shades of brown. The wood vessels are very thin and grouped in concentric arches. Wood rays are irregular and long, giving rise to medullary spots or pith flecks. Growth rings marked by fine bands of marginal parenchyma are difficult to distinguish. The wood is without distinctive odor or taste; its grain is fine textured and straight (*50*, *220*).

Weight.—The specific gravity of air-dry wood averages about 0.64 based on air-dry volume and weight. Air-dry wood weighs about 40 pounds per cubic foot for magnolia as compared to 48 pounds for white oak.

Seasoning.—Magnolia seasons without serious degrade; 1-inch boards air-dry in 6 months on St. Lucia.

Shrinkage.—The wood is reported by Stehlé (*220*) to be resistant to swelling, shrinkage, and expansion because of its homogeneity.

Mechanical properties.—There are no published data on the strength properties of magnolia. However, the wood is reported to be hard, tough, and strong. The timber is also reported to be resistant to shock, stress, compression, and tension, and is difficult to split or twist. Its elasticity is also reported as fairly good.

Working properties.—Magnolia is regarded as "probably the local wood which turns out easiest and best on the machines" (*153*) in the government-owned woodworking shop in St. Lucia.

This is in agreement with other reports that the wood works easily but does not take nails or screws well.

Durability.—Some confusion exists as to the resistance of magnolia to decay and insect attack. Stehlé (*220*) reports that the heartwood is never attacked by insects, while Lang (*153*) states that magnolia is susceptible to termite and fungus attack on St. Lucia. The latter rating is more comparable to the experience with the closely related laurel sabino of Puerto Rico.

Uses.—Magnolia is a highly cherished wood and commands a high price. It is prized for flooring because of its stability and the variety of colors present in the heartwood, and is also used extensively in small boat construction and in the hulls of fishing canoes. Other uses include marquetry, interior finish, gunstocks, and furniture. Its principal uses on St. Lucia are in truck bodies and for interior work (*93*).

Supply.—Limited supplies of magnolia may become available for export from Dominica, St. Lucia, Martinique, and Guadeloupe when adequate logging and milling facilities are established on these islands.

MAHOE

Hibiscus elatus

Nomenclature.—*Hibiscus elatus* Sw. is commonly known as mahoe, blue mahoe, or mountain mahoe in Jamaica. In Cuba it is known as majagua, majugua, emajagua, and majagua azul (*232*). Other common names are bois flot or seaside mahoe (*50*). Some authors have considered this species to be the upland variety of *H. tiliaceus* L., sea hibiscus, a closely related but small shrubby tree common on shores throughout the tropics. (Mallow family, Malvaceae.)

Distribution and habitat.—Mahoe is reported from Jamaica (*229*) and Cuba (*207*) and may occur in other areas in the Greater Antilles. The tree has been widely planted and naturalized from southern Florida and Cuba to Trinidad and Tobago, and on the continent from Mexico to Peru and Brazil. It has been planted quite extensively in St. Lucia from seed imported from Jamaica.

Mahoe occurs throughout Cuba and Jamaica under a wide range of elevations and soil conditions from sea level to 4,000 feet, but is not well suited to rocky, exposed, or degraded ridges, or to areas with a rainfall of less than 60 inches (*230*). Heavy cutting in the past has seriously reduced the volume of merchantable timber.

The tree.—Mahoe commonly grows to a height of 60 to 70 feet and a diameter of 12 to 18 inches, although on favorable sites trees occasionally attain diameters of 36 inches. The boles are straight and of fairly good length (*190*, *230*). The bark is clear in color, rather soft in texture, and consists of many layers that can be separated after beating. The inner bark is used for making rope and cord, which is reported to be very durable in salt and brackish water (*171*). *Hibiscus tiliaceus* of the lowlands seldom grows to commercial size.

The wood.—The sapwood is narrow and nearly white. The heartwood is basically a greyish brown or olive, but is often richly variegated with streaks of purple, metallic blue, and olive, or separated by plain olive patches. The grain is fairly straight and of medium texture. Freshly polished wood has the appearance of marble but lacks luster and unless well finished rapidly assumes a very dull color. No distinctive odor or taste is present in seasoned wood. Mahoe is considered one of the most valuable woods of Jamaica and Cuba (*171*, *143*).

Weight.—Mahoe is a moderately heavy wood reported to weigh 47 pounds per cubic foot when air-dry (*50*). On this basis, the specific gravity of air-dry wood would be 0.75. It is somewhat heavier, darker in color, and more durable than that of *Hibiscus tiliaceus*.

Seasoning.—No information available.

Shrinkage.—No information available.

Mechanical properties.—Mechanical tests are not available for mahoe but it is considered a hard, tough, elastic wood of overall good quality (*48*).

Working properties.—The timber works easily but needs particular care to attain a good polish.

Durability.—Mahoe, based on casual observations, is generally reported to be durable to very durable (*50*, *229*, *207*, *230*), but no authentic durability tests have been completed to verify these observations.

Uses.—The timber is most highly prized in Jamaica and Cuba for high-grade furniture, cabinetmaking, inlay work, and interior trim. It is also used for footings, sills, framing, flooring, shingles, and window and door frames in house and building construction. Other uses include railway sleepers, shipbuilding, as well as naves, spokes, and fellows in wheelwright work, and shafts and bodies of carts and wagons. But the timber is scarce and costly, and most of the available supply is consumed in the higher grade uses.

Supply.—The very limited supply of mahoe is not equal to the local demand and is not available for export. It should be readily marketed when sufficient volumes are available.

HONDURAS MAHOGANY

Swietenia macrophylla

Nomenclature.—Honduras mahogany is probably the most common trade name for *Swietenia macrophylla* King, which is also commonly known as South American mahogany, baywood, Central American mahogany, and broadleaf mahogany. According to the country of origin, the

timber is also known as Mexican, Tabasco, British Honduras, Guatemalan, Nicaraguan, Costa Rica, Panama, Brazilian, Peruvian, and Colombian mahogany (*195*). Caoba and caoba hondureña are the most commonly used names in Spanish-speaking areas. In Mexico the names zopilote and gateado have been used, and in Peru aguano (*42*). The French name for mahogany is acajou. The local British Honduras names are bastard lime, red cedar, and sisam (*190*). (Mahogany family, Meliaceae.)

Distribution and habitat.—Honduras mahogany occurs from southern Mexico southward along the Atlantic slope of Central America from British Honduras to Panama, and in Colombia, Venezuela, and parts of the upper reaches of the Amazon and its tributaries in Peru, Bolivia, and Brazil (*105*, *190*, *191*). The tree is not native to the West Indies islands, where it is replaced by West Indies mahogany (*Swietenia mahagoni*) on some islands (*165*). However, plantation-grown mahogany is found throughout Central America and the West Indies as well as in other tropical regions of the world (*241*).

The tree makes its best development both in plantations and in the forest on deep, fertile, well-drained soils, but it does fairly well on many sites from sea level to 3,000 feet in altitude.

A closely related species, *Swietenia humilis* Zucc. (*S. cirrhata* Blake), occurs in dry locations along the Pacific coast from western Mexico to Costa Rica (*190*). The wood is indistinguishable from that of *S. macrophylla*. Other names from South America—*S. candollei* Pittier, *S. tessmannii* Harms, and *S. krukovii* Gleason & Panshin—are usually regarded as synonyms of *S. macrophylla*. A form in British Honduras is named *S. belizensis* Lundell.

The tree.—Forest-grown mahogany trees are often very large, sometimes 150 feet in height and 6 feet or more in diameter above the heavy buttresses (*73*, *178*). However, the principal source of Honduras mahogany lumber in the area covered by this report will be from plantation-grown trees in the West Indies and in some parts of Central America. Plantation-grown trees often make very rapid growth, frequently reaching small saw-log size in 20 years on good sites, and under average conditions 12- to 14-inch saw logs (d.i.b.) are grown in about 40 years.

The wood.—The wood of plantation-grown mahogany from Honduras is described in Tropical Woods (*71*) as follows:

> Heartwood pinkish or salmon colored when freshly cut in the unseasoned condition, later becoming light reddish brown with a golden luster. Sapwood generally one to two inches wide, sharply demarcated, yellow to white. Grain commonly interlocked, producing a wide attractive striped figure on radial surfaces. Texture rather fine to medium, uniform; growth layers indistinct. Heartwood without characteristic taste or odor when seasoned.

Occasionally mottled, fiddleback, raindrop, roe, or curly figures are present in the wood (*42*). Deposits of dark-colored gum in the vessels are common and white deposits are sometimes present. The presence of ripple marks on the tangential longitudinal surface is usually apparent to the naked eye (*195*).

Saks (*197*), reporting on the veneering qualities of forest-grown *Swietenia macrophylla*, described the wood figure as follows:

> True Mexican mahogany produces broken stripe, roe and mottle figures in addition to the common figure and occasionally some other exceptionally rare designs. One of these is the fine curly figure with rain-drop marks in which the curls are ¼ inch in length and clearly designed, resembling hair waves. The rarest figure in Mexican mahogany is bird's-eye figure, similar to the bird's-eye in hard maple. Fiddleback is comparatively rare but if it occurs gives an excellent lustre. Plum pudding figure is produced by the seashell veined or male mahogany. Quartersawn mahogany usually shows a delicate stripe without the rigid regularity characteristic of the African mahogany. The well-known leaf or shell figure, narrow heart, wide heart and wild heart can be achieved in mahogany by plain slicing. However, the real beauty of the Mexican mahogany is largely in quarter sliced veneer. Rotary cut mahogany often completely loses its fine characteristics. Hardness and strength are as variable as the color in mahogany, which includes yellowish-white, tea-color, salmon-pink, and golden-brown variations. Mahogany changes to reddish-brown color with an overall golden hue after extended exposure to sunlight and air.

Weight.—Plantation-grown wood appears to be somewhat less dense than forest-grown wood. The specific gravity of forest-grown wood averages about 0.45, based on green volume and oven-dry weight and 0.53 based on air-dry weight and volume. Green wood weighs about 44 pounds per cubic foot and air-dry wood about 33 pounds per cubic foot (*249*, *248*, *149*, *125*).

Plantation-grown wood averages about 0.42 in specific gravity, based on green volume and oven-dry weight, and 0.50 based on air-dry weight and volume. Green wood weighs 40 pounds per cubic foot and air-dry wood 31 pounds per cubic foot. There appears to be no appreciable difference in the density and technical properties of wood from different countries or geological areas. This was substantiated by studies at Yale University (*248*) using forest-grown timber from several sources in Central and South America.

Seasoning.—Honduras mahogany, one of the nonrefractory woods, can be air seasoned and kiln dried rapidly and easily without appreciable warping or checking (*105*). Plantation-grown stock was seasoned in tests at Yale University (*248*) without degrade except for slight crook and bow. However, a high rate of longitudinal shrinkage usually accompanies the presence of tension wood and gelatinous fibers. This condition is not uncommon in Honduras mahogany and generally results in an increased amount of warping (*176*). Kiln Schedule 5 of the Forest Products Research Laboratory in England is recommended for kiln-drying (*222*).

Shrinkage.—Mahogany is well known for its unusually low shrinkage and stability. It has

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lower shrinkage values than any of the commonly used woods in the United States (*42*). In the Yale tests (*71*) plantation-grown wood was found to have average shrinkage values from green to ovendry of 2.4 percent radially, 4.2 percent tangentially, 0.42 percent longitudinally, and 6.6 percent volumetrically. The relative high longitudinal shrinkage is probably the result of the characteristic interlocked grain in the wood and the presence of tension wood in some specimens. Shrinkage tests of forest-grown material from Central and South America by Heck (*125*), Kynoch and Norton (*149*), and at Yale University (*248*) showed similar results. The averaged results of the three studies give shrinkage values of 3.1 percent radially, 4.2 percent tangentially, and 7.6 percent volumetrically.

Studies of the movement of forest-grown Honduras mahogany at the Forest Products Research Laboratory in England (*108*) substantiated this wood's reputation of being very stable in use. A movement of 1.0 percent radially and 1.3 percent tangentially were measured between equilibrium in 60- and 90-percent relative humidities. This amounts to a movement of $\frac{1}{8}$ and $\frac{5}{32}$ inch per foot, respectively. The wood attained a moisture content of 12.5 percent in the lower humidity and 19.0 percent in the higher humidity.

Mechanical properties.—The strength properties of Honduras mahogany are extremely good for a timber of its weight; for this reason it was once used almost exclusively for airplane propellers. Plantation-grown timber is slightly below forest-grown wood in bending strength and work to maximum load in static bending in proportion to its slightly lower density. But plantation-grown timber is generally superior in hardness, compression across the grain, and shear. In the air-dry condition, the plantation-grown material is very much lower in modulus of elasticity, although the two types of wood are about equal in shock resistance. Air-dry, forest-grown wood is also apparently slightly superior to forest-grown wood in tension across the grain and cleavage resistance (*71*, *249*, *248*, *15*, *125*, *149*).

Working properties.—Mahogany is one of the easiest and most satisfactory of all woods to work with either machine or hand tools and has very little dulling effect on cutting edges. In fact, mahogany is often a "standard of perfection" for rating the machining qualities of other woods. The frequent presence of tension wood gives rise to fuzzy surfaces in machining, which necessitates an unusual heavy sanding. However, excellent finishes are obtained in most operations with "wooliness" encountered in some material, where the use of sharp tools is essential. The wood is easy to glue (*240*), takes nails and screws well, and will take an excellent polish by any of the accepted methods (*105*, *42*, *265*).

Honduras mahogany is one of the easier woods to slice or rotary cut into veneer, although flitches will frequently develop cracks when not properly boiled. This is prevented by a 60-hour boiling process that starts with a cold soaking followed by a gradual increase of temperature up to 170° F. (*197*).

Durability.—Honduras mahogany is generally considered resistant to decay. Field tests of forest-grown wood from British Honduras showed heartwood to be resistant but not highly resistant to decay. In these tests sample specimens lasted 10.5 and 11.0 years in contact with the soil (*206*).

Pure-culture tests (*71*) rate plantation-grown mahogany very durable to durable in resistance to a white-rot fungus and very durable to a brown-rot fungus. The wood has shown little resistance to marine borer attack in either Hawaiian (*76*) or Atlantic (*58*) waters. It is rated moderately resistant to termites by Wolcott (*263*), who rates the wood at 59 as compared to 80 for West Indies mahogany. This critical rating of Honduras mahogany does not appear wholly justified in lieu of its extensive use in termite-infested areas of the Caribbean without any appreciable number of complaints of termite damage. The sapwood is quite susceptible to insect attack. Logs that are not properly sprayed with insecticides and end coated against sun cracks are vulnerable to pinhole borers and the subsequent brown discoloration (*197*).

Both plantation-grown and forest-grown mahogany have excellent weathering properties with only minor surface checking and warping occurring when exposed to the weather without the protection of paint (*55*).

Preservation.—Honduras mahogany is extremely resistant to impregnation with preservatives. Even under pressure treatments, only a small quantity of preservative is absorbed with only very light penetration along the end grain.

Uses.—Honduras mahogany is one of the most cherished cabinet woods in the world. Its uses are generally confined to the more expensive types of furniture and cabinetmaking, interior trim, paneling, and other uses where a high-grade, attractive wood is required. It is also used extensively in shipbuilding for paneling and interior work in both large passenger vessels and small boats. Because of its durability, stability in use, and good weathering properties, the timber is used for planking on yachts and small boats and also for the shells of racing or speed boats (*118*). It is employed also for several types of musical instruments, particularly pianos.

In some countries mahogany is the preferred wood for burial caskets because of its attractive appearance. The characteristic low shrinkage, stability, and ease of working make mahogany particularly adaptable for use in molds, dies, and pattern making. A large portion of all mahogany is used in the form of veneer and plywood, often with cedar (*Cedrela*) or other less valuable wood used as a core or backing.

Supply.—Plantation-grown mahogany from the Caribbean region may become available in limited quantity from Trinidad and possibly other areas within a few years. Present export supplies of forest-grown timber are largely confined to Mexico, British Honduras, Honduras, and South America.

WEST INDIES MAHOGANY

Swietenia mahagoni

West Indies mahogany, *Swietenia mahagoni* Jacq., is probably the best known and most cherished cabinet wood in the world. It has been exported from the West Indies for nearly four hundred years, first to Europe and later to the United States and throughout the world. The timber was once in bountiful supply on many of the Caribbean islands and as late as 1919, H. O. Neville included the following comments in his Hardwoods of Cuba (*171*):

> For domestic purposes, the Mahogany is used in such freedom that it seems sacrilege to the newcomer from the North, who has known this wood only in its finished and very expensive forms. Many hundreds of cords of this timber, ranging from 12 inches in diameter down, are annually burned under the boilers of our sugar mills and locomotives; hundreds of trees of the proper sizes are annually cut down and rough-hewed into railroad ties; and for posts, corralled fences, and the myriad other uses of the plantation, Mahogany is utilized. There will come a day not very far distant when the waste of this valuable timber will be regretted.

The "day" Neville forecast has arrived and West Indies mahogany is now of more historical than commercial significance. By 1946 the annual cut declined to 2 million board feet in Cuba (*207*). Haiti, Cuba, and Dominican Republic have banned the export of all mahogany logs and lumber, and the other Caribbean sources can only supply small quantities at intermittent intervals. Fortunately, another true mahogany, *Swietenia macrophylla* King, and a number of other "so-called" mahoganies, although inferior in some respects to West Indies mahogany, have filled the position formerly occupied by this wood.

An indication of the esteem in which the true mahoganies, *Swietenia* spp., are held in the woodworking field throughout the world is evident by the numerous timbers that are called "mahogany." Some of these woods are superficially similar to mahogany; others bear virtually no resemblance to the true mahoganies. Nevertheless, the adopted trade name "mahogany" helped to sell them; otherwise, the timbers would have carried their local names.

Nomenclature.—The tree and timber of *Swietenia mahagoni* are known on the export market as mahogany, true mahogany, Spanish mahogany, West Indies mahogany, Cuban mahogany, Dominican mahogany, Jamaica mahogany, and other names related to the source. The French word for mahogany is acajou, and the Spanish know it as caoba and caoba dominicana. In the Bahamas the tree is called madeira or redwood. It is sometimes known as bay mahogany or caobilla in Cuba and as mahogany petites feuilles in Guadeloupe. Foresters in the Caribbean area often refer to this species as small-leaf mahogany to distinguish it from *S. macrophylla*, referred to as broadleaf mahogany. (Mahogany family, Meliaceae.)

Distribution and habitat.—West Indies mahogany is native to southern Florida, the Bahamas, Cuba, Haiti, Jamaica, and the Dominican Republic. It has been introduced and naturalized in Puerto Rico and most of the Lesser Antilles, including St. Lucia, Grenada, St. Vincent, Martinique, Guadeloupe, the Grenadines, and the Leeward Islands. The tree also grows in Trinidad, Tobago, and the American Virgin Islands, but is not considered indigenous to those locations (*50*, *18*).

Mahogany has been planted in many parts of the world, including east and west tropical Africa, the Philippine Islands, Java, India, and Ceylon. Commercial timber has been produced in India and Java. It is extensively planted nowadays throughout the West Indies, largely on the drier sites where it competes more favorably with the native species (*18*, *229*, *165*).

The tree.—Mahogany trees are seldom found in abundance, but are generally scattered thoughout the forest, one or two trees per acre or even less. The tree thrives in rich, moist soil but because of heavy exploitation it is now generally confined to dry, stony, arid areas. The trees vary in size and in quality of wood according to site; trees growing on dry, rocky sites are generally of smaller diameter than those in the more moist, fertile areas. The wood of the dry areas is, however, proportionately better in that it is finer textured, heavier, darker, and more highly figured than that of the faster growing lowland tree.

The History of Jamaica[3] carries the following description of mahogany:

> The tree grows tall and straight, rising often sixty feet from the spur to the limbs; the foliage is a beautiful deep green; and the appearance, made by the whole tree, so elegant, that none would be more ornamental for an avenue or decorative planting. It generally bears a great number of capsules in the season. The flowers are of a reddish or safron color; and the fruit of an oval form about the size of a turkey's egg. It is easily propagated from seeds and grows rapidly. Some of them have reached to a monstrous size, exceeding one-hundred feet in height and proportionately bulky.

The tree is planted extensively on the drier sites on many of the West Indies islands. In some arid, rocky areas pure stands of mahogany have developed from the original plantings. Wadsworth (*245*) describes the establishment of mahogany on an adversely dry ridgetop site on the

[3] Long, Edward. The History of Jamaica. 3 v. London. 1774.

island of St. Croix in the American Virgin islands in which some of the trees contain 2 to 2½ straight logs 16 feet long. Dense thickets of straight saplings and poles of various ages had come in naturally on all sides of this nucleus of older trees. A sample plot in the densest part of the stand showed a volume of over 14,000 board feet per acre and a basal area of 210 square feet per acre. However, the average stocking per acre for the entire stand at the time of measurement was less than 3,000 board feet. West Indies mahogany, acknowledged to be a better wood, generally grows at a slower rate in plantations than *Swietenia macrophylla*. It is also considered more disease resistant (*165*).

The wood.—In color, the heartwood varies from a deep, rich red to a pinkish and occasionally a yellowish color, but deepens to a rich red or brown with age and exposure. The surface of freshly sawed boards quickly turns a dark red upon exposure to the sun. The sapwood is yellow to white and clearly differentiated from the heartwood. The texture, grain, color, and figure vary according to site, but, in general, the texture is fine and the grain straight to roey, wavy or curly, often with an exceptionally attractive figure. Interlocked grain was present in 10 percent of the samples studied in one test at the U.S. Forest Products Laboratory (*68*). Occasionally a mottled, fiddleback, raindrop, and roe figure are present. The stumps, crotches, and distorted parts of the trees often yield some of the most attractively figured wood, such as blister figure and burl. The luster is high, silky, and golden. Odor and taste are absent or not distinctive. Wet sawdust and shavings transmit a red stain to concrete and wooden surfaces and have been used for this purpose (*143, 229, 50, 42, 241*).

Weight.—The specific gravity of *Swietenia mahagoni* from the Dominican Republic is reported at 0.56, based on green volume and ovendry weight (*149*). The specific gravity of air-dry wood ranges from 0.70 to 0.85, averaging around 0.77. Air-dry wood weighs about 48 pounds per cubic foot and green wood about 68 pounds per cubic foot (*50, 265*).

Seasoning.—West Indies mahogany, being a nonrefractory wood, is easily air-seasoned or kiln-dried without warping or checking. Kiln Schedule 5 of the Forest Products Research Laboratory in England (*222*) is recommended for kiln-seasoning.

Shrinkage.—This species is noted for its low and uniform shrinkage. Shrinkage values from green to ovendry of 4.6 percent radially, 5.4 percent tangentially, and 6.9 percent volumetrically (*160*) show both a low rate of shrinkage and very good uniformity between the radial and tangential directions. These factors are responsible for mahogany's ability to hold its shape and stay in place much better than most other timbers of similar density. Shrinkage from green to air-dry amount to about half these values.

Mechanical properties.—According to strength tests conducted at the Forest Products Laboratory in Madison (*125*) and the University of Michigan (*149*), the wood has good strength properties, particularly in bending and compressive strength factors in which it is somewhat superior to English oak. The wood is strong enough for the uses to which it is ordinarily applied except for the tendency to be somewhat fissile, which can be a disadvantage where splitting may occur (*118*).

Working properties.—The wood works well with both hand and power tools and finishes to an exceptionally smooth lustrous surface. It also makes excellent veneer, glues and bends well, and is a superior wood for turnery. Because it takes a fine polish, the wood is particularly well suited for French polishing but is perhaps most attractive when finished with only a colorless wax. The worldwide custom of staining mahogany a dark red brown before polishing actually conceals most of the true beauty of the wood (*265, 42, 143, 196*).

Durability.—The heartwood of West Indies mahogany is highly resistant to decay and insect attack. Wolcott (*263*) rates the wood at 80 in resistance to dry-wood termites compared to 59 for Honduras mahogany. Recent laboratory tests (*169*) of the decay resistance of West Indies mahogany, Honduras mahogany, and several of the false mahoganies (*Khaya* spp. and *Shorea* spp.) from Africa and the Philippines showed that the true mahoganies were superior in decay resistance to the other species. Only West Indies mahogany showed absolutely no decay damage during the test. Honduras mahogany was next in decay resistance, followed by *Khaya* spp. and *Shorea* spp. These species are also inferior to both of the true mahoganies in insect resistance. But West Indies mahogany showed no appreciable resistance to marine borers in tests conducted in Hawaiian waters (*76*).

Uses.—The wood is principally used for lumber and veneer in the more expensive types of furniture and cabinetwork. In Europe, the major use of the lumber from the limited number of small logs available is in turned rails and rungs of chairs. It is also used for high-class joinery work, woodwork in yachts and pleasure ships, turnery, carvings, and for other comparable jobs. The wood is especially well adapted for pattern work because of its stability and ease of working, but it has been largely replaced by Honduras mahogany. However, its main local use is for turned products for the Caribbean tourist trade. Because of its resistance to termites (*228*), its natural beauty and ease of working, the wood is also used locally for window frames, doors, sills, interior woodwork, and inlay work.

Supply.—Limited quantities of logs or lumber may be available at intermittent intervals from Jamaica, Guadeloupe, Trinidad, Martinique, St. Vincent, and Grenada. Haiti, Cuba, and the Dominican Republic have banned the export of logs so that more timber can be used locally. In 1955, a small circular sawmill was established in St. Croix of the American Virgin Islands to convert West Indies mahogany growing on that island.

MANBARKLAK

Eschweilera longipes, Eschweilera subglandulosa

Nomenclature.—The timber from *Eschweilera longipes* (Poit.) Miers and *E. subglandulosa* (Steud.) Miers enters the export trade from Surinam as manbarklak (*175*). *E. longipes* is also called black kakaralli in British Guiana and mahoe noir in French Guiana. *E. subglandulosa* is known as black kakaralli, barklak, kakaralli, and toledo wood, and in Trinidad as guatecare. (Brazilnut family, Lecythidaceae.)

Distribution and habitat.—Surinam is the main source of manbarkalak from *Eschweilera longipes* and *E. subglandulosa*. These species are two of about 80 species of *Eschweilera* distributed from eastern Brazil through the Amazon Basin to the Guianas, Trinidad, and Costa Rica. Fifteen or more species of *Eschweilera* that grow in British Guiana are known as kakaralli, but at least 75 percent of the trees are the more valuable black kakaralli, *E. sagotiana* Miers, which closely resembles the manbarklak of Surinam (*95*, *190*). *E. odora* (Poepp.) Miers of the Amazon Basin and the Guianas is another very closely related species known as manbarklak in Surinam and mata-mata in other areas (*71*).

Manbarklak grows in dense stands along the estuaries in Surinam; it becomes less important along the rivers (*231*). It is found throughout British Guiana where it becomes frequent to abundant in the rain and seasonal forests (*82*).

The tree.—The trees vary from small to very large in size with heavy oval crowns and black to brown, mottled bark. They are normally 90 to 120 feet in height, 16 to 20 and occasionally up to 40 inches in diameter, and have moderately well-formed boles 40 to 60 feet long. The trees are often somewhat fluted or slightly buttressed (*82*).

The wood.—Manbarklak is an extremely heavy, hard, strong wood. The heartwood when first cut is greenish yellow to olive brown, turning a brownish buff upon drying. Black streaks are occasionally present in the heartwood. The sapwood is 1½ to 4½ inches wide, creamy tan and not well differentiated from the heartwood when green but becoming more apparent when seasoned (*248*). The wood is typically straight grained and uniformly fine textured. Both species contain a high percentage of silica. Samples of *Eschweilera subglandulosa* show up to 1.31 percent and *E. longipes* up to 2.43 percent silica, based on ovendry weight of the wood (*14*).

Weight.—The specific gravity of manbarklak, *Eschweilera subglandulosa*, averages about 0.87, based on green volume and ovendry weight, and 1.08 based on air-dry volume and weight. Air-dry wood weighs about 67 pounds per cubic foot and green wood around 78 pounds per cubic foot (*248*, *231*). Both species discussed in this report are very similar in density.

Seasoning.—The wood is fairly difficult to air-dry, seasoning at a moderate rate with slight crook and twist, slight end and surface checking, and slight casehardening (*248*).

Shrinkage.—Manbarklak is considerably heavier than white oak but undergoes about the same shrinkage in drying. Shrinkage values of 5.0 percent radially, 10.3 percent tangentially, and 15.9 percent volumetrically for *Eschweilera subglandulosa* are only slightly higher than the corresponding values of 5.3, 9.0, and 15.8 for white oak (*248*). The ratio of tangential to radial shrinkage is favorable for uniform drying. Shrinkage values for *E. longipes* are not available.

Mechanical properties.—The wood is extremely hard, dense, tough and strong but, except for shock resistance in which manbarklak is outstandingly high, the unseasoned (green) wood is average or below average in strength for a wood of its density. Bearing strength across the grain is particularly low. In the green condition it is slightly inferior to greenheart in all mechanical properties, except shock resistance; in this manbarklak surpasses greenheart. However, the strength properties of manbarklak are generally much better than those of any domestic wood of the United States (*190*, *95*).

Unlike most tropical hardwoods, manbarklak improves substantially in strength during seasoning. It equals the proportionate increase shown by temperate-zone hardwoods during seasoning in bending strength and compression perpendicular to the grain (bearing strength), and exceeds the average in side hardness and work to maximum load (shock resistance). The air-dry wood compares very well with greenheart in static bending, elastic resilience, and shear, but is inferior to greenheart in stiffness and tension across the grain (bearing strength). When green and air-dry, manbarklak exceeds white oak in all properties except cleavage (splitting) in which it is equal to oak when green and slightly more than half as strong as oak when air-dry (*248*).

Working properties.—The wood is difficult to work because of the high silica content. It is also difficult to glue but takes a good finish. Cutting edges are quickly dulled by the silica and the wood's inherent hardness, but when knives are kept sharp a slate-smooth surface is obtained. Rammer caps are required when driving manbarklak piling, because of the ease in which it splits (*82*, *231*, *248*, *95*).

Durability.—Untreated manbarklak, *Eschweilera subglandulosa*, is resistant to very resistant to decay, according to graveyard tests in British Guiana (*50*) and Trinidad (*39*), and pure culture tests at Yale University (*248*). Other tests of untreated heartwood in Surinam showed a life expectancy of 15 to 30 years in permanent contact with the soil, or 40 to 50 years when exposed to the elements.

Manbarklak is noted for its high resistance to marine borers, which some authors attribute to the high silica content of the wood. It is particularly resistant in brackish waters where greenheart (*Ocotea rodiaei*) has been severly damaged (*188, 190, 76*). The timber has withstood marine borer attack for 17 years in one test in Surinam, and had the best record of a large number of resistant species in 15 years of exposure to marine-borer attack in the ocean waters at Balboa, Canal Zone (*71*). One record is available of manbarklak piling "at least 50 years old being perfectly sound and as hard as nail and quite untouched by teredo."

Manbarklak, *Eschweilera subglandulosa*, ranked fourth in resistance to marine borers of 37 tropical American hardwoods under test at Wrightsville, N.C. (*58*). In this test one manbarklak panel was lost to teredo and 3 others suffered only slight damage over a 36-month period. *Licania macrophylla* Benth., *Parinari rodolphii* Huber, and *P. campestris* Aubl. ranked slightly above manbarklak in the order listed. Greenheart ranked well below manbarklak in twelfth place.

Wolcott (*263*) rates black kakaralli, *Eschweilera sagotiana*, a closely related species, slightly above West Indies mahogany in resistance to dry-wood termites. This very resistant rating agrees with tests in Trinidad, where manbarklak also resisted subterranean termites.

Uses.—Because it has very good resistance to marine borers, manbarklak is especially suited for use in both temperate zone and tropics in marine construction, especially for marine piling (*231, 248*). Good strength properties and high resistance to wear or abrasion make the timber well suited for ice sheathing for boats, factory flooring, shoe keels for landing boats and beaters and bed plates in pulpmill equipment (*116*). It is also used locally for house framing, mine lagging, railway ties, and posts. The timber is especially useful where good decay and termite resistance is essential.

Supply.—Manbarklak is available in commercial quantities from the Guianas.

MANNI

Symphonia globulifera

Nomenclature.—*Symphonia globulifera* L. f. is found in both tropical west Africa and the American tropics, and is the only species of the genus *Symphonia* occurring outside of Madagascar. In addition to the common trade name of manni, the timber is commonly known as chewstick in the English trade. Other local and trade names are as follows: matakkie, masagrie in Surinam; manil, bois cochon in French Guiana; waika chewstick, corbán in British Honduras; leche amarilla in Honduras; yellow mangue in Trinidad; mangle blanc in Dominica; hog plum, doctor's wood, boarwood in Jamaica; palétuvier jaune in French West Indies; vanani in Brazil; cerillo, boncillo in Costa Rica; permán in Venezuela; barillo in Panama; brea-caspi in Peru; boarwood, doctor gum in British West Indies; barillo, leche amarillo in Honduras; manniballi, brick-wax tree in British Guiana. (Mangosteen family, Guttiferae.)

Distribution and habitat.—Manni occurs in the West Indies in Cuba, Jamaica, Hispaniola, Guadeloupe, Dominica, St. Lucia, and Trinidad, and on the continent from Mexico southward through Central America to northern South America. Its distribution in South America includes Colombia, Venezuela, the Guianas, Brazil, Peru, and Ecuador. The species occurs in Africa through the Ivory Coast and Gabon south to the Belgian Congo and Angola.

It is a rather common tree in the mixed-hardwood and palm forests of low, humid locations and at times is the dominant species in limited areas (*190*). In British Honduras the tree is most common and attains its best development in swamps along the southern rivers from Moho to Temash. It also occurs at the rate of 1.5 trees per acre along part of the coastal plain but is absent from the limestone regions (*150*). In Surinam the tree is locally abundant in swamp forests and marsh forests outside the young coastal plain and is occasionally found in the rain forest (*231*). It is found throughout British Guiana where it occurs as a dominant to occasional tree in the marsh forests and riparian forests (*82*).

In Trinidad manni grows principally in swampy areas, where it is often locally abundant, especially in the palm swamps. It also occurs in most other Trinidad forest types that receive 50 inches or more rainfall, but in most places of the territory it is only an occasional tree (*165*). In Jamaica the tree is found principally in damp mountain woods (*229*). In French Guiana it is scattered throughout the forest, except in the marshy regions where it sometimes forms almost pure stands (*69*). Elsewhere in the West Indies, it is also generally confined to the more moist humid areas.

The tree.—On favorable sites the trees often grow to 100 feet in height and have long, straight, slightly buttressed boles that average 20 to 30 inches in diameter and 70 to 80 feet long. However, trees up to 36 inches and 130 feet high are found in British Guiana and British Honduras (*150, 82*). Trees are commonly supported by stilt-

like roots, and sometimes have elbow buttresses up to 4 feet in height. In swampy areas the tree develops pneumatophores. The crowns are small with the long, whippy, drooping, irregularly whorled branches resembling those of spruce. The bark is rather thick, smooth, red brown and exudes a sticky yellow latex when cut. This latex becomes black and pitchy upon exposure in which condition it is used for calking boats.

The wood.—The sapwood is distinct, a near white that contrasts sharply with the varied colored heartwood. This latter may be yellowish, grayish, or greenish brown; several shades of these colors may occur as stripes on the face of a single board. A distinct but unattractive silver grain figure is visible on planed quartersawed boards. The luster is medium to high; the texture is rather coarse with a feeling somewhat harsh. The grain varies from straight to irregular. Soft parenchyma tissue is abundant and readily visible on a clean-cut end surface as wavy broken or continuous lines crossing the fine, invisible rays. Growth rings are absent or poorly defined. Freshly cut wood has a "tarry" odor, but dry wood has neither a distinctive odor nor taste (*5,231,143*).

Weight.—The specific gravity of manni based on ovendry weight and green volume averaged 0.544 (0.470 to 0.593) in tests at the Forest Products Laboratory in Madison (*68*), 0.58 in tests at Yale University with material from Surinam and British Guiana (*250*), and 0.59 in tests with wood from British Honduras by the Forest Products Research Laboratory in England (*15*). The specific gravity of air-dry wood based on volume and weight in that condition is generally reported at from 0.65 to 0.78, averaging about 0.72. Weight of air-dry wood averages 44 pounds per cubic foot. Green wood weighs about 67 pounds per cubic foot at 85.4 percent moisture content. These averages are very similar to those of white oak (*Quercus alba*).

Seasoning.—British Honduras, Surinam, and Dominica report manni as seasoning well with very little checking or distortion. However, the Forest Products Research Laboratory in England states that though the wood seasons fairly rapidly, it is inclined to check and split during seasoning and should not be exposed to direct sunlight, and, if possible, some protection should be given to the ends of boards to retard drying. Wangaard (*250*), reporting on tests at Yale University, states that wood seasons rapidly with moderate surface checking, slight to moderate end checking, and casehardening and warp in the form of crook and twist. Mold was observed on some material. It is generally concluded that a slower rate of drying would reduce seasoning degrade.

Shrinkage.—Manni undergoes moderate shrinkage during seasoning and is fairly stable in use. Wood from French Guiana of 0.775 and 0.728 specific gravity (air-dry) underwent a volumetric shrinkage of 12.7 and 11.3 percent, respectively, from the green condition to ovendry. Material of similar density from Surinam and British Guiana, tested at Yale, averaged 5.7 percent radially, 9.7 percent tangentially, 0.15 percent longitudinally, and 15.6 percent volumetrically from green to ovendry. White oak of similar density undergoes a shrinkage of 5.3 percent radially, 9.0 percent tangentially, and 15.8 percent volumetrically (*160*). Shrinkage from green to air-dry would be about half these values.

Mechanical properties.—Mechanical tests have been conducted on wood from British Honduras by Yale University (*90, 250*) and the Forest Products Research Laboratory in England (*15*) and by Pfeiffer with material from Surinam (*175*). Pfeiffer derived values somewhat lower than those obtained at Yale and in England. The difference has been attributed to the consistently higher moisture content and the somewhat lower specific gravity of the air-seasoned material used in Pfeiffer's tests.

Test averages in England and at Yale University showed manni superior to white oak in static-bending properties and in maximum crushing strength parallel to the grain. Manni is slightly inferior to oak in shear parallel to the grain, cleavage, and side hardness but is slightly superior in end hardness. In general, the wood compares very favorably with white oak in all mechanical properties tested and in density, rating it as a wood that is strong for its weight. In toughness manni proved quite inferior to yellow birch, sugar maple, and some oaks (*160*).

Working properties.—Manni is a very easy wood to work. It hardly dulls cutting edges, although it is somewhat harsh and splintery. Because manni has an abundance of soft parenchyma tissue, the surface tends to roughen in planing and shaping, particularly on irregular grain. However, in general it may be sawed, planed, turned, shaped, and bored without difficulty (*82, 231*).

Machining tests at the Forest Products Laboratory in Madison (*68*) indicate the wood turns, bores, sands, and mortises very satisfactorily under rather severe machining conditions, but raised and chipped grain may occur in planing and shaping. However, for 15 tropical American species tested, the wood was above average except in shaping and turning, which exceptions were only slightly below average. Splitting may occur during nailing because of the wood's somewhat fissile nature (*5*) but, in general, it holds nails and screws well. Manni also polishes easily and affords a satisfactory surface for the application and retention of glue, paint, and varnish (*90, 191, 178*).

Durability.—The wood is durable in contact with the ground and has very good durability in water. Presumably it is not resistant to marine borers. Graveyard tests in British Guiana (*50*) and England (*206*) showed that the wood will last 5 to 6 years and 12 years, respectively, in con-

tact with the ground. It is also rated resistant to decay in graveyard tests conducted in Trinidad (*39*). Pure culture tests conducted in England rated manni very resistant to both white-rot and brown-rot fungi (*84*). Recent tests at Yale (*250*) were less favorable. They show the heartwood varied in decay resistance from very durable to moderately durable, averaging durable in resistance to a white-rot fungus and very durable to durable to a brown-rot organism. Subject to termite damage, manni rated by tests in Puerto Rico and Trinidad as only moderately resistant to drywood and subterranean termites (*263*). Logs are reported by Fanshawe to be subject to damage by pinhole borers.

Preservation.—Heartwood is highly resistant to impregnation with preservatives. Absorption in the sapwood is limited to the vessels, for the fibers do not take the preservative (*150*).

Uses.—The timber of *Symphonia globulifera* is used locally throughout most of its range for a variety of purposes and has occasionally been exported in small lots from tropical America to the United States and Europe for veneer and plywood (*191*, *178*). Saks (*197*) reports that the wood should be suitable for rotary-cut veneer after thorough tests have been completed.

In the West Indies and Central America, manni is used in general construction work, flooring, piling in nonteredo areas, carpentry, railway ties, shingles, boxes and crates, cooperage, boat keels, and bridge timbers. Because of its good machining and finishing qualities, it is looked upon with favor for furniture, cabinetwork, and interior and exterior finish. The yellow variety is particularly recommended for exteriors; it has a more attractive color and takes a higher finish.

In British Honduras the wood was used for crossties; it was reported as fairly durable and held well in the track. However, the heartwood became brittle with age and broke under pressure of the rolling stock without sufficient ballast under the rails (*86*, *208*). According to Horn, railway crossties of this species have been exported from the Lower Amazon region of Brazil (*133*).

Manni has been used for cooperage in British Guiana as a substitute for gum staves in the manufacture of molasses barrels. Demougeot (*69*) states it is particularly well suited for use in barrels of small dimensions for it has a finer grain, is less permeable, and makes a more solid barrel than oak. Barrels made of manni are reported to be more rigid than those of oak and to last longer when filled. The staves of empty barrels are also less apt to shrink and break. The Forest Products Research Laboratory in England suggests that the timber may be a satisfactory substitute for oak in construction work.

Manni has been selected in the government housing program of British Guiana as one of the 10 woods acceptable for siding and flooring; one of 18 woods acceptable for interior partitions and battens; and one of 8 timbers acceptable for structural timbers, scantlings, and other similar items.

The papermaking characteristics of manni from Trinidad have been studied by the Imperial Institute in England (*116*), where tests indicated the wood produces "a well digested pulp which furnishes a soft, opaque, bulky, brown paper, of fairly good strength. The pulp bleached fairly readily, and then furnished a pale cream-colored paper of similar character and strength to that from the unbleached pulp." The wood is suitable for making acceptable book and printing paper.

The resin is used for medicinal purposes in tropical America under the local names of doctor gum in West Indies, mani in French Guiana, and danani in Brazil. The resin serves specifically in the medicinal field as a vulnerary and diuretic, as a gout plaster, and as a substitute for copaiba. It is also reported to be used as a tonic and an efficacious balm in the healing of ulcers and absesses (*90*). The resin, which darkens on exposure, is reported by Le Cointe (*155*) to serve as a ship pitch and tar, called cerol in Brazil, where it is used for caulking boats, for fitting arrowheads to spears, as a substitute for shoemaker's pitch, and to impregnate cord for use as torches, for it burns without smoke or odor.

Supply.—Exportable supplies are available in the Guianas, British Honduras, Trinidad, Guadeloupe, and Dominica.

MANNIBALLI

Inga alba

Nomenclature.—*Inga alba* Willd. is one of the many species of the genus *Inga* distributed throughout tropical America. Many species are cultivated for decorative purposes but their principal use is for shade trees in coffee and cacao plantations. The timber is marketed as manniballi and maporokon in British Guiana, prokonie in Surinam, and bois pagoda or bois sucre in French Guiana. A synonym is *I. praxinea* Willd. (Legume family, Leguminosae.)

Distribution and habitat.—Manniballi grows in the Guianas and the Rio Negro area of Brazil. In Surinam the tree occurs in the rain, marsh, and high savanna forests (*231*). In British Guiana it is an occasional to frequent tree of general distribution throughout the primary and secondary forests (*82*).

The tree.—Manniballi is a medium-sized, unbuttressed tree with a heavy rounded crown. In British Guiana trees may attain heights of 110 feet and diameters up to 30 inches in the most favorable sites, but it is usually 16 to 20 inches in diameter and less than 100 feet in height. The boles are often fluted, varying from poor to moderately good in form and up to 50 feet in length (*82*).

The wood.—Whitish sapwood of manniballi is indistinct from the pale reddish-brown to reddish-white heartwood that is occasionally streaked with darker colors. The wood is coarse textured, lustrous, and with a straight to roey grain. Distinctive taste or odor is lacking in seasoned wood. Growth rings are generally rather distinct (*231*, *50*, *22*).

Weight.—Manniballi is a moderately heavy wood. The specific gravity of air-dry wood is reported by the Surinam Forest Service (*231*) and Benoist (*22*) at 0.57, based on air-dry volume and weight at 15 percent moisture content. Air-dry wood weighs about 36 pounds per cubic foot, about the same as Douglas-fir of the United States.

Seasoning.—No data are available on the seasoning properties of manniballi. However, experience in Puerto Rico with guaba (*Inga vera* Willd.) and guamá (*I. laurina* (Sw.) Willd.), both closely related species, indicates these species dry rapidly with a moderate amount of degrade from cup, twist, and crook. On this basis, manniballi can be classed as moderately difficult to air-season. Logs and freshly cut lumber are susceptible to discloration by sap-stain fungi.

Shrinkage.—The wood undergoes moderate shrinkage during seasoning. A radial shrinkage of 1.1 percent and tangential shrinkage of 3.1 percent from green to air-dry (15 percent moisture content) is reported in recent tests (*231*), as compared to 3.1 and 7.2 percent, respectively, from green to ovendry. The ratio of tangential to radial shrinkage is slightly above normal, indicating the possibility of considerable distortion during seasoning unless the material is carefully stacked.

Mechanical properties.—Recent mechanical tests of manniballi by the Argicultural University of Wageningen, Holland, show it to be average or better in toughness, cleavage, shear, compression parallel to the grain and in all static-bending properties. It is considered to be moderately hard and strong in comparison to woods of similar density (*82*, *231*).

Working properties.—According to numerous reports, the wood is easy to work and finishes to a smooth surface.

Durability.—Manniballi, as well as the other species of *Inga*, is reported to have little resistance to insects or decay. Wolcott (*263*) found guaba (*I. vera*) of Puerto Rico very susceptible to damage by the dry-wood termite of the West Indies. Pfeiffer (*175*) rated *Inga* spp. as "little durable" in contact with the ground and easily attacked by subterranean termites. Presumably, manniballi is also very susceptible to damage by marine borers.

Uses.—The timber has been recommended for utility plywood, flooring, sheathing, general construction, carpentry, interior woodwork, furniture, boxes and crates, and light cabinetmaking. It can give good service for many uses where resistance to decay and insects is not a factor.

Manniballi has been selected in the government housing program of British Guiana as one of the 12 timbers acceptable for use as structural timber, scantlings, and similar uses; it is one of 10 timbers acceptable for siding and flooring, and one of 18 timbers acceptable for interior partitions and battens. The relatively low radial shrinkage as compared to tangential shrinkage suggests the use of quartersawed material in flooring and other uses where stability is required.

Supply.—British Guiana and possibly Surinam and French Guiana can supply manniballi for the export trade.

MARBLEWOOD

Marmaroxylon racemosum

Nomenclature.—*Marmaroxylon racemosum* (Ducke) Killip is the only species of the genus *Marmaroxylon*, meaning marblewood, so named from the appearance of the lumber (*185*). However, this species is known also as *Pithecellobium racemosum* Ducke (*P. racemiflorum* Ducke). (Legume family, Leguminosae.)

The wood is often called snakewood in the English trade and in British Guiana, because it resembles the color and markings of the skin of certain snakes. It is commonly known as bois serpent, bois zebra, and bois macaque in French Guiana. In Surinam the local names are bousi tamarin, puta locus, slang houdou, and snecki housou. Timber cut in Brazil is known generally as angelim rajado (streaked angelim) and occasionally as ingá caetitú or urubuzeiro.

Distribution and habitat.—Marblewood grows in the lower Amazon region and the Guianas. It is reported to be fairly common in parts of Brazil where it has been known in the trade for many years. In the Guianas the tree occurs infrequently on the drier sites in the upland rain forests and seasonal forests. It was first authentically discovered in British Guiana in 1937, when a large 100-foot tree was found growing in the rain forest on high land in the Essequibo River basin.

The tree.—It is, in general, a medium-sized unbuttressed but basally swollen tree. Trees are commonly 16 to 20 inches in diameter and 90 to 100 feet in height with clear boles up to 50 or 60 feet long. Marblewood probably makes its best growth in French Guiana, where the tree is rare but large. Trees with clear boles 60 to 80 feet long and diameters of 18 to 24 inches above the basal swelling are not uncommon in this area (*185*, *82*).

The wood.—Marblewood, though not abundant, is an attractive wood and highly valued in some areas. The sapwood is yellowish and not clearly demarcated from the light yellow to orange-brown heartwood, which is overlaid with

characteristic large, irregular purplish-brown and occasionally black streaks and patches. These markings, being darker than the yellowish background, give the wood a distinctive and unique beauty. The wood also exhibits a fine pencil-striping of light-colored lines. It is very hard, strong, medium to coarse textured, and rather harsh to the touch. The grain is straight to irregular; luster is low to medium; and no distinctive odor or taste are evident in seasoned wood (*82*, *143*, *190*).

Weight.—Specific gravity of air-dry wood falls within a range of 1.05 to 1.25, based on air-dry volume and weight. Air-dry wood weighs from 65 to 78 pounds per cubic foot.

Seasoning.—There is no information available concerning either air-seasoning or kiln-seasoning of the wood.

Shrinkage.—Marblewood shrinks 14.3 percent in volume from equilibrium in 100-percent humidity (green and thoroughly saturated) to ovendry, based on the original green volume. Shrinkage from green to air-dry would amount to about half this amount, or roughly 7 percent. This is a moderately high rate of shrinkage but is not unusual for woods of high density. It is equal or below similar values for some woods of much lower density (*50*). Other shrinkage values are not available.

Mechanical properties.—In tests of mechanical properties at the French Centre Technique Forestier Tropical (*50*), marblewood exhibited lower strength than many other woods of similar high density. Generally the wood is hard and stiff, but falls below other woods of similar density in bending strength, resistance to splitting, compression strength, and resistance to impact bending. It compares fairly well in most strength properties with West Indies mahogany (*Swietenia mahagoni*), which is, however, of much lower density. On the basis of its greater density, marblewood should be the much stronger of the two and is, consequently, not particularly fitted for uses where strength is important.

Working properties.—Working marblewood with either hand or machine tools is difficult because of its high density. But it is reported to finish smoothly and to take an exceptionally fine polish.

Durability.—The wood is generally considered resistant to decay, but no graveyard or laboratory tests are found in the literature (*82*). Wolcott (*263*) lists marblewood as resistant to termites, rating it slightly above Honduras mahogany (*Swietenia macrophylla*) in this respect. He rates the resistance of Honduras mahogany at 59 and marblewood at 64, based on laboratory tests with captive members of *Cryptotermes brevis* Walker known as the West Indies dry-wood termite or "polilla." Tests in Hawaiian waters indicate that the wood has little resistance to marine borers (*76*).

Uses.—Although the wood possesses good strength, it appears that its highest use is for furniture, cabinetmaking, turning, joinery, marquetry, flooring, and decorative panels, as these uses can best capitalize on the wood's unique attractiveness. It is also used for heavy and durable construction and for wheelwright work in French Guiana and Brazil, despite the timber's moderate strength properties and high value. The wood also seems suitable for cutlery handles, novelties, and for other special uses requiring a hard, heavy wood of unusual appearance.

Supply.—French Guiana is the only area in the Caribbean reported to have marblewood available for export. Small quantities may be available on special order from Surinam and British Guiana.

MORA

Mora excelsa, Mora gonggrijpii

Mora [4] timber is supplied by two very similar species, *Mora excelsa* Benth. and *M. gonggrijpii* (Kleinh.) Sandw. It is one of the most plentiful high-quality heavy timbers in the Caribbean area. The two species grow on totally different sites and are not similar in appearance or growth habits, yet their wood can scarcely be separated. As a result, the timber of both species is sold separately or in combination.

Nomenclature.—The timbers are generally marketed together under the trade name mora or on occasion as morabukea when *Mora gonggrijpii* is predominant. Local names for *M. excelsa* are prakue, waspisiana, and torore in British Guiana; peto, roode, witte mora, perakaua, and mora-yek in Surinam; muru in Trinidad; peto and mora de Guayana in Venezuela; mahot rouge in French Guiana; and belarbre in Martinique.

Mora gonggrijpii is principally known as morabukea throughout its range, although other local names may have restricted usage. Some authors include *Mora* within the genus *Dimorphandra*. Synonyms of *M. excelsa* include *M. guianensis* Schomb., *Dimorphandra excelsa* (Benth.) Baill., *D. mora* Benth. & Hook. f., and *D. guianensis* (Schomb.) Baill. *D. gonggrijpii* Kleinh. is a synonym of *M. gonggrijpii*. (Legume family, Leguminosae.)

Distribution and habitat.—*Mora excelsa* is widely distributed in the Guianas but much less so in Trinidad and the Orinoco Delta of Venezuela. It makes its best development on low-lying, moist sites but not those constantly inundated. In British Guiana it is strongly dominant on river levees and flood plains on alluvial clay or silt soils, occurring in dense stands along stream courses on the heavier soils. It is also of frequent occurrence in the rain and seasonal forests on

[4] Marish is listed under Kauta, out of alphabetical order.

hillsides and in low-lying sandy areas and is of occasional occurrence in the marsh forests. Individual stands of from 10,000 to 15,000 board feet per acre in merchantable trees are not uncommon. Although the tree occurs in pure stands, it is normally a gregarious species and often the dominant species in the stand (*29*, *20*, *121*).

Mora gonggrijpii is not as widely distributed or as abundant as *M. excelsa*, being restricted to British Guiana and Surinam (*190*). It is the dominant species in the morabukea forests of British Guiana where it covers large areas in the interior, but it is rare in the northwest district and along the coast. The tree is best adapted to hillsides on heavy clay soils even though it occurs occasionally in other types of rain forest. The tree is also widely distributed in Surinam.

The tree.—*Mora excelsa* is an outstanding tree in appearance. The huge buttresses and flanges at the base of the large trees spread out 15 feet from all sides of the trunks and at times extend for 50 feet up the tree (*121*). Normally the tree is 100 to 120 feet high and 2 to 3 feet in diameter with clear boles for 50 or 60 feet above the buttresses that extend horizontally to 8 feet and from 5 to 15 feet up the trunk. Trees 160 to 200 feet high and 4 feet in diameter are reported. Their boles are straight and have fairly good form but are sometimes flattened. Logs are commonly 30 to 40 feet long and 1½ to 2½ feet in diameter at the butt; but some run to 60 feet long and 5 feet through at the butt. Large trees are often hollow butted, yet they still contain much sound timber (*29*).

Mora gonggrijpii is smaller on the average than *M. excelsa*, although occasional specimens are as tall as the largest moras. Its plank buttresses seldom extend more than 6 to 10 feet high. The tree is commonly 16 to 20 inches in diameter and 100 to 120 feet in height, with long crylindrical boles 60 to 80 feet in length. Occasional trees are found up to 24 inches in diameter and 150 feet tall (*82*).

The wood.—The wood of both species is almost identical in appearance, weight, structure, and strength. The sapwood of the mora tree is yellowish to pale brown, 2 to 6 inches wide, and distinct from the dark brown, reddish brown, or dark red heartwood, which is streaked with white or brown lines. The wood is mealy in appearance and rather harsh to the feel. The grain is straight to commonly interlocked, very variable and often has attractive bird's-eye, wavy, or sometimes ribbon-grain figures (*142*). Growth rings bounded by terminal parenchyma are present. The luster is high, and the texture varies from medium to coarse, usually the latter. It has a distinct astringent taste and a slightly sour odor. Two timber varieties are recognized: black and white. Black mora has more heartwood and is heavier and more durable than the white mora.

The wood of morabukea is similar to that of mora, being very hard, heavy, tough, and strong with the same general physical properties. Morabukea is sometimes slightly harder and, to some extent, finer in texture than mora (*143*, *265*).

Weight.—The wood of both mora and morabukea ranges from 0.90 to 1.10 in specific gravity, averaging about 1.00 based on air-dry weight and volume. The specific gravity based on green volume and ovendry weight is reported at 0.78 by Kynoch and Norton (*149*), Yale University, and the Forest Products Research Laboratory in England. The weight per cubic foot averages about 77 pounds for green wood and 62 pounds for air-dry wood (*15*, *231*, *82*, *29*).

Seasoning.—There are conflicting reports as to the seasoning characteristics of the timber. The Forest Products Research Laboratory in England (*222*) reports mora seasons slowly in the kiln with appreciable degrade. The timber was reported to have a tendency for shakes to extend during seasoning, surface checks to develop rapidly, and a good possibility that cupping and twisting will prove serious. Kiln Schedule 2 of the Forest Products Research Laboratory in England is recommended.

Mora was rated difficult to season in tests at Yale University (*250*). Stock dried at a moderate rate with moderate crook and slight checking. Only slight casehardening was noted in this test. In British Guiana, the wood of the mora tree is reported to air-season and kiln-dry well with very little checking if properly stacked and carefully handled (*29*).

On the basis of these reports, mora should be classed as moderately difficult to season. A slow rate of drying and careful stacking are recommended to keep warp and other degrade to a minimum.

Shrinkage.—Mora undergoes a high rate of shrinkage during seasoning. *Mora excelsa* is reported by the Forest Products Research Laboratory in England to have a radial shrinkage from green to air-dry (12 percent moisture content) of 5.0 percent and tangential shrinkage of 7.5 percent, compared to 4.0 and 7.0 percent, respectively, for *M. gonggrijpii* (*15*). Wangaard, Stern, and Goodrich (*250*) report that *M. excelsa* from Surinam and British Guiana undergoes an average shrinkage from green to ovendry of 6.9 percent radially, 9.8 percent tangentially, 0.36 percent longitudinally, and 18.8 percent volumetrically. These values are somewhat greater than corresponding values for white oak of 5.3, 9.0, and 15.8 percent for radial, tangential, and volumetric shrinkage, respectively (*242*). Mora's ratio of tangential to radial shrinkage is within the range considered favorable for reasonably uniform drying in respect to stresses that occur during seasoning.

Both mora and morabukea are relatively unstable in use; as timbers they have large move-

ments. Both species move 3.5 percent tangentially from equilibrium in a 60-percent relative humidity to equilibrium in a 90-percent relative humidity. Mora also undergoes a radial movement of 2.3 percent, and morabukea 2.0 percent under the same conditions (*108*).

Mechanical properties.—Mora (mora and morabukea) is a very strong, stiff, hard, tough wood. When green, mora is considerably denser and stronger than any domestic wood of the United States. However, when compared to other tropical woods of similar density, mora falls below the average in most strength properties, except in shock resistance and stiffness, which are average. It greatly exceeds green white oak in all properties except tensile strength across the grain and cleavage resistance. In the air-dry condition mora is superior to white oak in bending and crushing, stiffness, and hardness, and it is more shock resistant. However, mora is inferior to the lighter white oak in compression and tension across the grain, cleavage, and shearing strength. In general, its strength characteristics average about 30 percent greater than those of white oak (*149*, *15*, *29*, *250*).

Working properties.—The wood is moderately difficult to work but machines well. It is fairly hard to saw, and springs in sawing with a dulling effect similar to that of teak. It planes to a smooth surface unless interlocked grain is present, in which case there is considerable "pick up" and chipped grain. This can be reduced by using a cutting angle of 10 degrees on knives. Saws having teeth with a 10-degree hook spaced at a medium wide interval are recommended. The wood turns easily, seldom splintering, and requires little sanding. It finishes smoothly and is easily polished. The wood holds nails and tie spikes extremely well, and is very difficult to split. Morabukea is considered a little more difficult to work than mora.

Durability.—The durability of *Mora excelsa* appears to differ between locations and sources, but it generally resists decay in contact with the ground. The timber is reported to last 15 years or longer in contact with the ground in England (*206*). Even better results are realized in British Guiana, where mora is considered variable in resistance to decay but lasts up to 20 years in the ground. However, Brooks reported it to last only 2 to 3 years in the soil in Trinidad, where it is considered susceptible to decay (*39*, *29*).

Findlay (*84*) reports that, on the basis of pure culture tests, material from British Guiana rated resistant to decay, but wood from Trinidad rated moderately resistant to nonresistant. These results are in general agreement with the post tests in British Guiana and Trinidad. Pure culture tests at Yale University (*250*), using wood from Surinam and British Guiana, rated mora durable to a brown-rot organism and very durable to a white-rot fungus. No difference was noted in the durability of the material from Surinam or British Guiana.

Mora is readily susceptible to damage by marine borers (*76*) but very resistant to dry-wood termites and other insects. A low silica content (0.02 percent) may be a factor in its poor resistance to marine borers.

Morabukea is considered more resistant to decay than mora, averaging very resistant as compared to resistant for mora (*50*). Morabukea is rated slightly higher than West Indies mahogany (*Swietenia mahagoni*) in termite resistance (*263*); it is very susceptible to damage by marine borers. The sapwood of both species is susceptible to pinhole borers, powder-post beetles, and longhorn beetles, and is not durable in the ground.

Preservative treatment.—The sapwood responds readily to preservatives, but the heartwood of mora resists impregnation. Under prolonged pressure treatment, sapwood absorbs only 4 pounds per cubic foot, compared to the 10 to 15 pounds required. In heartwood, penetration is fairly uniform but extends only about ⅜ inch deep.

Uses.—Being hard, heavy, tough, and strong, mora timber has many uses. Because of its fire resistance, it is rated by Lloyds as an A–1 material for stem posts, ribs, knees, and framing in ship building (*118*). Because of its instability and lack of cabinetwood beauty, the wood is not well fitted for furniture, interior flooring, turnery, and similar uses. But it is well qualified for bridge timber, house framing, bridge decking and planking, marine construction, and piling in teredo-free areas. The timber is also successfully used for mining timbers, mill beds, heavy-duty industrial flooring, and heavy construction of all types.

Mora has been used successfully in Holland for piling in teredo-free areas. Danks (*67*) reports its use in England for warehouse flooring, where its ability to withstand hard wear is an appreciated quality. Hohenkerk (*128*) reports that untreated mora ties were decayed only at the rail grooves, but otherwise were sound after 8 years' service on a poorly ballasted roadbed in a hot, humid section of British Guiana.

Pulped by the soda process, the wood yields a good quality pulp suitable for strong paper (*113*). It also is highly rated as a charcoal wood, having a caloric value of 13,800 B.t.u. (*51*).

Supply.—Mora timber is available in relatively large quantities from British Guiana and Surinam, and in lesser amounts from French Guiana and Trinidad.

NARGUSTA

Terminalia amazonia

Nomenclature.—A number of species of the genus *Terminalia* grow in the American tropics of which *T. amazonia* (J. F. Gmel.) Exell is the most widely distributed. Several other species

occurring in the Caribbean area have similar wood, but too little is known about them to assume that they have the same properties as nargusta. Included in this group are *T. latifolia* Sw. of Jamaica, discussed separately as broadleaf, and *T. chicharronia* (Griseb.) Wright (*T. intermedia* (A. Rich.) Urban) of Cuba. *T. catappa* L., Indian-almond, is a widespread exotic planted and naturalized in tropical America. *T. obovata* (R. & P.) Steud. is a synonym of *T. amazonia*. (Combretum family, Combretaceae.)

In addition to the preferred trade name of nargusta, this species and its various forms are known by the following vernacular names: fukadi, pookadi, coffee mortar in British Guiana; almendro, bullywood in British Honduras; guaba, almendro in Honduras; cochun in Mexico; amarillo in Panama; white oliver in Trinidad; guayabo león in Colombia; pau-mulato brancho in Brazil; roble in Ecuador; amarillón in Costa Rica; pardillo negro and chicharro in Venezuela; volador, guayabo, naranjo in Guatemala.

Distribution and habitat.—Nargusta is common on the moist slopes and flat lands within the rain forests of southern Mexico southward through Central America and into northern South America to Brazil and Peru and on the island of Trinidad (*190*, *71*).

It is widely distributed in the rain forests of Trinidad, where it is most abundant on poor sands and gravel. It also thrives on clay soils within this colony but is absent from the drier sites (*165*). In British Guiana the tree is common throughout the seasonal and wallaba forests. It is one of the commonest trees in British Honduras except on the deeper limestone soils of the northern plain area. Concentrations of 4 to 5 trees per acre are not unusual in British Honduras, especially in the lighter canopy forests.

The tree.—Nargusta is a large, virtually evergreen tree with a long, clear symmetrical bole above the large buttresses (*6*). It attains heights of 70 to 140 feet and reaches up to 4 or 5 feet in diameter, depending on the site and location. However, trees with diameters larger than 20 or 25 inches are often hollow (*71*, *105*). Boles are commonly 60 to 70 feet long on the better sites (*82*). In British Honduras the tree is noted for its ability to coppice and for fallen trees to send up new shoots that develop into large trees astride the fallen parent. The bark is a dull brown, rather thin with shallow longitudinal fissures (*150*, *165*).

The wood.—The sapwood, a yellowish color, is not readily separated from the heartwood for the wood usually darkens gradually from the sapwood to the heart or pith of the tree. The heartwood is varied; it may be a brownish yellow, light yellowish brown, or yellowish olive. In some trees the wood has distinct and prominent reddish streaks and stripes at widely spaced intervals. The luster is medium to rather high. The wood is of medium texture and usually shows marked irregularity in the grain, which is normally interlocked showing a fairly distinct "stripe" or "roe" figure on quartersawed boards. Growth rings are usually not clearly defined, and no distinctive odor or taste are evident in seasoned material (*143*, *6*, *246*).

Weight.—Nargusta is a rather heavy wood, with an average specific gravity of 0.66 (0.53 to 0.77) based on ovendry weight and green volume (*71*). The specific gravity of air-dry wood generally averages about 0.80. Air-dry wood averages about 50 pounds per cubic foot and greenwood about 71 pounds per cubic foot (*150*, *105*, *82*, *165*).

Seasoning.—Nargusta is a moderately difficult wood to air-season and kiln-dry. Depending on the timber source, it also exhibits considerable variability in seasoning characteristics. In one test in the United States, wood from British Honduras air-seasoned at a fast rate with no checking and only slight warping, but wood from British Guiana seasoned more slowly with very pronounced end and surface checking, particularly in thick stock (*71*, *249*). In a similar test in England, wood from British Honduras air-seasoned rather slowly with a tendency to split and check although piled under cover in the most favorable conditions. In this test very little warping occurred and knots generally remained sound (*105*).

The wood kiln-seasons slowly with little warping but with a marked tendency to split and check and for existing shakes to become more extended. It is also difficult to remove moisture from the center of quarter-cut material over 2 inches thick. Kiln Schedule 3 of the Forest Products Research Laboratory in England is recommended (*222*).

Shrinkage.—Nargusta undergoes moderate shrinkage for its density. Shrinkage from green to ovendry averages about 4.8 percent radially, 7.9 percent tangentially, 0.18 longitudinally, and 12.7 percent volumetrically. These values are somewhat lower than shrinkage of sugar maple and white oak and very similar to those for white ash, although all three species are considerably lower in density than nargusta (*242*, *249*).

Shrinkage from green to air-dry (12 percent moisture content) is reported to be 2.5 percent in the radial direction and 5.0 percent in the tangential direction, or $\frac{5}{16}$ inch and $\frac{5}{8}$ inch per foot, respectively (*222*). The ratio of tangential to radial shrinkage indicates moderately uniform shrinkage characteristics, which may account for the absence of severe warping during seasoning.

Nargusta timber responds to atmospheric changes with only moderate movement. It undergoes a radial movement of 1.7 percent and a tangential movement of 2.7 percent, or $\frac{13}{64}$ and $\frac{21}{64}$ inch, respectively, between equilibrium in a relative humidity of 60 percent and equilibrium in a relative humidity of 90 percent (*108*). Heartwood of nargusta is moderately resistant to moisture

absorption, being intermediate to mahogany and white oak in this characteristic (*198*).

Mechanical properties.—Nargusta varies somewhat in strength according to its source and density. Tests at Yale University (*71*, *249*) indicate the wood's strength properties are related directly to its density. Seasoned wood from Trinidad is reported to be 20 to 30 percent superior to the wood of the same species from British Honduras (*105*). Similarly, wood from Panama is inferior to that of British Guiana and British Honduras in compression strength across the grain.

The timber from all sources is heavy, hard, and strong. Tests of wood from Trindad and British Honduras by the Forest Products Research Laboratory in England (*105*) and of wood from British Guiana, British Honduras, and Panama by Yale University (*71*, *249*) are in reasonably good agreement. Nargusta in both the green and air-dry condition was found to be definitely superior to white oak (*Quercus alba*) in all static bending and compression parallel to the grain properties. In the green condition it is also superior to white oak in compression and tension perpendicular to the grain and shear, but after air-drying it becomes slightly inferior to oak in these same properties. It is definitely inferior to oak in cleavage in both the green and air-dry condition, but is about 70 percent harder than that species.

Seasoned nargusta from Trinidad is about 70 percent harder than oak, 40 to 60 percent stiffer, tougher, stronger in bending and in compression along the grain, and 30 percent stronger in shear, but is about 40 percent less resistant to splitting.

Working properties.—The timber is somewhat difficult to work with hand and machine tools. It is comparable to beech (*Fagus*) in its resistance to cutting and sawing and other machining operations. Straight-grained wood planes, molds, bores, mortises, and saws cleanly but with a slight tendency to char in crosscutting, drilling, and mortising. Raised grain may occur when planing quartersawed boards with interlocked grain, and a much greater amount of tearing may occur when fiddleback ripple is present. A little tearing of knots may also take place in planing. Nargusta turns to a very smooth finish. It is easy to glue and stains and polishes easily to a high luster. In nailing, nail holes must be prebored to prevent splitting (*150*, *240*, *178*, *191*, *6*).

Saws having 54 teeth with 15-degree hook are recommended. A knife angle of 10 degrees is best for planing interlocked or fiddleback grain material (*105*). Nargusta is a fair to poor wood for steam bending, but Woods (*265*) reports that it bends well without steaming.

Durability.—The resistance of nargusta to decay appears to be variable. Graveyard tests in England (*206*), using wood from Trinidad and British Guiana, showed the wood to be very durable in the ground, lasting about 12 years. In similar tests the wood was rated only slightly resistant in British Guiana (*50*) and fairly resistant in Trinidad (*39*).

Nargusta was found to be very durable to both brown-rot and white-rot fungi in one series of pure culture tests at Yale University (*249*). Similar tests at the U.S. Forest Products Laboratory (*199*) rated nargusta as only resistant (durable). This rating was substantiated in graveyard tests at two locations in the United States. On the basis of the available data, nargusta seems to be durable to very durable with the possibility of considerable variability.

The wood is resistant to the dry-wood termite of the West Indies, ranking intermediate to Honduras mahogany and West Indies mahogany in this characteristic (*263*). However, graveyard tests in Trinidad indicate only fair resistance to subterranean termites. Logs left in the woods for any length of time are subject to attack by ambrosia beetles. Pinhole borers are also reported to attack the wood. It is not reported to be resistant to marine borers. Unpainted wood exposed to the weather checks some and loses its surface smoothness, classifying nargusta as only fair in resistance to weathering (*55*).

Preservation.—This species is extremely resistant to impregnation with creosote, which even under high pressure does not penetrate laterally except in a few isolated vessels. The sapwood is also relatively difficult to treat with only the vessels being penetrated (*105*).

Uses.—The characteristics of this wood make it suitable for many uses; it has hardness, durability, high strength properties, moderate shrinkage and movement values, and attractiveness. It can be substituted for oak in many places, including flooring, railway ties, cartwrights' work, cabinetwork, and furniture. The timber appears to be well suited as framing, planking, and decking in boatbuilding, and for turned articles. It has been recommended for use in plywood and instruments. Because of the wood's durability, nargusta is well suited for general construction, bridgework, outside construction, and railway ties. The bark is used for tanning in British Honduras and other areas. It has been selected as one of the 18 local species in British Guiana suitable for use in interior partitions and battens in the government housing program.

Supply.—British Honduras, British Guiana, and Trinidad are the principal sources for export supplies of the timber.

PAKURI

Platonia insignis

Nomenclature.—The wood of *Platonia insignis* Mart. from British Guiana is imported into the United States under the English trade name of

pakuri. Other local British Guiana names for the wood are wild mammee apple, pakouri, and pakoorie. In Surinam it is called pakoelie, geelhart, papoelie, and bakoerie. The French Guiana names are parcourie, parcouril, manilparcouri, and paracouril. It is commonly known as bacoropary, bacury, and pacuru in Brazil, matozama in Ecuador, and bacury-guazú in Paraguay (*88*). (Mangosteen family, Guttiferae.)

This species is similar to *Symphonia globulifera* L. f., the manni timber of British Guiana and manil of French Guiana. The woods of manni and pakuri are also similar in structure. The most apparent difference between the wood is the color; pakuri tends to be darker than manni and, according to Demougeot (*69*), gradually turns black upon exposure to the air. The natives of French Guiana often confuse standing trees and their vernacular names.

Distribution and habitat.—Pakuri occurs from British Guiana, Surinam, and French Guiana to Brazil, Paraguay, Ecuador, and Colombia. The tree grows scatteringly throughout French Guiana, especially in marshy regions and, with manil, comprises about 5 percent of the total timber stand of the colony. It is of rare occurrence in the marsh forests of Surinam, and in British Guiana is rare to locally frequent in the wallaba, rain, and seasonal forests of the near interior (*82*, *231*, *69*).

The tree.—Pakuri is an unbuttressed, heavy crowned, canopy tree of medium to large size. They are commonly 90 to 100 feet tall and 24 to 36 inches in diameter. The boles are cylindrical, well formed, and clear of branches for 60 or 70 feet. The bark is white, exfoliating, fibrous, and is valued both for cordage and for its black viscous resin used for caulking boats.

The wood.—Heartwood of pakuri is dark yellowish brown or orange brown with conspicuous grayish parenchyma markings, often in the form of streaks or striping. The sapwood is yellowish white and clearly demarcated from the heartwood, which is reported to gradually turn black on exposure. A moderately hard and heavy wood, it has a low luster and no distinctive odor or taste. The texture is medium; the grain is generally straight but at times irregular (*143*, *69*).

According to a review in Tropical Woods (20: 37), the wood of *Platonia insignis* from Surinam upon extraction with benzene was found to have a residue of 1.5 percent of a substance that appeared to be euxanthone, melting point 239° C., which was identified by comparison with an authentic specimen of euxanthone prepared from Indian-yellow. The substance Indian-yellow is a magnesium salt to euxanthin acid, which is obtained in Bengal from the urine of cows fed mainly on the leaves of the mango tree (*Mangifera indica* L.). So far as is known, euxantone has never been found in a free state in the vegetable kingdom.

Weight.—The specific gravity, based on air-dry weight and volume, ranges between 0.70 and 0.85, averaging about 0.80. Air-dry wood weighs between 44 and 53 pounds per cubic foot, averaging about 50 pounds (*50*).

Seasoning.—No information is available on seasoning characteristics. However, lack of such information sometimes means lack of difficulty in seasoning.

Shrinkage.—Pakuri undergoes a relatively high rate of volumetric shrinkage during seasoning. Tests in France showed a shrinkage of 16.7 percent from green to ovendry based on the ovendry volume (*50*). This would amount to 17.3 percent, based on the original green volume. These results compare closely with Pfeiffer's determination of 17.1 percent swelling (movement) between ovendry and equilibrium in 100 percent humidity, and 10.2 percent swelling from ovendry to the air-dry condition in 70-percent relative humidity (*175*). Thus, pakuri's movements as a result of atmospheric changes are quite large.

Mechanical properties.—Mechanical properties of pakuri were included in "Allowable Stresses for Surinam Timbers" by Pfeiffer in Volume II of Surinam Timbers (*175*) and by the Centre Technique Forestier Tropical, Nogent sur Marne, France (*50*). Both studies showed pakuri to be a moderately strong wood but still weaker than other tropical American hardwoods of similar density. It was found to be inferior to white oak of the United States and purpleheart of British Guiana and Surinam in practically all strength properties. The wood's best feature is probably its elasticity.

Working properties.—The wood works fairly well with both hand and power tools, and though it takes nails poorly, it polishes very well (*82*, *231*). Pakuri's uses indicate that it is no more difficult to work than most other woods of comparable density, and possibly with less difficulty than some characteristically cross-grained timbers.

Durability.—Pakuri is rated durable in respect to decay (*82*, *231*) and resistant to dry-wood termites, rating 76 as compared to 80 for West Indies mahogany (*Swietenia mahagoni*) (*263*) in resistance to the drywood termite of the West Indies. No information is available as to the timber's resistance to marine borers.

Uses.—Pakuri is used in the Guianas for piling, boatbuilding, furniture, turnery, carriage building, and general carpentry and construction. In French Guiana it is also used for rum (aguardiente) barrels, packing cases, and crates. It has been recommended for plywood, house framing, flooring, and paneling. However, the relatively high rate of shrinkage and movement would exclude the wood from use in such flooring, paneling, and other places where this characteristic

is undesirable. Perhaps the highest uses for the wood is in tight cooperage, boatbuilding, and utility plywood.

Supply.—French Guiana, Surinam, and British Guiana have exportable supplies of this timber, with French Guiana probably having the largest accessible volumes.

PARAKUSAN

Swartzia jenmanii, Swartzia polyphylla, Swartzia schomburgkii

Nomenclature.—Parakusan is the common name applied in British Guiana to the wood of *Swartzia jenmanii* Sandw., *S. polyphylla* DC., and *S. schomburgkii* Benth. Other species of *Swartzia* are described under Wamara. (Legume family, Leguminosae.)

The species furnishing parakusan timber are of frequent to locally common occurrence in the rain forests of British Guiana, especially in the poor type of rain forest from the northwest district to the Demerara River.

The tree.—These three species of *Swartzia* are unbuttressed canopy trees with deeply fluted and twisted trunks without a central core. The trees are commonly 24 to 36 inches in diameter and 90 to 110 feet high. The boles are clear of branches for 60 to 70 feet but, because of the deeply fluted and twisted nature of the bole, only short, thin billets are obtainable.

The wood.—The wood is a lustrous pale creamy yellow. The grain is straight and the texture fine. The wood is hard, tough, and resilient.

Weight.—The specific gravity of air-dry wood is reported at 0.75 to 0.80, based on weight and volume when air-dry. Air-dry wood weighs from 47 to 50 pounds per cubic foot (*82*).

Seasoning.—No data available.

Shrinkage.—No data available.

Mechanical properties.—Results of mechanical tests on this timber are not available. Tests on other more dense species of *Swartzia* indicate that this timber may possess high strength properties, particularly in resilience (*50*).

Working properties.—Parakusan is reported to be an easy wood to work and to finish very smoothly (*82*).

Durability.—The timber is said to be moderately resistant to decay but subject to sap-stain fungi in the log and during seasoning of the lumber.

Uses.—Parakusan is used in British Guiana for paddles and is recommended for tool handles by the Forest Department of that country. The timber will likely have many additional uses when more is known concerning its properties.

Supply.—Parakusan is one of the most plentiful timbers in British Guiana and is available for export in large quantities.

CARIBBEAN PINE

Pinus caribaea

Nomenclature.—*Pinus caribaea* Morelet is the principal coniferous species of the Caribbean region. Until recently it was considered the same as slash pine of southeastern United States, but the discovery of minor morphological differences between the trees of the Caribbean area and southeastern United States required a separation of the species. There are also small but important differences in the wood of the two species. Inasmuch as the original description and nomenclature of *P. caribaea* were made from material obtained on the Isle of Pines, that name was retained for the Caribbean species and *P. elliottii* Engelm. assigned to the United States species slash pine. A synonym of *P. caribaea* is *P. hondurensis* Loock. Other species of *Pinus* are native in Hispaniola, Cuba, and Central America. (Pine family, Pinaceae.)

The timber is known in British Honduras as British Honduras pitch pine, pitch pine, white pine or huhub; in Honduras as ocote, pino ocote, and pino veta. It is called pino, Gautemala pitch pine, Nicaraguan pitch pine, and Caribbean pine in Guatemala; and pino macho and Cuban pine in Cuba. In Nicaragua this pine is called pino, auau, or ocote, but *Pinus oocarpa* Schiede is called ocote also. The timber from the Caribbean area and *P. elliottii* of the United States are commonly sold in the United States in combination with and under the name of longleaf pine. *P. palustris* Mill (*242*, *250*).

Distribution and habitat.—*Pinus caribaea* grows in the Bahama Islands, western Cuba and the Isle of Pines, and in Central America from British Honduras to eastern Guatemala, northern Honduras, and northeastern Nicaragua (*158*). This species does not occur in Bermuda (*118*).

Extensive pine forests are found on the dry sandy soils of the interior Mountain Pine Ridge in British Honduras at an average elevation of 2,000 feet. The well-demarcated pine zones are separated by belts of rain forest on the deeper and richer soils. The pine occurs principally in pure stands with stunted hardwoods, coarse grass, and other low plants beneath (*223*). These stands are presently the principal source of lumber in British Honduras, and exceed all other forest products combined in sale value (*35*).

In Honduras, the species grows in the northern pine belt about 50 miles inland from the coast in open, parklike stands on the slopes of the hills and mountains and on the ridges and plateaus. Stands vary from 2,000 to 10,000 board feet per acre but are not consistent in volume over any large area. It grows largely on a red subsoil or laterite soil located on the exposed ridges and slopes, growing larger and taller on the higher elevations than on the lower slopes. Hardwoods

are often associated with the pine but never become the predominant species. Patches of hardwoods also often occupy the more fertile gully bottoms, stream beds, and heads of draws up to 1,500 feet, becoming less common at higher elevations and more or less disappearing above 2,500 feet.

Caribbean pine is found only at low elevations in Guatemala, sometimes extending to cliffs at the edge of the ocean but never occurring far above sea level. Standley (*216*) reports this species has much the same scenic appearance in Guatemala as the pine of the Florida everglades.

The optimum development of Caribbean pine occurs in northeastern Nicaragua between Rio Grande and Rio Prinzapolca. The best stands occur along a strip about 30 miles wide at the coast and extending inland for 55 miles, where it narrows to about a 15-mile width at the western end. Over most of this commercial range, the pine grows on scattered ridges of several thousand acres, separated by savannas or "brush" land along the creeks and rivers. The stands are usually light, averaging about 3,000 board feet per acre (*79*).

The tree.—The Forest Products Research Laboratory in England (*100*) describes *Pinus caribaea* of British Honduras as follows:

> The tree attains a height of about 100 feet with a corresponding diameter of about 3 feet, and is often free from branches for 50–70 feet. Its habit of growth when young is similar to that of the Loblolly Pine, *Pinus taeda*, but with increasing age it develops heavy horizontal branches and a rounded crown approaching more closely in appearance to the Longleaf Pine, *Pinus palustris*, or to old Scots Pine.

In Nicaragua the tree grows to 100 feet in height and 30 to 40 inches in diameter, occasionally exceeding these dimensions. The boles are often clear of branches for 70 feet with a moderate taper of 1 inch per 16 feet in height. According to Fahnestock and Garratt (*79*), timbers up to 50 feet long are occasionally cut and pieces 40 to 45 feet long are common in Nicaragua.

Trees in the pine stands in Honduras vary in size according to location. They are usually 14 to 18 inches in diameter on the lower elevations and one or two 16-foot logs high, while on the higher elevations the diameters increase to 30 to 34 inches or more and trees may have three or more 16-foot logs (*75*).

The wood.—*Pinus caribaea* of British Honduras is described by the Forest Products Research Laboratory (*100*) as follows:

> The wood is moderately heavy . . . somewhat coarse in texture, generally with a more or less pronounced resinous odor, but possessing no distinctive taste. The grain is typically straight. The heartwood, constituting 42 percent by volume of the eight logs selected from the consignment for examination, is reddish brown, the depth of color varying with the amount of resin present. The pale yellowish brown sapwood forms a zone 2–3 inches in width. Growth zones are clearly defined by bands of dense tissue and are conspicuous on all surfaces. As in the wood of Pines of temperate regions a relatively wide band of late wood appears to terminate the annual growth, but in addition from one to several lines of dense wood forming secondary rings are commonly present and the late wood also very frequently shows stratification. The transition from the light-colored early wood tissue to late wood is abrupt. The average number of primary rings per inch varies from 5 in the first few inches from the pith to about 16 near the bark, 7–10 inches from the pith.

The difference in color between the early wood and late wood produces a prominent stripe on longitudinal surfaces. The wood shows a medium luster and is greasy to the touch, because of the heavy resin deposits in the wood.

Weight.—Wood from British Honduras and Nicaragua averages 48 pounds per cubic foot at 12 percent moisture content. On this basis, the specific gravity averages 0.77 based on air-dry volume and weight (*250*, *100*, *15*). The specific gravity based on green volume and ovendry weight averages 0.66. Green wood weighs about 57 pounds per cubic foot at 66 percent moisture content.

Seasoning.—The timber air-seasons rather slowly with a tendency for end splitting in the thicker stock and for the sapwood of green lumber to be attacked by sap-stain fungi unless it is dried without undue delay (*8*). Protection of the ends of flitches and the use of narrow stickers are recommended. Thinner stock air-seasons fairly well provided drying is not too rapid, although considerable lengthwise bowing may occur in 1-inch stock if a wide sticker spacing is used. However, the distortion in other directions and forms is not serious. The timber also kiln-seasons rather slowly. Considerable care is required for checking, and splitting may be severe in the early stages of kiln-seasoning, along with a marked tendency for distortion to occur. Kiln Schedule 6 of the Forest Products Research Laboratory in England is recommended (*105*, *222*).

Shrinkage.—Caribbean pine shrinks moderately in drying. Shrinkage rates for wood from British Honduras of 6.3 percent radially, 7.8 percent tangentially, and 12.9 percent volumetrically from green to ovendry compare favorably with values of 5.5, 7.8, and 12.2 percent, respectively, for slash pine of the United States. Shrinkage from green to air-dry would amount to about half these values.

The timber is reasonably stable in respect to atmospheric changes (*8*, *250*, *242*).

Mechanical properties.—*Pinus caribaea* is a hard, dense, resinous timber of high strength properties, resembling longleaf pine, the densest grade of American pitch pine. In the green condition, Caribbean pine is heavier and considerably stronger in most properties than slash pine (*P. elliottii*) of the United States. However, the two species are nearly equal in compression across the grain and cleavage, and slash pine is definitely

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superior in tension perpendicular to the grain. In comparison to other woods of similar density, unseasoned Caribbean pine is above average in stiffness and average in shock resistance, but is somewhat below average in all other strength properties.

After air-drying Caribbean pine exceeds the average for woods of similar density in stiffness, shear strength and toughness, and equals the average in cleavage, modulus of rupture, work to maximum load, and maximum crushing strength. It falls below the average in hardness, bearing strength, and tension across the grain.

Seasoned wood of this species is very similar to *Pinus elliottii* except in shock resistance where Caribbean pine is definitely inferior. It is also slightly superior in bending strength stiffness, cleavage resistance, shear, stiffness, and hardness but slightly inferior to *P. elliottii* in tension across the grain, elastic resilience, and maximum crushing strength. According to the Forest Products Research Laboratory in England, the best grades of Caribbean pine have a distinct resemblance to longleaf pine; but, at its best, it is not quite equal to prime longleaf pine, although it can be safely substituted for that species in many uses (*8*, *118*, *250*, *100*, *112*).

Working properties.—The timber is easy to work with either machine or hand tools, comparing closely with longleaf pine in resistance to cutting and cleanness of finish. Its dulling effect on cutting edges is usually not severe unless prolonged runs are made with cutters or teeth clogged with resin. Resin also adheres to tool edges, machine tables, and fences causing difficulty in ease and steadiness of feeding if the resin is not occasionally removed. Incompletely or partially seasoned timber is particularly troublesome.

There is a slight tendency for pickup in planing and molding near knots; this can be minimized by careful setting and jointing of knives to assure that each knife shares equally in the cutting. But in most operations a clean finish is obtained.

Caribbean pine takes nails and screws satisfactorily and is successfully stained and varnished, although pitch blisters sometimes cause trouble in painting. The wood bends moderately well, but some trouble is encountered with resin exudations during the steaming process (*105*, *100*).

Durability.—The heartwood is moderately resistant to resistant to decay but apparently varies between the highly resinous and less resinous wood, as well as with the individual fungus attacking the wood. Timber from British Honduras is durable for 10 to 15 years on the basis of graveyard tests in England (*206*). However, heartwood of *Pinus caribaea* was rated as only moderately resistant to fungal attack on the basis of pure culture tests by the Forest Products Research Laboratory in England (*100*). Similar tests at Yale University (*250*) found the wood very durable to a white-rot fungus but nondurable to a brown-rot fungus. On this basis, preservation is required when the wood is used under conditions favorable to decay.

Logs are occasionally attacked by pinhole borers, which usually cause no damage beyond the sapwood. The timber's resistance to termites is largely governed by the resin content of the wood. Very resinous heartwood is very resistant to termites; the resistance decreases along with the resin content (*242*). In termite resistance, Caribbean pine is similar to West Indies pine (*Pinus occidentalis* Sw.) of the Dominican Republic, which is rated resistant, compared to the rating of moderately resistant for longleaf pine of the United States (*263*). The timber has little resistance to marine borers.

Preservation.—The heartwood is moderately resistant to preservatives but can be thoroughly impregnated by pressure treatment. Retention of preservative material varies considerably with differences in resin content of the wood. The sapwood absorbs preservatives readily by either the open-tank or pressure processes.

The U.S. Forest Products Laboratory (*242*) recommends a retention of 20 pounds of coal-tar creosote per cubic foot for all species of southern yellow pine piling, lumber, and structural timbers used in coastal waters; 8 pounds per cubic foot for railway ties and poles; 12 pounds for piling used on land or in fresh water; 6 pounds for posts, lumber, and elevated structural timbers; and 10 pounds for lumber and structural timbers used in fresh water, in contact with the ground, or for important structural members not in contact with the ground or water.

Uses.—Caribbean pine is suitable mainly for the same purposes for which the other pitch pines are used. Its uses are too numerous and well known to be covered in detail here. It is a good structural timber and quite suitable for heavy joinery flooring and all types of light construction, with adequate preservative treatment. The timber has many other uses, including posts, poles, marine piling and structures, railway ties, bridgework, and mining timbers. In the Caribbean area the principal use is for general construction and carpentry.

Supply.—Caribbean pine is presently the major timber harvested in British Honduras. More pine was cut there in 1954 than all other species combined—1,016,000 cubic feet, of which 40 percent was used locally and the balance exported, principally to the West Indies. Only 5.2 percent of the export volume was sold outside of the West Indies (*35*).

The extent of the supply of Caribbean pine in Central America and the Antilles is not accurately known. Present supplies are good, but there are indications that some type of cutting control and forest management will be required to prevent depletion of merchantable stands (*118*).

PODOCARP

Podocarpus coriaceus, Podocarpus guatemalensis

Podocarpus is one of the few genera of conifers native to tropical America. Various species are scattered in mountains from the West Indies and southern Mexico south to southern Chile (*190, 47, 19*). (Yew family, Taxaceae; or podocarpus family, Podocarpaceae.)

Nomenclature.—In the West Indies the most widely distributed species is *Podocarpus coriaceus* L. C. Rich., which ranges from Puerto Rico to Trinidad. Formerly, it was also referred to as *P. salicifolius* Kl. & Karst., an uncertain name now rejected (*50*). The tree and wood are known in Guadeloupe and Martinique as laurier rose, and in Puerto Rico as caobilla. Names in Trinidad and Tobago are podocarp and wild pine. *P. trinitensis* Buchh. & Gray is another species of Trinidad. A few more species occur in mountains of Cuba, Jamaica, and Hispaniola.

Podocarpus oleifolius D. Don and *P. guatemalensis* Standl. have the greatest ranges of the few Central American species. The common name in Guatemala and Honduras is ciprés. In British Honduras *P. guatemalensis* is marketed as British Honduras yellow wood and is often called cypress.

Distribution and habitat.—The common species *Podocarpus coriaceus* is native in Puerto Rico, St. Kitts, Montserrat, Guadeloupe, Dominica, Martinique, St. Lucia, Tobago, and Trinidad. *P. oleifolius* ranges from southern Mexico to Venezuela and Peru; *P. guatemalensis* from British Honduras and Guatemala to Panama (*190, 216, 178, 223, 18*).

Podocarpus coriaceus, a tree of the uplands, occurs rarely to occasionally on poor sandy or semiswampy soils in the higher elevations of Trinidad and Tobago and seldom occurs below 2,000 feet elevation in Guadeloupe (*165*). *P. guatemalensis* grows on well-drained sites on hills of metamorphic rocks in British Honduras, reaching a concentration of seven trees per acre in the Manatee area. This species is also found in the Temash-Moho River swamp forests in association with santa-maria (*150*), but is reported to make its best development above 2,000 feet elevation (*223*).

The tree.—Podocarp (*Podocarpus coriaceus*) is a dominant evergreen tree in Trinidad, reaching 80 to 100 feet in height and 24 inches or more in diameter (*165*). Cypress or yellow wood (*P. guatemalensis*) is a canopy tree in British Honduras, reaching 80 to 90 feet in height and 24 inches to occasionally 30 inches in diameter on good sites. In mature trees the bole is generally clear of branches for 40 feet and often somewhat fluted but without buttresses (*150*). Although conifers, some species have leaves resembling those of willows (*Salix*).

The wood.—The wood is soft, light in weight, and of good quality, superficially resembling white pine (*Pinus strobus.*) Sapwood and heartwood are not separable except in old trees, which have a reddish-brown core up to 6 inches wide. The wood is a uniform pale yellowish brown, with straight grain and a fine, uniform texture. Growth rings are faintly marked by bands of slightly darker and more dense tissue. Gum ducts are absent but resin cells are present, giving the wood a finely stippled appearance resembling white pine. Exeedingly fine ripple marks are visible on the tangential surface. No odor or taste is evident in seasoned wood (*178, 265, 135, 150*).

The description of podocarp by Stehlé (*218*) differs from the above as follows: "pink sapwood, heartwood brown, yellowish, reddish, or dark, heavily streaked with purplish hues, fairly soft, cross-grain." It would appear that his specimens included the dark center core of old trees.

Weight.—The specific gravity averages about 0.51, based on air-dry volume and weight. Air-dry wood weighs about 32 pounds per cubic foot and green wood 42 pounds at 50 percent moisture content (*15, 150, 165, 265*). The timber is slightly heavier than the white pines of northern and western United States, but considerably lighter than the yellow pines of the southeastern United States and the Caribbean area.

Seasoning.—The British Honduras Forest Department reports that the wood air-seasons rapidly with little distortion or splitting (*150*). It is reported to kiln-dry at a moderate rate with some tendency to split and check but with little tendency to warp. Kiln Schedule 6 of the Forest Products Research Laboratory in England is recommended (*222*).

Shrinkage.—The timber undergoes little shrinkage in seasoning and is very stable in use. It is intermediate to Central American cedar and Honduras mahogany in shrinkage and comparable to both timbers in stability. A radial shrinkage of 2.0 percent and tangential shrinkage of 3.5 percent from green to air-dry (12 percent moisture content), or $\frac{1}{4}$ inch and $\frac{7}{16}$ inch per foot, respectively, are indicative of uniform seasoning (*222*). It is a timber with small movement values in response to atmospheric changes. It increases 0.9 percent radially and 1.7 percent tangentially or $\frac{7}{64}$ inch and $\frac{13}{64}$ inch per foot, respectively, from equilibrium in a 60-percent to a 90-percent relative humidity (*108*).

Mechanical properties.—Determinations of the air-dry strength properties of *Podocarpus coriaceus* from British Honduras were made by the Forest Products Research Laboratory in England (*15*). This timber was found equal or superior to Scotch pine (*Pinus sylvestris*) or Baltic redwood in all properties tested except stiffness

in bending in which Scotch pine was slightly superior to podocarp.

Working properties.—The timber works easily with all hand and power tools with about the same resistance to cutting as American basswood or American whitewood (*Tilia americana*) or Scotch pine. It nails easily without splitting and takes stain, varnish, and paint satisfactorily (*162, 165*).

Durability.—Graveyard tests in England using wood from British Honduras indicate that the heartwood is durable in contact with the ground and can be expected to last 10 to 15 years under average conditions in that country (*206*). In British Honduras, it is considered moderately durable in contact with the ground and durable when used above ground in exposed locations (*150*). Stehlé (*218*) rates podocarp very resistant to decay in the Lesser Antilles.

Preservation.—Podocarp is reported to have a fairly low resistance to impregnation with preservatives. Good penetration and retention result from pressure treatments, but some difficulty is encountered in open-tank processes (*150*).

Uses.—The timber has proved suitable for the better class of joinery work, low-cost furniture, and for general utility, where high strength is not required. It should also be suitable for boxes, crates, interior work, concrete forms, and many other purposes for which pine is imported. The wood gives satisfactory service as sills and beams in British Honduras.

Because of its low shrinkage, stability, close straight grain, and good machining characteristics, podocarp should be very suitable for patternmaking. A similar species, *Podocarpus gracilior* Pilger, from East Africa is acceptable for utility plywood; podocarp may be suitable for the same use but lacks the attractive figure or grain required for decorative veneer.

Supply.—Podocarp is presently available from British Honduras and possibly other areas in Central America, and in the future may become available from Guadeloupe and Martinique.

PURPLEHEART

Peltogyne pubescens, Peltogyne porphyrocardia, Peltogyne venosa var. *densiflora*

Nomenclature.—Purpleheart is the usual trade name for several species of the genus *Peltogyne*. About 20 species of *Peltogyne* are reported from tropical America but only three species are of economic importance in the Caribbean area covered by this report. These are *Peltogyne pubescens* Benth., *P. porphyrocardia* Griseb., and *P. venosa* (Vahl) Benth. var. *densiflora* (Spruce) Amsh. (*P. densiflora* Spruce). *P. venosa*, growing in the Guianas and Amazonas, Brazil, is of general economic importance in the Amazon region. (Legume family, Leguminosae.)

The wood is often know as amaranth, saka, or violet wood in the English trade. Local or vernacular names used in different areas are koroboreli, saka, amaranth, and sakavalli in British Guiana; purperhart, lastan, dastan, malako, and kuruburelli in Surinam; amarante, bois pourpre, bois violet, and violet in French Guiana; sapater or zapatero in Trinidad; pau roxo, barabú, ellongrypho, pao violeta, guarabú rajado in Brazil; and morado in Venezuela.

Distribution and habitat.—The several commercial species of purpleheart are distributed widely throughout tropical America. Their combined range extends from Mexico through Central America and into South America to southern Brazil.

Peltogyne pubescens occurs from Mexico through Central America to Colombia, Venezuela, the Guianas, and to Para, Amazonas, and Rio Branco in Brazil. *P. porphyrocardia* is reported only from Trinidad and British Guiana, and *P. venosa* var. *densiflora* from British Guiana to Brazil and Colombia (*149*).

There appears to be little need for anxiety over the botanical identity of the several species, for all the timbers have about the same general appearance and structure regardless of their source. Logs emanating from different sources are usually sold in the trade as purpleheart, violet wood, or amaranth without further distinction. Lack of preference among the users for wood of different origins or species would indicate that there is little variation between species and that they can be safely treated as one timber (*166*).

The trees grow in the moist soils along the rivers and in the fertile valleys in the Guianas and along the Amazon River. All three species covered here are of general distribution throughout the near interior of British Guiana, with *Peltogyne porphyrocardia* occurring most frequently in the far interior (*28*). *P. pubescens* is found as an occasional to frequent tree on white sands in the wallaba forest and on river flood plains in the mora forest of British Guiana (*82*). In Surinam this species occurs as an occasional tree on sandy soils in the rain-and-high savanna forest (*231*). *P. venosa* var. *densiflora* is an occasional tree in the rain and evergreen seasonal forest in British Guiana.

In Trinidad, *Peltogyne porphyrocardia* occurs principally on hard, red clay soils in an isolated area of possibly 1,000 acres in the southern watershed reserve. The tree also grows on dry sites, but seems to do best on hard, dry clays receiving a rainfall of 60 to 70 inches annually (*165*). It grows in British Guiana on the same sites occupied by the other two species. Some of the finest stands of this species in British Guiana are found along the Unabaruka, a branch of the Supenaam River, and the Kaburi River, a branch of the Mazaruni River.

The tree.—Purpleheart of the Guianas is a semideciduous, predominant tree with small planktype buttresses 2 to 3 feet high in *Peltogyne pubescens*, and 6 to 12 feet high and sometimes spread out over a 15-foot diameter in *P. venosa* var. *densiflora*. The trees, moderately large, grow to 4 feet in diameter and 170 feet high, but are usually 1½ to 3 feet in diameter and 90 to 120 feet high. Boles are clear for 60 to 90 feet, straight, cylindrical above the buttresses and with considerable taper.

The heavy crown is umbrella shaped with flat, spreading branches and flexible branchlets. The bark is flaky, thin, and reddish brown to blackish brown. Logs are usually 40 to 60 feet long and 2 to 3 feet in diameter at the butt, but are available up to 75 feet long and 4 feet in diameter.

The wood.—One of the most distinctive woods of tropical America, purpleheart is very hard, extremely heavy, strong, tough, and durable, but it is most often recognized for its unusual coloring, which at times is actually purple (*166*). The sapwood, distinct from the heartwood, is 2 to 4 inches thick and creamy white to light pinkish cinnamon streaked with light brown. The heartwood is a grayish purple when freshly cut, later becoming a violet purple to deep purple through an oxidation process. Sapwood and heartwood are clearly demarked.

In due time, the purplish color is lost and the wood turns a permanent attractive dark brown. However, the exterior brown color is only at the surface and by removing a thin layer the original coloring can be restored. Unfortunately, the oxidation process will again prevail, turning the wood first to purple and later to a walnut brown and finally to a black-brown color with age (*1, 82*). However, Wangaard reports that some specimens in the Yale University Wood Collection are still bright purple after many years, while others have turned a brownish-purple or brown color. The color is not always uniform throughout; sometimes it shows alternating streaks of dark violet with faint orange or yellow lines, which give the wood a peculiar variegated or mottle effect.

The uniform texture of purpleheart varies from fine to medium. The grain is usually straight and seldom interlocked but is sufficiently irregular, along with variation in luster and color, to give the wood a pleasing stripe figure on the quarter-cut surface. Bands of darker colored elements give the appearance of growth rings (*250*). The wood is of medium luster, somewhat greasy in appearance, and cold to the touch. No distinctive odor or taste is present in seasoned wood (*190*).

Weight.—*Peltogyne pubescens* and *P. venosa* var. *densiflora* from British Guiana and Brazil, respectively, are reported to weigh 54 pounds per cubic foot air-dry and 75 to 77 pounds green. Both species have an air-dry specific gravity of 0.87; specific gravity of *P. pubescens* averages 0.74, based on green volume and ovendry weight; *P. venosa* var. *densiflora* averages 0.75 on the same basis (*149, 15*). One report that wood of *P. pubescens* from British Guiana weighs 68 pounds air-dry indicates some fluctuation in density may occur (*149*). Density information is not available for *P. porphyrocardia*.

Seasoning.—Purpleheart is moderately difficult to season in the open air and in the kiln. It air-seasons slowly with light to moderate degrade. Wangaard reports moderate crook and slight twist occurring during air-seasoning tests at Yale University, along with slight end and surface checking and slight casehardening (*250*). The Forest Products Research Laboratory in England reports that purpleheart air-seasons rather slowly with some warp and a pronounced tendency to split (*110*). Thin lumber kiln-dries readily with only very minor degrade, but planks and other thick material require special attention to overcome the difficulty of removing moisture from the center of the heavy pieces. Kiln Schedule 5 of the Forest Products Research Laboratory is recommended (*222, 118*).

Shrinkage.—Purpleheart shrinks at a moderate rate for a timber of its density. Shrinkage values of 5.8 percent radially, 8.4 percent tangentially, and 13.2 percent volumetrically from the green condition to ovendry were reported by the University of Michigan (*149*) for *Peltogyne pubescens* from British Guiana. The Forest Products Research Laboratory in England (*222*) reports wood of this species from British Guiana shrinks 2.0 percent radially and 4.5 percent tangentially from green to air-dry (12 percent Moisture Content). These reports are in general agreement as shrinkage from green to air-dry is generally about half the value from green to ovendry.

In the Yale studies, the closely related *Peltogyne venosa* shrank 3.2 percent radially, 6.1 percent tangentially, and 9.9 percent volumetrically from green to ovendry. That these values are somewhat below those for *P. pubescens* can be attributed to the difference in density of the two species.

The wood has average or slightly better stability in reference to changes in atmospheric conditions. Coarse-grained wood (lighter) is reported to have greater stability and less total movement (shrinkage and swelling) than fine-grained (heavier) material.

Mechanical properties.—Purpleheart is intermediate between white oak (*Quercus alba*) and greenheart (*Ocotea rodiaei*) in strength properties. Compared to white oak, seasoned wood is roughly 100 percent harder, 50 percent stronger in bending and compression along the grain, 70 percent stiffer and more resistant to shock loads, and 40 percent stronger in shear and in resistance to splitting (*149, 250*).

In the green condition, purpleheart surpasses white oak in every property and is generally equal

or superior in strength to most other species of comparable high density. It is also superior to black walnut (*Juglans nigra*) in bending, compression, stiffness, elasticity, toughness, and hardness, but is inferior in resistance to splitting. However, purpleheart is about 50 percent heavier than walnut, which accounts for some of its superior strength qualities. Purpleheart is particularly outstanding in its ability to withstand suddenly applied loads and difficult strains (*28*, *15*).

Working properties.—Working purpleheart with either hand or machine tools is moderately difficult for the wood resists cutting and dulls cutting edges. It also exudes a gummy resin when heated by dull tools; this resin clings to cutter teeth and other tool parts and complicates the machining operations. Straight-grained material saws and planes well if sharp tools are used, but some care is required on irregular-grained material to prevent "pick-up," especially on the radial surface.

The Forest Products Research Laboratory recommends saw type D or E for machining purpleheart (*28*). Material is best run slowly through machines equipped with high speed steel knives (*60*). A 15-degree cutting angle is required to properly machine wood with interlocked grain (*105*, *265*).

The wood turns smoothly and requires but little sanding to bring out a good finish (*237*). It is easily fastened by gluing and takes stain and either wax or French polish well, but its purple color is dissipated by spirit polishes. A lacquer finish is reported to hold this purple coloring. Purpleheart splits when nailed and requires preboring. It can be veneered with a hot glue.

Purpleheart is knife-cut into $\frac{1}{28}$-inch veneer or more generally sawed to $\frac{1}{16}$- and $\frac{1}{24}$-inch veneer without a preparatory steaming. It is inadvisable to steam the wood as the coloring matter, known as "phonicoin," is partially soluble under prolonged steaming (*166*).

Durability.—The wood of purpleheart is generally regarded to be highly durable in the American tropics. Graveyard tests in England (*206*) and British Guiana found British Guiana purpleheart durable to very durable in contact with the ground. Similar tests in Surinam also gave the wood a durable rating (*50*). In the English test, 2- by 2-inch stakes were found to have a life of 10 to 15 years. *Peltogyne porphyrocardia* in Trinidad was found to be highly resistant to both brown-rot and white-rot fungi in pure culture tests (*84*). Similar tests at Yale University with *P. venosa* from Brazil showed this species to be durable to a white-rot fungus and very durable to a brown-rot fungus.

Peltogyne pubescens proved to be very resistant to dry-wood termites in Peurto Rico, rating 92 as compared to 80 for West Indies mahogany (*Swietenia mahagoni*) and 91 for greenheart (*Ocotea rodiaei*) (*263*). However, in some areas purpleheart is considered only moderately resistant to termites, although this may only be based on casual observations rather than controlled tests as in Puerto Rico.

The wood is considered to have little resistance to marine borers in accordance with tests in Hawaiian waters (*76*). The wood of *Peltogyne venosa* var. *densiflora* is reported by Amos to contain only 0.02 percent silica (*14*). Most woods that resist marine borers contain a much higher silica content, generally 1 percent or more. Purpleheart burns slowly and is considered very resistant to fire.

Preservation.—The heartwood is extremely resistant to impregnation with creosote. Even under high pressure, penetration occurs only along a few isolated vessels (*105*). The sapwood is permeable.

Uses.—Purpleheart is a relatively expensive, high-quality wood and should, in general, be put into one of two uses: (1) Those requiring wood of great strength, particularly the ability to withstand strain and sudden shocks; and (2) those requiring wood of unusual beauty or coloring.

Purpleheart, because of unique shades and peculiar variegated or mottle color effect, is particularly well adapted for use in turnery, marquetry, cabinets, ornamental furniture, counters, office desks, counter tops, carving, inlaying, billiard cue butts, swagger sticks, paneling, decorative handles, veneer parquet flooring, handles, billiard tables, and other similar uses (*138*, *24*, *12*).

The good mechanical characteristics of the wood fits it for such specialized uses as gymnasium apparatus, diving boards, skis, mill rollers, shafts, and tool handles. Purpleheart is considered Brazil's best timber for spokes in cart wheels. Because the wood has dimensional stability, it is used in the tropics for window frames and sliding shades. Though expensive, its high strength, hardness, and resistance to decay qualify it for structural purposes, house framing, bridging, fresh water piling, and for many other parts of house construction from millwork to flooring and siding.

The wood at one time was very popular in Paris for boatbuilding and furniture. It is used nowadays in British Guiana for knees, transoms, deadwoods, stems, interior work, corrals, woodskin canoes, and other uses in boat and shipbuilding. It is one of 12 woods accepted in the British Guiana housing program for structural timbers and scantlings, and one of 10 native woods accepted for siding and flooring.

The bark of mature trees is used by the natives for canoes. In Brazil an aromatic resin is extracted from the wood and used in medicine, as a substitute for turpentine, and to produce a red dye for dying textile fabrics (*128*, *174*).

Supply.—There is not an unlimited supply of this wood, but the remaining merchantable stands

are not being fully exploited. British Guiana is estimated to have 91,000,000 cubic feet of sound merchantable purpleheart in accessible forest areas (*28*). Surinam and French Gniana also have sizable quantities for export.

RESOLU

Chimarrhis cymosa

Nomenclature.—The genus *Chimarrhis* is represented by several species in tropical America (*190*). One of these, *Chimarrhis cymosa* Jacq., is fairly common and of general economic importance in the West Indies. The tree is called resolu or bois rivière in the Lesser Antilles except in St. Vincent where it is known as waterwood (*162*). In Cuba the tree is called penda (*207*). (Madder family, Rubiaceae.)

Distribution and habitat.—Resolu is recorded from Cuba, Jamaica, Guadaloupe, Dominica, Martinique, St. Lucia, Trinidad, Colombia, Venezuela, and British Guiana (*207, 218, 50*).

The tree grows best in wet lowlands and borders of streams in Guadeloupe but occurs in limited quantities at the higher elevations in St. Lucia (*154*). In Trinidad its optimum habitat appears to be in the northern range with an annual rainfall of 100 inches or more. It grows here as an occasional to locally frequent tree in the crappodebasse forests, but it is rare in other forest types (*165*).

The tree.—Resolu is a medium-size, evergreen tree reaching a diameter of 5 to 6 feet and up to 80 feet or more in height. The trunk is straight with shallow buttresses. The outer bark is light colored, smooth and papery in appearance (*165, 154*).

The wood.—The wood is orange colored, moderately coarse textured, and medium hard.

Weight.—Resolu is reported by Stehlé (*218*) to range from 0.65 to 0.85 in specific gravity. Air-dry wood on this basis weighs from 41 to 53 pounds per cubic foot, about the same as white oak.

Seasoning.—The timber is reported to air-season in Dominica in 4 to 5 months but to split readily during drying.

Shrinkage.—Shrinkage is reported to be moderate.

Mechanical properties.—Published results of detailed mechanical tests are not available for resolu; however, according to limited data reported by Stehlé, it is medium hard, fairly elastic, and semifissile (*150, 218*). The wood is reported to be brittle by the Government of Dominica (*50*).

Working properties.—Resolu works without difficulty but is said to split when nailed unless prebored.

Durability.—The heartwood is reported as "probably durable" by Record and Hess (*190*) and as durable by Stehlé (*218*). The Government of Dominica reports it is not liable to termite attack (*50*).

Uses.—Resolu is used principally in construction for sheathing, flooring, and framing, but may be suitable for many other uses where a strong, durable wood is required.

Supply.—The timber is not plentiful, but small quantities may come on the market when adequate logging and conversion facilities become available on several of the larger islands in the Lesser Antilles.

ROBLE

Tabebuia rosea, Tabebuia heterophylla

Roble, the Spanish name for oak (*Quercus*), is applied to several groups of trees in tropical America, including a few species of *Tabebuia*. The wood of these trees is superficially like oak but lacks the characteristic rays of the oak group (*190, 193*). On the Continent the common species is *T. rosea* (Bertol.) DC., while in parts of the West Indies *T. heterophylla* (DC.) Britton is more frequent. (Trumpet-creeper family, Bignoniaceae.)

Nomenclature.—*Tabebuia rosea* formerly was known as *T. pentaphylla*, a name now rejected. The wood is commonly exported as roble, apamate, or amapa, and also occasionally from British Honduras as mayflower (*126*). Other common names are mano de león in Guatemala, cortés in Honduras, roble de savana in Panama, ocobo in Columbia, apamate in Venezuela, and pink poui in Trinidad.

Tabebuia heterophylla, a variable species of the West Indies, was included by some authors under *T. pentaphylla* also. Synonyms, considered by some as varieties, are *T. pallida* (Lindl.) Miers and *T. dominicensis* Urban. Common names are roble and roble blanco in Puerto Rico, poirier rouge and poirier blanc in Guadeloupe and Martinique, poirier in Dominica and St. Lucia, and apamate or pink poui in Grenada. The name white-cedar is used in the Virgin Islands, Dominica, St. Lucia, and Grenada.

Distribution and habitat.—The natural range of *Tabebuia rosea* extends from Mexico through Central America to Colombia and Venezuela. It is found on various sites from wet lowlands to dry uplands, and may occur in essentially pure stands, as isolated trees, or in a mixed forest.

Tabebuia heterophylla is native from Hispaniola, Puerto Rico, and Virgin Islands through the Lesser Antilles to Grenada and Barbados. In Puerto Rico, roble grows from sea level to 3,000 feet in elevation and is widely distributed (*244*).

The tree.—*Tabebuia rosea*[5] is a medium-size tree 40 to 60 feet high, but occasionally reaching a height of 90 feet. Its diameter is commonly 18

[5] Described under *Tabebuia pentaphylla* in Nos. 95 and 98 of Tropical Woods and in numerous other reports on this wood from Central and South America.

to 24 inches, yet at times it reaches 36 inches in diameter. Boles grow clear for 20 to 35 feet and occasionally 50 feet above the buttresses, which often extend 7 to 10 feet above the ground (*147*). The trunk, frequently fluted or irregular, is sometimes squarish in cross section. It is one of the best known and most useful trees of Central America; when in blossom it has few rivals in beauty. For this reason, it is often planted as a shade and ornamental tree throughout its range. The West Indian species generally is a smaller tree than that of the mainland (*147*, *65*, *71*, *177*).

The wood.—Wood of both species is very similar in appearance and properties. The sapwood is narrow, white to yellowish when first cut, turning light brown after drying and exposure; generally it is not clearly distinct from the heartwood.

The heartwood is light brown with a grayish or, more commonly, a golden hue. Fine brown lines of parenchyma give the wood a distinctive figure on the quartersawed surface and an attractive feather pattern on the tangential or flat-sawed surface. The grain is straight to interlocked, showing a ribbon-stripe on the quartersawed surface when interlocked. The texture is medium to somewhat coarse. The luster is medium. No distinctive taste or odor is present in dry wood. Some consider the wood to resemble white ash (*Fraxinus americana*) more than white oak (*147*, *71*, *249*, *265*, *190*).

Weight.—The wood is comparatively heavy. *Tabebuia rosea* from Panama (*71*) weighs 37 pounds per cubic foot air-dry and 55 pounds green. Wood from Venezuela (*149*) is reported to weigh 35 pounds air-dry and 58 pounds green. The specific gravity of air-dry wood averages 0.58 (0.56 to 0.60), being similar to white ash but somewhat lighter than Caribbean pine (*Pinus caribaea*). The wood of *T. heterophylla* from Puerto Rico is somewhat lighter, averaging 59 pounds per cubic foot when green and 42 pounds air-dry. Specific gravity for this species averaged 0.58 based on green volume and ovendry weight, and 0.67 when air-dry.

Seasoning.—Roble air-seasons at a fast rate with a nominal amount of surface checking and slight warping (*71*). One-inch lumber has been seasoned in Puerto Rico in 4 months and in Dominica in 3 to 4 months without any appreciable degrade. No checking occurred during air-seasoning tests in Puerto Rico and only very slight warping in the form of twist and bow. The wood also kiln-dries with little degrade. Forest Product Research Laboratory's (*222*) Kiln Schedule 4 and Schedule T4–D2 of the Forest Products Laboratory in Madison (*147*) have been recommended for roble.

Shrinkage.—This species had a moderate rate of shrinkage, being intermediate to mahogany and black walnut in this respect (*248*). Wood of *Tabebuia rosea* from Panama, British Honduras, and Honduras has an average volumetric shrinkage from green to ovendry of 9.5 percent, a radial shrinkage of 3.6 percent, and tangential shrinkage of 6.1 percent in tests at Yale University (*71*). Similar tests conducted on *T. heterophylla* from Puerto Rico gave shrinkage values of 9.7 percent volumetrically, 4.1 percent radially, and 5.5 percent tangentially. Shrinkage from green to air-dry would be about half these values. The low ratio of tangential to radial shrinkage is usually indicative of very favorable seasoning characteristics.

Mechanical properties.—Roble is tough and strong for its weight. Mechanical tests on *Tabebuia rosea* at Yale University (*71*, *249*) found the unseasoned wood was superior to most species of comparable density in all static-bending properties except stiffness. It is also superior in cleavage, tension across the grain, and toughness, and is average for a wood of its density in compression parallel to and perpendicular to the grain, in hardness, and in shear.

Roble is noticeably better in several strength properties than white ash and white oak of the United States, even though it is slightly less dense than either of these species. It is appreciably better in bending strength, elastic resilience, crushing strength and tension across the grain than either species, both of which are valued for these same characteristics. It is intermediate to these species in stiffness, hardness, shear, and cleavage, and about equal to oak in compression across the grain and shock resistance. In the air-dry condition, roble is only slightly below oak and ash in modulus of elasticity and is nearly comparable to white oak in shock resistance. Roble is similar or superior to black walnut (*Juglans nigra*) in many of its mechanical properties (*147*).

Working properties.—Except in planing, roble has excellent working properties. It can be sawed, shaped, bored, and turned with excellent results, and stays in place after manufacture (*89*, *265*). Some care is required in planing to prevent torn and chipped grain. However, the wood can be planed to a glossy smoothness; it machines cleanly with clean smooth edges but has a tendency to split when nails or screws are driven without adequate size lead holes. It takes mahogany and oak stains well and can also be finished naturally with excellent results. It takes a high polish under all types of finishing (*150*) and is considered easy to glue (*240*). The wood's steam bending properties vary from good to poor (*57*).

This species has excellent workability as flat-cut sliced veneer but requires a careful boiling before slicing. Quarter-cut material gives a mottle figure that one large Mexican producer considers superior to all other species. However, slicing must be precisely done to avoid torn and rough grain. The veneers dry evenly to a smooth flat appearance, are easy to joint in splicers, and possess good gluing properties (*197*).

Durability.—The heartwood of *Tabebuia rosea* rated as moderately durable to a white-rot fungus and very durable to a brown-rot fungus in pure culture tests at Yale University (*249*). Pure culture tests at the U.S. Forest Products Laboratory rated *Tabebuia* sp. as very durable (*199*). It was also found to be very durable in graveyard tests in British Guiana. The wood has little resistance to marine borers (*76*). Amos (*14*) reports roble (*T. rosea*) as having only 0.01 percent silica compared to the 1.0 percent or more present in most woods showing good resistance to marine organisms. The wood of this species is rated only fair in weathering characteristics; when exposed to weather, unpainted material remains free from warp but loses its smooth surface and develops considerable checking (*55*). Wolcott (*263*) rates roble (*T. heterophylla*) very susceptible to termite damage on the basis of tests with the West Indies dry-wood termite in Puerto Rico.

Uses.—Roble's appearance and technical properties resemble those of ash and oak species, which it replaces for many uses. It is particularly suitable for handles of all types, sporting goods, and agricultural implements. Because of its stability, ease of working, pleasing appearance, and good strength, the wood is also especially suited for flooring, boat decking and other boat parts, millwork, furniture, cabinetwork, and general construction. It is used extensively for furniture and interior trim throughout its tropical range (*65*). It is also used and recommended in the Caribbean area for paddles, shingles, and carts. Lower grades are often made into packing boxes and crates. In Mexico it is becoming a highly prized species for face veneer, probably its highest use.

Supply.—Honduras, British Honduras, and the islands of Guadeloupe, Martinique, and Grenada have roble in exportable quantities. It grows in many other Caribbean locations and should be available in sizable quantities (*178*).

HONDURAS ROSEWOOD

Dalbergia stevensonii

Honduras rosewood, *Dalbergia stevensonii* Standl., is one of a group of about 15 rosewood timbers known throughout the world to the cabinetmaker and others for their good technical qualities, richness of color and grain, and usually pleasant fragrance. The rosewoods are among the most important trees of Central America; at least seven species, and probably more, are of economic importance in tropical America. One of these, Honduras rosewood, has been known in the trade for at least 100 years, but this fine wood has never been exploited to anywhere near its potential (*190*).

Nomenclature.—Honduras rosewood was classified as a species of *Dalbergia* for many years. Not until December 1927, however, was its present identity established by Paul C. Standley, who named it in honor of Neil S. Stevenson. (Legume family, Leguminosae.)

The tree and timber are known simply as rosewood in British Honduras. In the trade it is generally known as Honduras rosewood and in the United States also as nogaed or nogaed wood (*193*). Another closely related species, *Dalbergia nigra* Fr. Allem., is of considerable importance in Brazil where it is known as jacaranda. Unfortunately, several other species representing several genera in the family Leguminosae are also known as jacaranda in that area. Several of them belong to the genus *Machaerium* and resemble Honduras rosewood but are lighter in color and not so highly figured.

Two other related species of common occurrence in Central America are *Dalbergia retusa* Hemsl., the cocobolo of the west coast of Central America, and *D. tucurensis* Donn. Smith (*D. cubilquitzensis* (Donn. Smith) Pittier), the rosewood of Guatemala and Honduras and also British Honduras and southern Mexico. Other species of good quality are found in Mexico and Central America but not in sufficient volume for export (*190, 132*).

Distribution and habitat.—Honduras rosewood is confined entirely to British Honduras where it is one of the best known timbers. Neil S. Stevenson, collector of the herbarium material leading to identification of the species, describes its habitat as follows (*223*):

> It grows in damp Broken Ridge of the riverain type from the Sarstoon River northward to the Monkey River in the Toledo District of British Honduras. Between Deep River and the Temash it appears in fairly large patches, concentrated for the most part along the rivers though occurring also in their interriverain and drier areas.

The tree.—The tree attains a height of 50 to 100 feet and is commonly forked at about 20 or 25 feet from the ground. The trunk is fluted. The rough papery bark is about one-fourth inch thick, the scaly outer part varying in color from a pale brownish gray to a dingy yellow-brownish gray. When freshly cut the bark has a distinctive odor, suggesting stored apples, and a slightly bitter taste. The dried bark separates readily into a thin solid outer layer and an unusual mottled inner portion (*225*). Trees grow to 3 feet in diameter (*110*).

The wood.—The wood is very hard and heavy. The sapwood is generally 1 to 2 inches thick and sharply delineated from the heartwood. It is a white color, marked with yellow vessel lines when first cut but turning yellow rather quickly afterwards (*105*). The heartwood is pinkish brown to purple with irregular black markings or zones, which are independent of the growth rings. These alternate dark and light bands give the wood an unusual and very attractively figured appearance.

The texture is medium and the grain straight to slightly roey. Luster is low to medium. The wood has no distinctive taste, but fresh heartwood has a roselike odor which generally dissipates with age. It is this vanishing roselike odor that is responsible for the name rosewood, not the presence of roselike flowers as is commonly supposed.

Weight.—The specific gravity of air-dry wood based on weight and volume in that condition varies from 0.92 to 1.08, averaging about 1.00 (*143*). Air-dry wood weighs from 58 to 68 pounds per cubic foot, averaging about 62 pounds.

Seasoning.—The wood is reported to season slowly with a tendency to check and split. Kiln Schedule 3 of the Forest Products Research Laboratory is recommended (*222*).

Shrinkage.—Though shrinkage values have not been determined for this species, it is reputed to hold its place well after manufacture, indicating a low rate of shrinkage during drying. Harrar reports that cocobolo (*Dalbergia retusa* Hemsl.), a closely related species from Central America, shrinks 2.65 percent radially, 4.26 percent tangentially, 0.21 percent longitudinally, and 7.20 percent volumetrically from green to ovendry (*123*). Wangaard (*250*) reports shrinkage values of 2.9 percent radially, 4.6 percent tangentially, 0.34 percent longitudinally, and 8.5 percent volumetrically for material from one log of *Dalbergia* sp. from Brazil. Shrinkage from green to air-dry would be about half these values. Honduras rosewood has similar shrinkage values and thus is comparable to Honduras mahogany, a wood noted for its unusually low and uniform shrinkage.

Mechanical properties.—Honduras rosewood has not been subjected to mechanical tests, perhaps because it has been used for specialized purposes where strength is not of prime importance. Tests conducted on Indian rosewood *Dalbergia latifolia* Roxb.) from southern India(*250*), which may be quite similar wood, showed it to possess high strength properties for its density. In the air-dry condition it was 2½ times as hard as oak, and 20 percent harder than greenheart. It was 25 percent stronger than oak in bending and in compression along the grain, 20 percent more resistant to suddenly applied loads, and about 20 percent stiffer. Honduras rosewood is also noted for its high qualities in these properties, making it exceptionally suitable for the uses to which it is put in the United States. It is somewhat harder and heavier than Brazilian rosewood (*Dalbergia nigra* Fr. Allem.).

Recent tests at Yale University using material from one log of *Dalbergia* sp., possibly *D. nigra*, from Brazil showed the wood to be considerably superior to white oak in all strength properties except in tension perpendicular to the grain and cleavage, in which oak was superior.

Working properties.—Hardness makes this timber somewhat difficult to work. It is moderately difficult to saw and machine; it dulls cutting edges more readily than many other woods. It planes well but must be held securely during planing to prevent vibration. A cutting angle of 20 degrees on planer knives is recommended, particularly for wood having interlocked or wavy grain. It makes excellent turnings and finishes well, except for some trouble with very oily specimens, but does not take a high natural polish (*265*). Saw type F, as described in Appendix C of Empire Timbers (*105*), is recommended.

Durability.—The heartwood is highly durable in contact with the ground. One record shows a house post in Punta Gorda, British Honduras, remaining completely sound after 37 years, except for the sapwood which had disappeared much earlier (*187*, *132*). Information is not available on the wood's resistance to termites or marine borers.

Uses.—Because of its unusual beauty and excellent technical properties, Honduras rosewood is highly regarded for a number of specialized uses. Manufacturers of musical instruments use the wood for finger boards for banjos, mandolins, and guitars, and for percussion bars in xylophones and other similar instruments. Well-figured wood is used also in guitar bodies, mandolin ribs, harp bodies, piano legs, piano pilasters, veneered piano cases, and organ stops. Some of the best figured wood is made into veneer for furniture, cabinets, carpet sweepers, billiard and pool tables, and bank and store fixtures. Darker and more highly figured wood is often used in brush backs, jewelry trays, and jewelry cases.

Rosewood is employed in the manufacture of high-grade carpenter tools, and in other items like canes, moldings, picture frames, and novelties, and is used to some extent for molding, trim, and other interior work in boats and shipbuilding. The rosewood from Brazil is used extensively for the handles of knives and small tools. Honduras rosewood should be equally suitable for this use.

Supply.—Honduras rosewood is available only in British Honduras, where large volumes await utilization.

SAMAN

Pithecellobium saman

Saman resembles black walnut (*Juglans nigra*) in technical properties, structure, and general appearance and is at times substituted for that wood.

Nomenclature.—Saman is currently designated by some authors as *Pithecellobium saman* (Jacq.) Benth. and by others as *Samanea saman* (Jacq.) Merrill. (Legume family, Leguminosae.)

The timber is known as saman in Puerto Rico, Colombia, Venezuela, Trinidad, St. Vincent, and parts of Central America. In Mexico it is called algarrobo, guango, saman, or rain-tree, and gouannegowl in Haiti. In various other parts of its range, it is also known as campano, sanaguare,

urero, algarrobo del pais, aguango, cenizero, carreto, and zora, in addition to the name saman in many localities. The tree is commonly called the rain-tree (English) or the Spanish equivalent, arbol de la lluvia, perhaps because the leaflets close up in cloudy and rainy weather and at night. Monkeypod is the common name in Hawaii.

Distribution and habitat.—Saman is native in southern Mexico, Central America, and northern South America, south to Peru, Bolivia, and Brazil. The tree has been widely planted and naturalized from Mexico southward, throughout the West Indies, and in the tropical regions of the Old World. It is commonly planted as a street tree in many areas and is also used for cattle and crop shade. Its enormous widespreading crown makes it ideal for shade in parks, pastures, and barnyards. It is said to be one of the most beautiful of all neotropical trees. The tree is completely naturalized in Mexico and Cuba where the pods are highly valued for stock feed. The tree was introduced in the Philippines about 1860 and subsequently in many other areas of the Eastern Hemisphere (*85*, *193*).

Saman appears to thrive on almost all sites, but makes its best growth on well-drained fertile soil as in Mexico, where it does best on rich alluvial flood plains (*229*). In Colombia the largest trees are also found in rich soils along streams.

The tree.—Saman attains heights of 100 to 125 feet and diameters of 3 to 4 feet in the forest, but when grown in the open develops massive widespreading crowns and short, thick trunks (*94*). It is reported to be a small tree in northeastern Peru (*255*); a large tree in Colombia (*65*); a large, low spreading tree with the main trunk rarely over 10 to 15 feet high but having girths up to 20 feet in Mexico; and a short-boled tree with an enormous crown in Trinidad (*165*).

The wood.—The sapwood is generally narrow and white to yellow or light cinnamon. It is clearly differentiated from the dark walnut to dark chocolate-brown heartwood, which turns a light brown when seasoned. The wood is often marked with darker streaks resembling Circassian walnut or butternut in this respect. It may be either straight grained or cross grained and of medium texture and luster. Young trees are reported to grow rapidly and produce lighter, softer, and more easily worked wood. Later growth is slower, and the wood is comparatively heavy, tough, rather refractory and of a darker color, sometimes almost black (*190*). Seasoned wood is without distinctive odor or taste.

Weight.—The specific gravity of air-dry saman averages about 0.56, based on the weight and volume of wood in that condition. Air-dry wood weighs about 35 pounds per cubic foot, and green wood about 51 pounds per cubic foot at 71 percent moisture content. Density calculations at Yale University on two logs of saman from Venezuela showed a specific gravity of 0.48 (0.37 to 0.56), based on volume when green and weight when ovendry, which compares favorably with the density quoted for air-dry wood (*94*, *65*, *256*).

Seasoning.—In the Philippines this wood was found to shrink and warp considerably and to require very careful drying (*94*). However, air-dry plank material received at Yale University appeared to be free from any excessive checking or warping (*249*). One-inch lumber developed considerable degrade during seasoning under cover in Puerto Rico. Moderate to severe bow and crook developed along with a small amount of cup and twist. Surface checking was not evident.

Shrinkage.—Saman undergoes an exceptionally low shrinkage for a wood of its density. Shrinkage tests at Yale University (*248*), U.S. Forest Products Laboratory (*68*), and Tropical Forest Research Center, Puerto Rico, produced values similar to Honduras mahogany. These results are listed below (based on shrinkage from green to ovendry, expressed as a percent of the original green dimensions):

Saman:	*Radial*	*Tangential*	*Longitudinal*	*Volume*
Yale University	2.0	3.4	0.13	6.0
U.S. Forest Products Laboratory	4.2	5.8	----	8.5
Tropical Research Center	2.4	4.2	.40	6.9
Average	2.9	4.4	.26	7.1
Honduras mahogany	3.1	4.2	----	7.6

Though these results are not in full agreement, they show a low rate of shrinkage comparable to mahogany, noted for its low and uniform shrinkage. The Yale tests gave values below those for mahogany, while the Forest Products Laboratory tests produced higher values in each direction.

Mechanical properties.—Mechanical tests conducted at Yale University (*248*) showed unseasoned saman to have about average strength for a wood of its density. Work values in static bending were above average, tensile strength across the grain and cleavage were below average, and modulus of elasticity (stiffness) was very low. Upon air-drying, the wood improves slightly in most strength properties but not as much as hardwoods of the United States. Work to maximum load (shock resistance) decreased considerably upon drying, while both tensile strength across the grain and cleavage resistance were reduced slightly.

Saman when green is intermediate to butternut (*Juglans cinerea*) and Honduras mahogany (*Swietenia macrophylla*) in most strength properties. In general, green saman equals or exceeds green mahogany in all properties but stiffness, tension across the grain, and cleavage resistance, in which it more closely equals the weaker butternut.

Air-dried saman is below average on the basis of its density in all strength properties except hardness. In this condition it is again inter-

mediate to butternut and mahogany, but it more closely resembles the weaker butternut and is about equal to mahogany in hardness. It is particularly deficient in modulus of rupture and modulus (stiffness) of elasticity. Thus it rates as a wood of medium hardness and strength.

Working properties.—Saman is an easy wood to work, due partially to its moderate density. Straight-grained material works easily and well. Material with irregular grain works to a fairly smooth finish in planing, but some care is required to obtain clean cuts in boring and mortising. The wood takes a beautiful finish.

Durability.—Saman is usually considered a durable wood in the American tropics. In pure culture tests at Yale, it was found durable to a white-rot fungus and very durable to a brown-rot fungus. It resists attack by dry-wood termites, rating 76 as compared to 80 for West Indies mahogany and 59 for Honduras mahogany in tests conducted in Puerto Rico (*263*). No information is available regarding use of the wood in teredo-infested waters.

Uses.—Saman is seldom recognized as a valuable commercial timber and is often not utilized in many areas even where it is planted (*135*). In many locations the trees are more valuable for shade than for lumber, or they are too large to be transported to the sawmill. However, selected lumber has an attractive grain and is used in Trinidad and Mexico for first-class furniture, and in Costa Rica for medium-quality furniture and cabinetwork. In some areas the wood is used for dugout canoes, split posts, and construction timber and at times cross sections of the massive trunks are used for cart wheels.

This wood, because of its low shrinkage rates, workability, resistance to termites and decay, plus some attractiveness, should be best fitted for furniture, frame construction, cabinetmaking, turning, millwork, and face veneer. It should be particularly useful for patternmaking because of its medium density and low shrinkage values. In the Philippines, stumps and crotches are used for figured veneer. Saman is definitely a wood deserving consideration for the export trade.

Supply.—Trinidad seems to be the only place in the area covered by this report currently having an exportable supply.

SANTA-MARIA

Calophyllum brasiliense, Calophyllum lucidum

Santa-maria is a well-known and highly respected timber in the American tropics, but until recently has been of little interest to the export trade.

Nomenclature.—Two species constitute the principal source of santa-maria timber in the Caribbean area: *Calophyllum brasiliense* Camb., including var. *antillanum* (Britton) Standl. (*C. antillanum* Britton) and var. *rekoi* (Standl.) Standl., and *C. lucidum* Benth. The timber of both species is similar in appearance and technical properties and is marketed under one trade name without separation. This similarity extends through all the American species of *Calophyllum*. One author, after examining the wood of the tropical American species and finding them all very similar in every respect, suggested the use of a single trade name for all species (*120*). (Mangosteen family, Guttiferae.)

The status of the above species and several others in the American tropics is still unsettled and further changes in nomenclature may be expected (*214*). Although santa-maria is the most widely used trade name, the timber is also exported as maria and at times as birmah, laurac, degame, and chijole.

The timber is also known by many vernacular names: palo de maría in Puerto Rico; galba in French and British West Indies; kurahara, edaballi, wild calabash in British Guiana; birma in British Honduras; ocuje in Cuba; baría, santa maría in Dominican Republic; dalemarie in Haiti; koerahara, koerli or lorahara in Surinam; jacareuba in Brazil; palo maría in Colombia; leche de maría, palo maría, cedro cimarrón in Mexico; barillo, mario, vario in El Salvador; maría in Honduras; krassa in Nicaragua; calaba in Panama; and mario in Guatemala.

Distribution and habitat.—Santa-maria grows throughout the West Indies from Cuba and Jamaica to Trinidad, and on the continent from southern Mexico southward through Central America and into northern South America. It is found on all types of soils, often in association with mahogany and Spanish cedar. The trees seem to do best in wet, humid sites but grow exceedingly well on pure sand and on rocky sandstone soils. In the mixed rain forests of British Honduras, it is one of the commonest large trees (*224*). In other countries the trees are common on very dry sites, where they are usually one of the few good quality timbers present (*48*). *Calophyllum brasiliense* var. *antillanum* was found suitable for reforestation in Puerto Rico on the poorest of eroded shallow, acid soils in several difficult environments (*129*). In Trinidad this species does well both on wet sites subject to prolonged flooding and on very dry sites, often on extremely acid soils incapable of supporting any type of permanent agriculture (*53*).

The tree.—Santa-maria trees attain a height of 100 to 150 feet and diameters of 3 to 6 feet, with long, straight, clean boles up to 50 to 70 feet and occasionally to 90 feet long. They are generally unbuttressed, straight, well-formed canopy trees with a dense rounded crown. The trees grow rapidly when young and are fairly tolerant of shade. The bark varies in color, becoming yellowish green on the older trees, with distinctive diamond-shaped fissures that become more pro-

nounced or corrugated with age. Crushed or cut bark produces a yellow gum-resin that has medicinal value (*98*, *150*, *165*).

The wood.—Heartwood of santa-maria varies in color from pink or yellowish pink to brick red or rich reddish brown, marked with fine darker red striping formed by thin bands of parenchyma. Sapwood is 1½ to 2½ inches wide, lighter in color and distinct but not always clearly differentiated from the heartwood. The texture is medium and fairly uniform, while the grain is generally interlocked but sometimes is straight. Luster is medium, and odor and taste are not distinctive. The wood is very attractive, usually has a ribbon figure on the quartersawed surface. The timber is sometimes mistaken for mahogany, being somewhat similar in color and often showing good figure, but it is heavier, stronger, and more durable in some uses (*190*, *143*, *120*).

Weight.—The specific gravity of *Calophyllum brasiliense* and its varieties ranges from 0.54 to 0.70, averaging about 0.61, based on air-dry weight and volume. The specific gravity based on green volume and ovendry weight is reported at 0.52 (0.42 to 0.59) by Wangaard (*250*). The weight of air-dry wood ranges from 34 to 44 pounds per cubic foot, averaging about 38 pounds. Green wood weighs about 51 pounds per cubic foot at 50 percent moisture content (*50*, *150*, *15*, *120*). On the basis of fragmentary reports, *C. lucidum* may be somewhat heavier than *C. brasiliense*. One report (*82*) lists it at 50 pounds per cubic foot.

Seasoning.—The wood is moderately difficult to air-season. It seasons slowly with considerable warping and splitting and a tendency for knots to split. Moisture is somewhat difficult to remove from the center of planks. However, when logs are quartersawed and the material carefully seasoned, preferably by kiln-drying, the material is of first-class quality. A low temperature-high humidity kiln schedule, such as Schedule 1 of the Forest Products Research Laboratory in England is recommended (*222*, *53*, *265*, *102*).

Shrinkage.—Santa-maria (*Calophyllum brasiliense* var. *rekoi*) exhibits a low rate of shrinkage for a wood of its density. Shrinkage values from green to ovendry of 4.8 percent radially, 7.1 percent tangentially, and 12.3 percent volumetrically compare with values of 5.2, 7.1, and 11.3 percent, respectively, for black walnut (*Juglans nigra*). Similar values for *C. brasiliense* from Puerto Rico amounted to 6.2, 8.4, and 14.3 percent, respectively. Longitudinal shrinkage was 0.30 percent. Shrinkage from green to air-dry would amount to about half the above values (*250*).

The timber is moderately stable in use, comparable to Douglas-fir, English oak, and Scotch pine. Wood in equilibrium with a 60-percent relative humidity, increases 1.7 percent radially and 2.8 percent tangentially, or $^{13}/_{64}$ and $^{21}/_{64}$ inch per foot, respectively, when brought into equilibrium with a 90-percent relative humidity (*108*). In comparison, Honduras mahogany undergoes a change of 1.0 percent radially and 1.3 percent tangentially.

Mechanical properties.—Mechanical tests have been made on *Calophyllum* sp. and *C. brasiliense* var. *rekoi* by Greene (*120*), on *C. brasiliense* var. *antillanum* at the Forest Products Research Laboratory in England (*15*) and on *C. brasiliense* var. *rekoi* at Yale University (*250*).

According to the tests at the Forest Products Research Laboratory, air-dry santa-maria is one of the better woods in the 40 pounds per cubic foot and under class. It falls below such dense woods as greenheart, purpleheart, mora, and wallaba in general strength properties, but has average or better strength for woods of its density class and exceeds Honduras mahogany in all properties tested. In the air-dry condition, santa-maria compares favorably with white oak of the United States, exceeding it in stiffness (modulus of elasticity), crushing strength (maximum crushing strength parallel to grain), and in both end and side hardness. It is slightly inferior to white oak in bending strength (modulus of rupture), shock resistance (work to maximum load), shear, and cleavage.

The values obtained by Edward C. Greene, Jr. and at Yale University are somewhat below the Forest Products Research Laboratory values, but show santa-maria comparing favorably with white oak in both the green and air-dry condition.

Working properties.—Santa-maria is moderately easy to work, but the thin, soft-tissue parenchyma layers may pick up badly, when flat-sawed (tangential) surfaces are planed and when there is interlocked grain (*118*). This trouble can be alleviated by using a cutting angle of 20 degrees, thereby reducing the amount of sanding required to remove the machining defects. A little extra care is also needed to prevent tearing at the exit of the tool in drilling and mortising. When brown gum streaks are present, they cause rapid dulling of the cutting edges; otherwise, the wood is compared to English oak in its resistance to cutting (*98*). Saw type D of the Forest Products Research Laboratory is recommended. The wood is reported to hold nails and screws firmly and to glue satisfactorily; it takes stain and paint very well and polishes satisfactorily.

In exploratory machining tests at the U.S. Forest Products Laboratory, santa-maria was rated above the average of 25 domestic hardwoods in shaping, sanding, and mortising, and below average in boring, planing, and turning. About half the test specimens were found to have interlocked grain (*68*).

In a special test for furniture production, santa-maria was reported to work easily and with no greater tendency to pick up than Benin mahogany and with working costs similar to birch, maple, Benin mahogany, or pitch pine. Because this

wood lacks good figure, the manufacturer considered the wood suitable for "low" grade furniture, as a substitute for maple, birch, pitch pine, and African mahogany. A small test of santa-maria for motor bodywork showed the timber to lack the toughness and elasticity to compare favorable with ash and beech for this purpose (*150*).

Attempts to use santa-maria for veneer have not been entirely unsuccessful in Mexico. It is reported to require a 72-hour boiling period to be peeled or sliced, develops cracks very readily during peeling, and is not uniform in color or grain. Interlocked grain also gives trouble in rotary cutting, and gum streaks cause splitting when the sheets are dried. The wood is too rough for core stock but produces an attractive rotary cut face stock. Quarter-sliced veneer sometimes has an attractive greenish stripe and metallic luster (*197*).

Durability.—Santa-maria is rated as nondurable in contact with the ground in Trinidad (*39*), but in other areas is considered very durable to moderately durable. The timber was found to be very durable in graveyard tests in England, where 2- by 2-inch square stakes were still sound after 13 years in the ground (*206*). Considered one of the best timbers for giving long service, particularly in dugout canoes or dories, it can stand weathering well when used for exposed outdoor uses.

Pure culture tests at Yale University rated the heartwood of *Calophyllum brasiliense* var. *rekoi* durable with respect to both white-rot and brown-rot fungi. Findlay (*84*) also rated this species resistant to decay in similar tests (*171*, *135*). Wolcott (*263*) rates the wood very susceptible to dry-wood termites in Puerto Rico. It has no appreciable resistance to marine borers (*39*).

Preservation.—The heartwood is very resistant to impregnation with preservatives by both open-tank and pressure treatments up to 140 pounds per square inch. Under the hot-and-cold system, absorption is only 4 pounds per cubic foot with a penetration of not over one-fourth inch (*53*). As is often proved, the sapwood is not difficult to impregnate (*150*).

Uses.—Santa-maria, one of the most used woods in the American tropics, goes into general construction, bridgework, railway ties, general wheelwright's work, dugouts, heavy carts, canoes, general shipbuilding, shingles, flooring, interior construction, and furniture. It is a good general utility wood where a fairly strong and moderately durable timber is required. The wood produces a fair quality face veneer but is not used extensively for this purpose because of the mechanical problems in veneer-cutting operations.

Supply.—British Honduras, British Guiana, Trinidad, and possibly some of the smaller islands of the West Indies have santa-maria in exportable quantities.

SARA

Vouacapoua macropetala

Nomenclature. — *Vouacapoua macropetala* Sandw. from British Guiana was first described in 1937. The wood is commonly known as sara or by the Arawak name of sarebebeballi. A closely related species, *V. americana* Aubl., the wacapou of the Guianas and Brazil, is also covered in this work. (Legume family, Leguminosae.)

Distribution and habitat.—Sara is locally common on rocky hillsides within the rain forest of British Guiana, where it is reported to occur on sandy clay soils in the hilly country of the lower Mazaruni, Essequibo, and Demerara Rivers (*190*, *82*). The species has not been reported from outside British Guiana.

The tree.—Of moderate size, generally 16 to 20 inches in diameter, the tree grows occasionally up to 24 inches in diameter and 80 to 90 feet high. The poorly formed boles are normally 50 to 60 feet long. The trees were buttressed to a height of 6 feet and often have adventitious shoots.

The wood.—The wood is dark yellowish brown with moderately coarse texture and fairly straight grain. It is reported to be very hard, tough, and strong.

Weight.—Sara resembles purpleheart and angelin in density. The specific gravity of air-dry wood ranges from 0.87 to 1.00, based on the weight and volume in that condition. Weight per cubic foot of air-dry wood on this basis ranges from 54 to 62 pounds.

Seasoning.—Sara is reported to require care in seasoning like the very similar wacapou, which seasons at a moderate rate with moderate warping and twisting and with some end and surface checking and casehardening.

Shrinkage.—Although shrinkage data are not available for this species, it presumably undergoes shrinkage similar to the closely related species, *Vouacapoua americana*, discussed in detail under the name of wacapou.

Mechanical properties.—There are no reports of mechanical tests of this species. However, it probably is similar to wacapou, *Vouacapoua americana*, in strength properties, which would place it in a class above white oak but below greenheart in most properties (*248*).

Working properties.—Sara is not difficult to work, finishes smoothly, and takes a high polish.

Durability.—The wood is reported moderately resistant to decay. Wacapou, which is similar, is resistant to termite attack and also to marine borers.

Uses.—The British Guiana Forest Department recommends sara for flooring, house framing, posts, sleepers, wheelwright work, and cabinetmaking. The timber lacks sufficient durability to make first-class posts or sleepers. However, if the wood possesses the same resistance to teredo as

Vouacapoua americana, it would be very useful for marine work in teredo-infested waters.

Supply.—British Guiana is prepared to export sara in reasonably large quantities.

SIMAROUBA

Simarouba amara, Simarouba glauca

Nomenclature.—About six species of the genus *Simarouba* are reported to occur in tropical America. The principal species furnishing timber are *Simarouba amara* Aubl. and *S. glauca* DC., although *S. versicolor* A. St. Hil., the pau parahyba of the coastal forests of eastern Brazil, is also used for making boxes and for general carpentry in that country. *S. tulae* Urban grows in Puerto Rico, where it is known as aceitillo cimarrón. It is at times confused with the West Indies satinwood, *Zanthoxylum flavum* Vahl, which is also known as aceitillo in Puerto Rico (*190*). (Ailanthus family, Simaroubaceae.)

Simarouba wood is known most widely by its generic name simarouba, although the tree is often called paradise-tree. Other local names are simarupa in British Guiana; soemaroepa in Surinam; acajou blanc in French Guiana, Martinique, and Guadeloupe; marupa, pau parahyba, malacacheta, caixeta in Brazil; marouba in Trinidad; bois blanc in St. Lucia and Dominica; maruba in Grenada; boarwood, maruba in St. Vincent; jocote in Guatemala; bitter damson in Jamaica; bois blanc, frêne in Haiti; daguillo in Dominican Republic; gavilán in Cuba; bitterwood in Florida; gall tree in Barbados; olivo in Costa Rica; and pasa-ak in Mexico. The names aceituno or aceituna and negrito are also used in Central America and in some of the West Indies. *Simarouba glauca* and sometimes *S. amara* are also often known as negrito in parts of Central and South America (*50, 146, 85, 36*).

Distribution and habitat.—*Simarouba amara* is found in northern South America from Venezuela and the Guianas to Brazil and in Trinidad and Tobago. *S. glauca* occurs in Cuba, Jamaica, Dominican Republic, and southern Florida, as well as in Mexico and Central America. This species is generally of lesser commercial importance because of its small size and scattered distribution (*259, 258, 64*).

Simarouba amara prefers sandy soils, occurring as a rare to occasional tree in the rain and high savanna forest in Surinam; in British Guiana it is of frequent occurrence in the seasonal forests and as an occasional tree in the rain forests. It is generally found on well-drained upland sites in the West Indies. *S. glauca* grows on similar sites in most of its range (*193, 231, 136*).

The tree.—*Simarouba amara* is a large, unbuttressed, evergreen tree of the upper story, attaining heights of 140 feet and diameters of 20 to 24 inches, occasionally 36 inches. The trees have straight, cylindrical, strongly tapered boles frequently 70 to 90 feet long. The bark is fairly smooth and whitish brown to grayish brown on young trees, becoming irregularly fissured in places on older trees. Cut bark has a slightly bitter smell. *S. glauca* generally occurs as an understory tree, seldom reaching more than 80 or 90 feet high and 24 inches in diameter. Clear boles are normally less than 30 feet long (*150, 165, 177, 121, 73*).

The wood.—Freshly cut heartwood of simarouba is whitish or cream colored with occasionally a yellow or greenish cast. When dry it becomes a uniform cream color with occasional oily streaks. There is no distinction between the heartwood and sapwood. The wood is almost entirely without figure except for a few, widely spaced narrow vessel lines. The luster is light; the texture is uniform and medium; the grain is straight; and growth layers are indistinct. Although the wood has no characteristic odor, it has a bitter quininelike taste (*143, 127, 190, 135*).

Weight.—Simarouba (*Simarouba amara* and *S. glauca*) is a moderately light wood with an average specific gravity of 0.38 (0.34 to 0.41) based on ovendry weight and green volume determinations at Yale University (*127*). The specific gravity of air-dry wood, based on air-dry weight and volume, is reported by the British Guiana Forest Department at 0.40 (*82*), by the Surinam Forest Service at 0.44 (*231*), in Pfeiffer's Surinam Timbers at 0.45 to 0.53 (*175*), and by Kribs (*143*) at 0.40 to 0.50. Averaging these reports gives an air-dry specific gravity of 0.44, which is in agreement with the Yale results. On this basis, air-dry wood weighs 27 pounds per cubic foot and green wood about 40 pounds per cubic foot.

Seasoning.—According to reports from Dominica (*50*), St. Lucia (*153*), and British Honduras (*150*), the wood has a tendency to split during seasoning. However, recent investigations at Yale (*127*) found simarouba easy to air-season. Boards dried at a rapid rate with only slight end checking, but precautions were necessary to avoid staining of the sapwood during the air-seasoning process. Other sources also report the timber is very susceptible to sap-stain fungi. Simarouba is said to air-dry in 2 months in British Guiana and in 3 months on the island of Dominica (*50*).

Shrinkage.—Simarouba exhibits low shrinkage values but is somewhat unstable in response to atmospheric changes. *Simarouba amara* undergoes a radial shrinkage of 2.3 percent, tangential shrinkage of 5.0 percent, and volumetric shrinkage of 8.0 percent from green to air-dry, comparing favorably with similar values for Honduras mahogany of 3.5, 4.8, and 7.7 percent, respectively (*127*). It should be noted, however, that the ratio of radial to tangential shrinkage is not as favorable as that of mahogany. Shrinkage from green to air-dry would be about half the above values.

The wood readily responds to atmospheric changes, but not excessively. Swelling (movement) is reported by Pfeiffer (*175*) to amount to 2.56 percent in volume from ovendry to equilibrium in a 40-percent relative humidity (heated room), 5.65 percent to equilibrium in a 70-percent humidity (air-dry), and 10.40 percent to equilibrium in a 100-percent humidity (maximum moisture content). These values are far below those for woods of greater density than simarouba and somewhat below certain other woods of similar density.

Mechanical properties.—Simarouba is not a strong wood, but its strength properties are normal for a wood of its density. It is somewhat brittle and has a tendency to split along the grain, but it is superior in some properties to other woods of similar weight. In the air-dry condition, it is similar in most strength properties to yellow-poplar of the United States except for being slightly inferior in bending strength and in tension and cleavage resistance across the grain. It is superior to yellow-poplar in proportional limit stresses in static bending and compression parallel to the grain, hardness and shear. Both woods are very similar in side hardness and compression across the grain (*249*).

Working properties.—The wood works easily and can be machined to a smooth clean surface. Working qualities are similar to those of white pine and basswood. It is reported to saw, plane, drill, and turn easily and satisfactorily and to take and hold nails easily without splitting (*150*). Sharp tools and fairly high speeds are essential in turning. It is easy to paint, stain, or varnish. It glues well, but special care is required to maintain the full strength of the wood. Simarouba is somewhat prone to split and to be brittle during working because of its relatively low density and moderate strength (*265*). *Simarouba amara* has suitable machining properties for matchmaking in Jamaica (*230*), but *S. amara* has been reported too brittle and splintery for this use in British Guiana.

Durability.—Graveyard tests in British Guiana (*82*) and Surinam (*175*) found simarouba low in resistance to decay. Similar tests on the island of St. Lucia also indicate Simarouba is susceptible to decay (*153*). However, recent pure culture tests at Yale University (*249*) indicated simarouba heartwood was extremely variable in decay resistance but averaged moderately durable to a white-rot fungus and durable to a brown-rot fungus.

The wood has generally been considered relatively insect resistant because of the characteristic bitter taste of the bark and wood. But Wolcott (*263*) found it one of the most susceptible of woods to the dry-wood termites of the West Indies, and it is also considered very susceptible to damage by marine borers. Simarouba is rated only fair in resistance to weathering and, in general, unsuitable for prolonged outside use. Unpainted boards do not warp or lose their surface smoothness when exposed to the weather but do sustain severe surface and end checking. To prevent blue stain, lumber should also be protected from the weather during shipment and while in use.

Preservation.—Simarouba absorbs preservatives very readily and is thereby rated low in resistance to impregnation.

Uses.—The moderate density, ease of working, and relative softness make simarouba a popular wood for house sheathing, boxes, crates, and all types of interior construction. It is also used for shelving, drawer lining, cheap furniture, and shoe heels with considerable success. The very similar structure of *Simarouba amara* and *S. glauca* indicates the contradictory results experienced in matchmaking in British Guiana and Jamaica resulted from the varying techniques used and cannot be attributed to differences in the two woods. Simarouba has been used in the United States for organ pipes, piano keys, and patterns, principally because of the wood's low shrinkage and workability.

Suggested uses for simarouba include veneer and plywood, cores for furniture, slack cooperage, paper pulp, baskets, musical instruments, toys, and many types of household utility articles. In general, it is an acceptable wood for many uses presently filled by white pine, basswood, yellow-poplar, and black gum. It can also replace, and sometimes surpass, in usefulness the yellow pines of the United States and the American tropics. Simarouba is presently being used for interior partitions and battens in the government-sponsored housing program in British Guiana. However, the timber's low resistance to insects and decay and relatively poor weathering characteristics limit it to uses above ground and in unexposed locations.

Supply.—British Guiana, Surinam, and French Guiana have sufficient volumes of simarouba to meet the expected export demand. It may also be available from some of the islands of the Lesser Antilles in limited quantities.

SNAKEWOOD

Piratinera guianensis

Nomenclature.—Snakewood has been exported from the Guianas since the time of their European settlement and is well known in the American and European market. The principal species supplying commercial snakewood is *Piratinera guianensis* Aubl., known also as *Brosimum guianensis* (Aubl.) Huber and *B. aubletii* Poepp. & Endl. (*190*). However, several other closely related species are also marketed as snakewood, since the

trade has little interest in the botanical origin of the logs as long as they are sound and possess the proper figure. *P. panamensis* Pittier grows from Panama as far north as southern Mexico. *P. lancifera* Ducke and *P. paraensis* (Huber) Ducke are reported from the Guianas. (Mulberry family, Moraceae.)

The wood is known in the European market as letterwood, in the American trade as snakewood, and in the French market as bois de lettres. The name snakewood is preferred and has been adopted as the British standard name for wood of this species (*36*). It is also called leopard wood in the trade. All these trade names refer to the wood's peculiar markings or irregular dark spots, which resemble the letters of the alphabet, the spots of a leopard, or the skins of highly colored snakes.

Other local names for the wood include bourra courra and tibokushi in British Guiana; letterhout, basri letri, letterhoot, koelero in Surinam; amourette, bois de lettre gris, lettre moucheté, satine gris, satine rouge, and piratiner in French Guiana; casique care or guaimaro in Panama; palo de oro in Venezuela; and gatia in Trinidad.

Distribution and habitat.—The several species of *Piratinera* occur throughout the Amazon region of Brazil and extend northward through the Guianas, Venezuela, Colombia, Panama, and into southern Mexico and the West Indies (*189*). The principal species, *P. guianensis*, grows in British Guiana, Surinam, French Guiana, Brazil, Bolivia, and Trinidad, and possibly other West Indies islands (*165*). *P. panamensis* ranges from southern Mexico to Panama. It is likely that other species in the Caribbean area are also marketed as letterwood without distinction as to species.

Snakewood is not found in abundance at any point within its extensive range. The tree is found occasionally in the rain and marsh forest of Surinam and occurs as a rare to locally occasional tree in British Guiana throughout the rain and seasonal forest.

The tree.—Snakewood, a tree of small dimensions, seldom grows more than 80 feet high and 1 to 2 feet in diameter. It is a small-crowned canopy tree without buttresses but usually swollen at the base. The bole is cylindrical and clear of branches for 40 to 50 feet (*82*). The smooth bark contains a thick, sticky, white latex.

The log.—The tree is slow in forming heartwood, which is the only part used commercially. A tree of 15-inch diameter may, on occasions, have only 1 to 4 inches of heartwood, while a 20-inch tree will ordinarily have not more than 7 inches (*167*). The amount of heartwood is reported to vary according to location. Certain areas produce timber with considerable heartwood, while in other areas even large trees may not be worth felling.

The timber is exported with all the sapwood removed in the form of small logs or sticks measuring 4 to 10 inches in diameter and generally about 7 feet long or slightly more. The last remnants of sapwood are removed just prior to shipment to reduce freight costs and to allow inspection of the figure on arrival at destination. At one time most wood was shipped to the United States on consignment because of the difficulty of establishing a definite price until the buyer could determine the quality of the logs. The logs are sold by weight and are reputed to be one of the most expensive woods in the trade.

The wood.—The sapwood, which the trade rarely sees, is light yellow to nearly white, very thick, and often not clearly demarcated from the heartwood. The heartwood is a dark red to reddish brown with conspicuous irregular black radial markings (speckles), or with black vertical stripes sometimes found with the speckles. The distinctiveness of markings is reduced as the color of the backgrounds is darkened by exposure. The wood is extremely hard and heavy, fine textured, with straight grain and medium luster. It has no distinctive odor or taste.

The black markings for which this wood is named are apparently found in all species of *Piratinera* but vary in their occurrence and appearance. They extend out from the center of the tree, varying considerably in size and number between trees, logs, and even in the same piece. In tracing the markings along a radius, they are branched and anastomosed so that the figure changes as each successive layer of wood is removed. Dark areas are the result of variations in the color of the gummy deposits that fill all the cell cavities, the darkest parts being at the margins rather than in the center of the patches. Some trees have only black vertical bands that may also occur at times at irregular intervals in otherwise speckled wood. Woods workers cannot tell if a standing tree has figured or plain (bastard) wood, since these differences are related to individual trees and apparently have no relationship to species, variety, or external appearance (*190*, *12*).

Weight.—The wood is extremely heavy. The specific gravity of air-dry wood ranges from 1.01 to 1.35, based on volume and weight in that condition. Air-dry wood weighs from 63 to 84 pounds per cubic foot (*50*, *143*).

Seasoning.—No information available.

Shrinkage.—There are no published data on shrinkage. However, one specimen of snakewood (letterwood) soaked at Yale University for 9 months underwent practically no change in specific gravity but increased in size about 19.6 percent and absorbed sufficient water to attain a moisture content of 29.7 percent of the ovendry weight. This would indicate that the wood has relatively large shrinkage values.

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Mechanical properties.—Snakewood is a very strong, hard wood, but it splits rather easily and is inclined to be splintery (*231*). Although it is also difficult to bend without buckling, it possesses a certain degree of elasticity. In view of the mechanical properties, the early popularity of this wood for walking sticks must have been based on beauty rather than utility.

Working properties.—The wood is worked with considerable difficulty. Because it is hard, snakewood is difficult to cut and takes nails poorly yet finishes smoothly and takes a beautiful polish (*265*, *237*).

Durability.—Reported to be very resistant to decay (*82*), the wood is rated considerably above Dominican mahogany (*Swietenia mahogoni*) in resistance to the dry-wood termite of the West Indies; Wolcott (*263*) rates the wood only slightly less than repellent to termites. Immersion of the wood in salt water around Hawaii indicated that the heartwood is moderately resistant to marine borers (*76*). But this fact is of more academic interest than practical use because of the size and value of the trees and the small proportion of heartwood. The sapwood, like that of all trees, is not durable to insects or decay.

Uses.—Snakewood was once considered very desirable for walking sticks in the United States, but its use has declined because of uncertainty of supplies, variable quality of the logs, and relatively high prices. Some snakewood is still made into canes, but most is used for such items as inlay work, turnery, fancy handles for cutlery and umbrellas, drum sticks, fishing rod butts, violin bows, and archers' bows. Larger pieces are occasionally sawed into thin veneers for cabinetwork (*82*, *50*).

The wood was once well regarded in England and the United States for making the butts of fishing rods, but was too heavy to be used in the tips. Small logs are presently exported from Cuba to Puerto Rico for this use. It is one of the principal woods used for bows by the Indians in the Guianas, although archers do not nowadays consider the wood particularly suitable for this use. Snakewood bows admittedly afford a good cast but are too stiff for the average man. The bows also tend to break under severe strain and to tire out in a relatively short time. They also snap back with such a sudden kick that archers are unable to use them for any extended period of time, more or less eliminating their use in tournaments or contests.

Because of limited supply, small size, and high cost, snakewood is best suited for specialty items that capitalize on its unusual beauty, hardness, and density. Its tendency to split as well as its brashness also excludes it from many specialized uses where great strength is required.

Supply.—Snakewood is available in limited quantities on special order from British Guiana, Surinam, and possibly French Guiana and other Caribbean areas.

STERCULIA

Sterculia pruriens, Sterculia caribaea, Sterculia rugosa

Nomenclature.—The genus *Sterculia* comprises about 60 species of trees and shrubs distributed throughout tropical and subtropical regions in both hemispheres. *S. pruriens* (Aubl.) K. Schum., *S. caribaea* R. Br., and *S. rugosa* R. Br. are the principal species of commercial importance in the Carribbean area covered by this report. Other species growing in the American tropics include *S. apetala* (Jacq.) Karst (*S. carthaginensis* Cav.), a widely distributed tree of common occurrence in the American tropics from southern Mexico to Peru and Brazil; *S. cubensis* Urban reported from Cuba; *S. recordiana* Standl. from Panama; and *S. mexicana* R. Br. from Mexico and British Honduras to Costa Rica. (Chocolate family, Sterculiaceae.)

The timber of the three Caribbean species covered here is similar in physical and mechanical properties and is generally superior to some of the other species. They are, therefore, frequently marketed under the usual trade name maho without distinction between species or sources of supply. The name sterculia is more appropriate to distinguish this wood from *Hibiscus elatus*, the mahoe of Jamaica.

Other names used locally and in the trade for wood of the numerous species of *Sterculia* are as follows: mahoe in Trinidad; camagüey, guana in Cuba; anacagüita in Puerto Rico; mahot-cochon in French West Indies; mahot cochon, mapou baril, mapou puant in West Indies in general; yahu in British Guiana; karst, castaño in Honduras; kola in French Guiana; karst in Panama; bastard mahogany in Jamaica; castaño in Central America in general; and bofrohoedoe, kobehe, and kroekroe-amète in Surinam. Other common names used in Central and South America are guararo and mano de danta, camojuru, camoruco and piñon.

Distribution and habitat.—*Sterculia caribaea* occurs in the West Indies from Jamaica, Guadeloupe, Dominica, Martinique, St. Lucia, and Trinidad to Venezuela and British Guiana (*165*). *S. pruriens* is said to occur in the Guianas and northern Brazil (*190*, *18*). *S. rugosa* is reported as a timber of importance in British Guiana and may occur elsewhere (*82*).

The species marketed as maho (sterculia) are generally not exacting as to site conditions. The trees grow on most all sites, are tolerant to poor drainage, and thrive on poor sandy soils. According to Marshall (*163*), *Sterculia caribaea* is one of the most plentiful species in Trinidad, being widely distributed throughout the colony wherever the annual rainfall exceeds 60 inches.

It is a very common dominant and understory tree in the Crappo-guatecare and the galba-palm forests (*165*, *116*) and is present but not plentiful in other forest types.

Sterculia pruriens and *S. rugosa* are of occasional to frequent occurrence in the heavy forest in British Guiana, where they are generally distributed throughout the near interior and Rupununi district, becoming more scattered in the eastern district (*82*). Other species of sterculia growing in Central and South America are generally recorded as well distributed on the lowlands and hills in the somewhat drier regions but seldom occurring on barren ridgetops.

The tree.—Sterculia is a large unbuttressed tree with a heavy, rounded crown. The trees are commonly 100 feet or more in height and around 24 inches in diameter at maturity, although on the best sites trees sometimes reach 130 feet in height and 36 inches in diameter. The boles are cylindrical, 60 to 70 feet long, and have very low taper. The outer bark is smoothish and a whitish-gray color; the inner bark is reddish (*82*, *165*, *61*).

The wood.—Sterculia is best described as a lightweight hardwood of plain appearance. It is a wood of fairly good quality, somewhat lighter in color, heavier, harder, finer textured and of better quality than the widespread *Sterculia apetala* of other regions in the American tropics (*190*, *82*, *50*). The heartwood is soft, light, and whitish or grayish with numerous brown ray flecks imparting an overall brownish effect.

The sapwood, which is not distinct from the heartwood, is reported to be about 2 inches wide and subject to discoloration by sap-staining fungi (*106*). The grain is usually straight and medium to coarse in texture. The wood is not especially fibrous as compared to some other members of the genus and is fairly lustrous. The rays are readily visible and are very prominent on a radial surface, where they appear as brown flecks up to one-eighth of an inch wide and covering up to one-third of the surface. The growth rings are obscure and have no effect on the appearance of a plain surface (*7*).

Weight.—The specific gravity of air-dry wood of *Sterculia pruriens* from British Guiana, based on weight and volume in that condition, is reported at 0.59 by Kynoch and Norton (*149*) and the Forest Products Research Laboratory in England (*15*). Air-dry wood averages about 37 pounds per cubic foot, and green wood about 53 pounds per cubic foot at 90 percent moisture content. Sterculia in the air-dry condition is slightly heavier than Douglas-fir (34 pounds), and much lighter than Caribbean pine (44 pounds) from Honduras.

Seasoning.—Sterculia is a moderately difficult wood to season. It air-seasons fairly rapidly but tends to warp and twist. The timber has been seasoned in 4 months on the island of Dominica (*50*). The method of piling for air-seasoning or the schedule used in kiln-seasoning should be arranged to retard the drying rate, for degrade should not be severe under moderate drying conditions (*106*). Kiln Schedule 1 is recommended by the Forest Products Research Laboratory in England (*222*).

Shrinkage.—The wood is subject to a relatively high rate of shrinkage in comparison to woods of similar density. Shrinkage values for *Sterculia pruriens* from green to ovendry amounts to 5.7 percent radially, 9.2 percent tangentially, and 13.6 percent in volume (*149*). Shrinkage from green to air-dry (12 percent moisture content) is reported by Stevens and Pratt (*222*) at 3.0 percent radially and 7.5 percent tangentially, or $^{15}/_{16}$ and $^{3}/_{8}$ inch, respectively. These values, determined in separate studies, do not agree on tangential shrinkage but agree well in the radial direction, on the basis that shrinkage from green to air-dry at 12 to 15 percent moisture content is generally about half the value of ovendry. The ratio of tangential to radial shrinkage is moderate, although both values are relatively large and may account for the difficulties in drying. Shrinkage values are not available for the other species in the group.

Sterculia, as might be expected, is also a timber with large movement values in response to changes in atmospheric conditions. Air-dry wood brought into equilibrium in a 90-percent relative humidity and then conditioned to equilibrium in a 70-percent relative humidity undergoes a change of 1.5 percent radially and 3.5 percent tangentially, or $^{3}/_{16}$ and $^{7}/_{16}$ inch per foot, respectively. The wood reaches a moisture content of 23 percent in the 90-percent humidity, which was equalled or exceeded by only 4 of the 136 species tested at the Forest Products Research Laboratory (*108*). Timbers in which the sum of the percentage of radial and tangential movement is more than 4.5 percent are considered by the Forest Products Research Laboratory to have large movement values. Consequently, sterculia's total movement of 5.0 is well into the large movement class.

Mechanical properties.—Tests of mechanical properties have been made on *Sterculia pruriens* from British Guiana at the University of Michigan (*149*) and the Forest Products Research Laboratory in London (*15*); results varied by properties but were generally comparable. Both tests indicate sterculia possesses normal strength properties in both the green and air-dry condition for a wood of its density. It is somewhat weaker in cleavage (splitting), but somewhat harder than the average for other woods of similar density. In general, sterculia is not a timber of great strength and should not be used where exceptional strength is required.

Working properties.—The wood works easily with both hand and machine tools and does not

blunt cutting edges readily (*153*, *190*, *165*). Although the finish tends to be somewhat fibrous, good results are usually obtained with reasonably sharp cutting edges. Compared to baromalli (*Catostemma commune*), this wood is slightly easier to cut and finishes to a less fibrous surface. Saws of the medium hardwood type are recommended. Spring-set circular ripsaws should have 54 teeth with 20- to 25-degree pitch as described under Type E in table 2 in A Handbook of Woodcutting, by the Forest Products Research Laboratory in England (*124*). Sterculia is a very poor timber for solid bent work. Nails are held firmly and cause no splitting. A good finish can be obtained with stains and polishes if a fair amount of grain filler is used (*106*).

Durability.—Sterculia is generally considered nonresistant to decay when in contact with the ground (*106*, *153*, *82*). Graveyard tests in British Guiana (*50*) and Trinidad (*39*) support these general observations; the timber was found very susceptible to decay in the ground in both locations. Tests in Puerto Rico (*263*) and Trinidad (*39*) indicate that the timber is also very susceptible to attack by dry-wood and subterranean termites. It is also considered to have little resistance to damage by marine borers.

Pinhole borers, which sometimes penetrate well into the heartwood, are a hazard in both logs and lumber. Blue stain may also occur if there is a delay in extraction or conversion of logs, or during the early stages of seasoning, or if lumber is close-piled immediately after conversion without treatment with a sap-stain preventative.

Uses.—This timber has no outstanding qualities and is subject to relatively large shrinkage and movement in use. Consequently, it is most suitable for light construction work, interior joinery, concrete forms, boxes and crates, and inside or otherwise protected wall boarding. Cheap coffins are sometimes made from the wood.

It appears that sterculia would be as satisfactory as the imported pine (*Pinus*) for many uses and is somewhat easier to work. Many millions of board feet of pine lumber are imported annually from the United States into the Caribbean area. If this wood could be obtained at prices below those of the lower grades of pine, it would make an acceptable substitute; but it lacks the quality to compete with the better grade hardwoods for furniture and heavy construction.

Sterculia (maho) was one of the group of seven most abundant timbers in Trinidad tested for papermaking at the Imperial Institute in London; it produced the best pulp yield and the best grade of paper. The average fiber length for each of the seven species tested was greater than that of aspen, which is the most commonly used hardwood in the manufacture of soda pulp (*116*).

Supply.—Sterculia is available in exportable quantities from the Guianas, Trinidad, St. Lucia, and possibly other islands of the West Indies.

SURADAN

Hyeronima laxiflora, Hyeronima alchorneoides, Hyeronima caribaea, Hyeronima clusioides

Nomenclature.—Though about 25 species of *Hyeronima* grow in tropical America, *H. laxiflora* (Tul.) Muell.-Arg. and *H. alchorneoides* Fr. Allem. are the only species of widespread importance. Two other species, *H. caribaea* Urban and *H. clusioides* (Tul.) Griseb., are of limited importance in certain parts of the West Indies. A few others including *H. cubana* Muell.-Arg. and *H. nipensis* Urban grow in Cuba (*207*). *H. jamaicensis* Urban is found in Jamaica. The generic name is spelled *Hieronyma* also. (Spurge family, Euphorbiaceae.)

The timbers of these and other species are best known as suradan, pilón, and tapana. Other common names are surdina, suradanni in British Guiana; anoniwana, okotjo, piento-bolletrie, sorodon in Surinam; curtidor in Honduras; zapatero in Colombia; margoncalo, marágonçalo, urucurana in Brazil; bulley tree, palo-chanco, Scotch ebo, zapatero in Panama; nancito in Nicaragua; cajuela, sagua, rosita in Cuba; cedro macho in Puerto Rico; chac-te-cook in British Honduras; nancito in Costa Rica; aguacatillo, trompillo, torito, catatú, coral in Venezuela; tapanare in Trinidad and Grenada; horseflesh mahogany in St. Vincent; and bois d'amande in St. Lucia.

Distribution and habitat.—Numerous species of *Hyeronima* occur throughout the West Indies and on the continent from southern Mexico to southern Brazil including the Guianas, Peru, and Colombia. *H. laxiflora* is reported from the Guianas, Peru, Colombia, and other parts of the Amazon Basin. *H. alchorneoides* is known from British Honduras through Central America to the Guianas and Brazil. *H. caribaea* is reported from the Islands of Dominica, St. Lucia, St. Vincent, Grenada, and Trinidad, and *H. clusioides* from Puerto Rico (*121*, *78*, *199*, *62*, *203*, *213*).

Hyeronima alchorneoides is of frequent occurrence in wet sites and seasonal marshes in Nicaragua. *H. laxiflora* is an occasional to locally frequent tree in the secondary forests and a relic in old forests on heavy soils throughout British Guiana. *H. caribaea* is widely distributed in the rain forests of Trinidad, but nowhere is it abundant. Absent from the semideciduous forest of this colony, this species thrives on a variety of soils, including even poor sands when sufficient moisture is available, but it does not tolerate poor drainage. On St. Lucia the tree is fairly common in areas of heavy rainfall and is reported to be increasing in numbers (*154*, *165*).

The tree.—The species covered in this report are large, straight evergreen trees with spreading, rounded buttresses. The trees may reach 130 feet in height and attain diameters of 3 feet or more, but are more commonly 100 feet in height and 20 to 24 inches in diameter. Clear stems may be up

to 70 feet long. The bark is light brown, fairly smooth, hard and brittle, averaging about one-fourth of an inch thick on large trees. The underbark is a deep red (*82*).

The wood.—Wood of the four species covered are similar in appearance and technical properties and are hereafter discussed as a group unless otherwise stated. The heartwood is a reddish brown to chocolate brown or a dark red, being somewhat similar to black walnut in appearance. The sapwood is pink and about 1½ inches thick. The grain in interlocked, giving a striped or ribbon-grain appearance to the wood. Growth rings are marked by changes in color at the margins of each season's growth, resulting in the appearance of a series of parabolic markings on the tangential surface. The wood is moderately coarse in texture, low in luster, and both odorless and tasteless when dry. Fanshawe (*82*) states the wood contains stones of calcium oxalate.

Weight.—Although the four species in the suradan group are reported to be very similar in weight, detailed information is available only for *Hyeronima laxiflora*. The specific gravity of this species, based on ovendry weight and green volume, averages about 0.65 (0.59 to 0.74), which is comparable to pignut hickory of the United States. The specific gravity of air-dry wood averages about 0.79. Air-dry wood weighs about 49 pounds per cubic foot and green wood about 74 pounds per cubic foot (*165*, *162*, *153*, *250*).

Seasoning.—Suradan is rated moderately difficult to air-season, according to tests at Yale University (*250*) and on St. Lucia (*153*). In the Yale tests, *Hyeronima laxiflora* seasoned rapidly with a moderate amount of defect occurring in the form of crook and surface checking. Slight casehardening and end checking also occurred, indicating the need for slower drying. Tests on St. Lucia with *Hyeronima caribaea* indicated care must be taken to prevent warping, but no other serious defects were reported. In these tests, 1-inch lumber air-seasoned to a moisture content of 22.3 percent in a well ventilated building, while pitch pine seasoned to 15.5 percent moisture content and white pine to 16.8 percent moisture content during the same period.

Shrinkage.—*Hyeronima laxiflora*, which is representative of the other species, undergoes moderately high shrinkage in comparison to many other tropical woods of similar density, but it is comparable to white oak in directional and volumetric shrinkage. The wood shrinks 5.3 percent radially, 9.4 percent tangentially, and 14.4 percent volumetrically from green to ovendry. In comparison, similar values of 5.3, 9.0, and 15.8, respectively, are reported for white oak. Shrinkage from green to air-dry would amount to about half these values (*250*, *160*).

Mechanical properties.—Suradan possesses normal strength properties in both the green and air-dry condition for a wood of its density except for marked deficiencies in work to maximum load (shock resistance), compression and tension across the grain (crushing strength and hardness), and cleavage (splitting). It is a moderately good bending wood except in shock resistance, comparing favorably in this with sweet birch (*Betula lenta*) of the United States (*250*).

Working properties.—Suradan is reported good in all working properties except planing. The U.S. Forest Products Laboratory (*68*) rates *Hyeronima alchorneoides* as having excellent sanding, boring, and mortising properties; very good turning properties; good shaping properties; and fairly poor planing properties. Except in planing, the wood machined better than the average for 25 domestic hardwoods of the United States.

Tests at Yale University rated *Hyeronima laxiflora* moderately difficult to work on the basis of its poor planing properties. The irregular occurrence of shallow chipped grain during planing results from the characteristic roey grain. Fanshawe (*82*) reports that *H. laxiflora* of British Guiana must be scraped well to acquire a smooth finish. Lang (*153*) reports that *H. caribaea* saws and finishes well in the government shop on St. Lucia. The wood glues well and finishes smoothly but, because of its rather large pores, requires a fair amount of filler to secure a perfect finish (*132*).

Durability.—The species discussed in this report vary from moderately durable to very durable in contact with the ground. *Hyeronima laxiflora* was found to be very durable when exposed to pure cultures of white-rot and brown-rot fungi (*250*). Fanshawe (*50*) also reports this species as highly durable. Durability tests of *H. alchorneoides* in soil at Barro Colorado Island, Canal Zone, and Turrialba, Costa Rica, rated this species as moderately resistant to resistant to decay in contact with the ground (*199*).

In Brazil, however, railway ties of this species are considered very resistant to decay. Substantiating this is a test by the Netherlands Railway in Holland where untreated ties from Brazil were more durable than treated white oak ties from the United States (*133*). *Hyeronima caribaea* has been reported as moderately durable in soil tests in Trinidad (*39*) and in St. Lucia (*50*). On the basis of these reports, a rating of resistant or durable appears to be appropriate for the combined species. *H. caribaea* is rated resistant to attack of subterranean termites by Brooks (*39*) and both *H. clusioides* and *H. laxiflora* are rated moderately resistant to the dry-wood or aerial termites by Wolcott (*263*).

According to Edmonson (*76*), *Hyeronima laxiflora* is one of the most resistant woods to marine borers in Hawaiian waters, showing only slight penetration after 13 months' exposure. This resistance cannot be attributed to silica content for Amos (*14*) reports finding only 0.01 percent silica

in the wood. In the Hawaiian tests, *H. clusioides* from Puerto Rico showed only moderate resistance to marine borers, indicating that different species of *Hyeronima* vary in their resistance to marine organisms.

Uses.—Because of its resistance to decay and marine borers, good strength, pleasing appearance, and fairly good working properties, suradan is well suited for use in marine piling and construction, railway ties, furniture, cabinetwork, decorative veneer, and both light and heavy construction. It is extensively used for boat construction in British Guiana, where it is considered suitable for most of the above uses. The timber is employed in Trinidad for framework, rafters, and sheathing in building construction. Suradan is considered an excellent wood for furniture in St. Lucia, where it is also used for posts and heavy timbers and is recommended for paneling and high-quality interior work. The government of British Guiana has recently specified suradan as acceptable for interior partitions and battens in the government housing program.

Supply.—Suradan is available in the Guianas and possibly from some of the Lesser Antilles, particularly St. Lucia and St. Vincent, and from Trinidad. British Guiana should be able to supply reasonably large quantities of the timber.

WHITE TABEBUIA

Tabebuia insignis var. *monophylla*, *Tabebuia stenocalyx*

Within the genus *Tabebuia*, the so-called white cedars are considered similar enough to be marketed as a group under a common trade name. The woods of these and other species are likely called white cedar, because of the resemblance of the bark to that of *Cedrela* spp. White cedar in no way resembles the wood of *Cedrela* growing in the tropics or the cedars of the United States (*190*). Other species of *Tabebuia* are discussed under roble and bethabara.

Nomenclature.—The species marketed as white cedar are *Tabebuia insignis* (Miq.) Sandw. var. *monophylla* Sandw. (*T. longipes* Baker), and *T. stenocalyx* Sprague & Stapf. The whitewood of Jamaica, *T. riparia* (Raf.) Sandw., formerly was known as *T. leucoxylon* (L.) Mart., a name now rejected as a homonym.

Tabebuia insignis var. *monophylla* is locally known as zwamp panta, panda, panda hoedoe, waroekoelie, alasoabo, johoto, courali, mattoe, and warokorie in Surinam; white cedar, warikuri, woraccori, and warakuri in British Guiana; and bois blanchet or cèdre blanc in French Guiana. *T. stenocalyx* is locally known as white cedar in British Guiana and wild calabash in Trinidad. *T. heterophylla* (DC.) Britton, described under roble, is known also as white cedar in the Virgin Islands, Dominica, St. Lucia, and Grenada. (Trumpet-creeper family, Bignoniaceae.)

Distribution and habitat.—Possibly because of confusion in identification, only fragmentary information is available concerning the species comprising the white-cedar trade group. *Tabebuia insignis* var. *monophylla* occurs in the three Guianas and Venezuela; *T. stenocalyx* is reported from British Guiana, Trinidad, and French Guiana (*50*).

Tabebuia insignis var. *monophylla* is dominant in some types of marsh forest and is frequent on other sites in British Guiana. In Surinam it occurs as a rare to occasional tree in the marsh forest, becoming locally frequent in the swamp forests. Information is lacking on the habitat and occurrence of the other species (*82*, *231*).

The tree.—*Tabebuia insignis* var. *monophylla* is a moderately tall, slim tree in British Guiana. The trunks have moderately poor form and heavy taper above the fluted buttresses, which range up to 12 feet in height. Trees are commonly 90 feet high and about 12 inches in diameter but occasionally grow to 16 inches. The trunks are often free of branches for 40 to 50 feet (*82*). *T. stenocalyx* is a larger tree, growing up to 150 feet tall with a low buttressed trunk nearly 3 feet in diameter.

The wood.—Heartwood of *Tabebuia stenocalyx* and *T. insignis* var. *monophylla* is variously described as creamy, yellowish, or grayish brown or sometimes brownish, often with dark flecks showing on the surface. Sapwood is lighter in color and not clearly differentiated from the heartwood. The texture is medium, the grain fairly straight, and the luster moderately high. It is a moderately hard, firm wood without distinctive odor or taste and without the yellow powder (lapachon) found in *T. serratifolia* (Vahl) Nicholson and other species in the lapachon group of *Tabebuia* (*82*, *231*, *190*).

Weight.—The wood is of medium weight with a specific gravity based on air-dry volume and weight averaging about 0.68 (0.64 to 0.74). The specific gravity based on green volume and oven-dry weight is reported at 0.55 by Kynoch and Norton (*149*). Air-dry wood averages around 42 pounds and green wood about 65 pounds per cubic foot (*190*, *82*, *231*).

Seasoning.—No information is available on the seasoning characteristics of the white-cedar group. However, their similarity to roble or apamate (*Tabebuia rosea* (Bertol.) DC.) suggests that the timber seasons easily with only slight degrade (*71*). On this basis, white cedar should kiln-dry easily without any appreciable degrade using Kiln Schedule 4 of the Forest Products Research Laboratory in England (*222*) or Kiln Schedule TD–42 of the Forest Products Laboratory in Madison

(*147*). One-inch lumber of roble (*T. heterophylla* (DC.) Britton) has been air-seasoned in Puerto Rico in 3 months with only slight degrade.

Shrinkage.—*Tabebuia insignis* var. *monophylla* undergoes a shrinkage of 5.8 percent radially, 7.7 percent tangentially, and 13.7 percent in volume from green to ovendry. This rate is relatively high but compares favorably with rates for white oak of 5.3, 7.3, and 11.5 percent, respectively. The ratio of tangential to radial shrinkage is very favorable, indicating that relatively little stress develops during drying. This tends to reduce warping, checking, and splitting. Shrinkage from green to air-dry would be roughly half the amount from green to ovendry (*248*, *50*, *149*).

Mechanical properties.—*Tabebuia insignis* var. *monophylla*, which is representative of the white-cedar group, is a hard, strong, resilient wood resembling roble or apamate (*T. rosea*) in strength characteristics, although somewhat superior in some respects. White cedar is superior to white oak (*Quercus alba*) in the green condition in all properties tested except compression perpendicular to the grain, tension, and shear. Upon air-drying, white cedar becomes stronger but not in proportion to white oak and other American hardwoods of the temperate zone. In this condition, white cedar is somewhat inferior to white oak in most strength properties, but still possesses good strength properties for a wood of its density (*149*).

Working properties.—White-cedar logs are reported to spring badly during conversion. Dry lumber saws, planes, shapes, bores, mortices, and sands easily with smooth clean edges in all operations. It finishes and polishes very smoothly with a glossy finish, resembling yellow birch (*Betula alleghaniensis* Britton) in some respects (*190*, *82*, *231*).

Durability.—Graveyard tests in British Guiana (*50*) showed the wood to be only slightly resistant to decay. Although definite information is lacking, it is reasonable to assume that white cedar is readily damaged by both termites and marine borers, as is roble or apamate (*Tabebuia rosea*).

Uses.—White cedar is well suited for use in tool handles and for boat decking and boat parts, where high resistance to decay is not essential. It is used extensively for furniture, flooring, interior house trim, building construction, and general carpentry. In the areas where it grows it is also used for paddles and packing cases. On the basis of its qualities, this timber could be substituted for ash in sporting goods, agricultural implements, and possibly for decorative veneer.

Supply.—White cedar is available for export from British Guiana, and possibly French Guiana and Surinam. Other Caribbean areas covered in this report do not have the timber in sufficient volume for export.

TATABU

Diplotropis purpurea

Tatabu is one of the strongest and most beautiful woods growing in the tropical forests of the Western Hemisphere. It is superior in many strength properties to the best woods of the United States, and, despite being somewhat difficult to work, may eventually become one of the more popular export timbers.

Nomenclature.—Presently, tatabu is known as *Diplotropis purpurea* (Rich.) Amsh., formerly having been designated both as *D. guianensis* (Tul.) Benth. and as *Bowdichia guianensis* (Tul.) Ducke. A variety is *D. purpurea* var. *brasiliensis* (Tul.) Amsh. (*D. brasiliensis* (Tul.) Benth.). Some botanists regard *Diplotropis* as a synonym of *Bowdichia*. However, Record and Hess (*190*) from a study of a limited number of wood specimens concluded that these two genera with only a few species are distinct. (Legume family, Leguminosae.)

The timber is marketed under the name tatabu in British Guiana, coeur dehors in French Guiana, zwarte kabbes in Surinam, and supupira or sucupira in Brazil (*193*, *50*).

Distribution and habitat.—Tatabu occurs in the upland areas of the rain and seasonal forests in the Guianas and in eastern and northern Brazil. It is an occasional tree in British Guiana, rare in Surinam, but fairly common in French Guiana and some areas in Brazil.

The tree.—Tatabu is commonly 90 to 100 feet in height and 16 to 24 inches in diameter, but trees up to 40 inches are occasionally found. The trunk is usually straight, cylindrical, unbuttressed, and up to 60 to 70 feet in length (*82*). However, long logs are uncommon because of the tree's crooked form (*136*, *151*).

The wood.—Tatabu is a very hard, heavy, tough, and strong wood. Freshly cut heartwood is generally chocolate brown turning to a lighter brown when dry and may occasionally be grayish brown or brown, often with dark gold-colored stripes or narrow stripes of a lighter brown. The sapwood is narrow, clearly demarcated from the heartwood and grayish or pinkish gray.

Short rows of pores are often visible without a lens, being made conspicuous by the surrounding layers of light-colored parenchyma. The pores are generally open but some contain a white or yellow substance making them appear as colored lines on the longitudinal surfaces. Rays are very fine and inconspicuous on all surfaces. Growth rings are usually not visible but on occasion show very faintly. The grain is straight to slightly interlocked or sometimes slightly wavy; the texture is coarse to very coarse. The luster is high and golden in the proper light, often with

a waxy appearance. No distinctive odor or taste is present (*136*, *151*, *143*).

Weight.—The specific gravity based on green volume and weight when ovendry averages about 0.78 (0.70 to 0.97). The specific gravity of air-dry wood, based on weight and volume in that condition, averages about 0.93. Green wood weighs about 78 pounds per cubic foot and dry wood about 58 pounds per cubic foot (*248*, *50*, *149*).

Seasoning.—Tatabu dries rapidly but is generally considered rather difficult to season. Under the usual air-dry procedures some checking, cupping, twist, crook, and end splitting are likely to occur. Considerable checking and cupping also occur in kiln-drying unless a slow drying schedule is used. In air-drying it should be piled with relatively small spacing between boards and with thin stickers to reduce the initial drying rate (*248*).

Shrinkage.—Tatabu shrinks but little during seasoning. Shrinkage values from green to ovendry of 4.6 percent radially, 7.0 percent tangentially, and 11.8 percent volumetrically are not excessive for wood of tatabu's density (*248*, *149*). It compares closely with black walnut in shrinkage and is considerably better than white oak or greenheart in this characteristic. Shrinkage from green to air-dry would be about half these values. The wood is fairly stable in use, responding only moderately to atmospheric changes (*108*).

Mechanical properties.—In the green condition, tatabu is superior in most strength properties to all woods indigenous to the United States. In the unseasoned condition, it also exceeds most tropical species of similar high density (*231*). Green tatabu is superior to green hickory and white oak in all mechanical properties, except shock resistance in which hickory is superior, and except tension across the grain and cleavage in which oak is superior.

In the air-dry condition, tatabu is equal or superior to hickory in all properties except shock resistance as measured by work to maximum load, compression across the grain, and shear. It is superior to air-dried white oak in all properties except compression and tension across the grain and cleavage resistance (*149*, *248*, *175*). On this basis tatabu would not serve as well as hickory for handles in striking tools.

Working properties.—The wood is moderately difficult to work. It saws rather easily, but is somewhat difficult to plane because of its frequently roey grain, which when present requires considerable sanding. The wood turns well, has high screw-holding power, and takes wax or polish satisfactorily if a filler is first applied (*231*, *123*).

Durability.—Fanshawe (*82*) and Pfeiffer (*175*) in British Guiana and Surinam, respectively, rate tatabu as moderately resistant to decay. However, tests at Yale University (*248*) indicate the wood is very durable in resistance to both white-rot and brown-rot fungus. Sucupira (*Diplotropis* sp.) railway ties are reported to outlast creosoted oak ties on the Netherlands Railway at Delft, Holland. Ties of this species were all sound after 17 years, while the oak ties were severely split (*133*). However, this is not entirely a test of durability against rot, as the splitting may have been a mechanical failure of the oak rather than the result of decay. Wolcott (*263*) rates this species nearly equal to West Indies mahogany, considerably above Honduras mahogany, and somewhat below greenheart in resistance to dry-wood termites.

Exposure tests of the timber in Hawaiian waters showed tatabu to have little resistance to marine borers (*76*). It was also quickly damaged by marine borers in a similar test in the Atlantic Ocean at Wrightsville, N.C., where it ranked 30th in resistance to marine borers of 37 species tested (*58*). Amos (*14*) reports the silica content of the wood as negligible.

Uses.—Hughes, in Forest Resources of British Guiana (*136*), refers to tatabu as follows:

> The qualities and properties of this wood have not been fully appreciated in the past. Extra work spent on its manufacture is amply repaid by the results achieved. This wood will definitely find a niche among our more beautiful woods in the future when it may be possible to exploit the forests to a greater extent than in the past.

The timber is used in British Guiana for heavy construction, boatbuilding, house framing, flooring, furniture, and turnery. Tatabu's high durability in the ground makes it well fitted for uses where a durable strong wood is required. Ducke (*73*) reports the wood is used extensively for civil and naval construction and crossties in Brazil. The timber's recognized beauty should promote its extensive use for furniture, cabinetwork, marine construction in nonteredo waters, and other similar uses in the countries of origin and on the export market (*132*). Its very good strength properties also suggest its use for tool handles and agricultural tools and vehicles. Tatabu has been selected as one of the species suitable for timbers, scantlings, and other structural members, as well as for flooring and siding in the government-sponsored housing program in British Guiana.

Supply.—The wood is in sufficient supply in the Guianas to fill export markets as they develop.

TAURONIRO

Humiria balsamifera

Nomenclature.—*Humiria balsamifera* (Aubl.) J. St. Hil. is the best known of four or more species of *Humiria* occurring in the American tropics. Other species of importance are *H. floribunda* Mart. including var. *subsessilis* Urban and *H. cassiquiari* Suesseng & Bergdolt. In British Guiana the timber of *H. balsamifera* is known as tauroniro and tabaniro, or by the English names of bastard bully and bastard bullet tree because of its similarity to bulletwood (*Manilkara* sp.).

Vernacular names applied to one or more species in different localities are as follows: basra-bolletrie, bastard bolletrie, meri, blackaberie and tawanango in Surinam; bois rouge, bois à flambeau, bois d'encens, triane, boume houmirí, caramura, homiry, omiry in French Guiana; turamira, couranira in Brazil; niña in Venezuela; and oloroso in Colombia. (Humiria family, Humiriaceae.)

Distribution and habitat.—*Humiria balsamifera* occurs in the Guianas, Colombia, Venezuela, and the Brazilian Amazon. In British Guiana it is a principal dominant species in the marsh forest and of occasional to frequent occurrence in the seasonal and wallaba (dry evergreen) forests of the near interior and the Rupununi district (*82*). It generally does best on light sandy soils. On other sites and soils the tree is often shrubby and of little commercial value. In Surinam the tree occurs on the low or savanna forest on either clay or sandy soils at elevations of about 70 feet (*250*, *231*, *190*).

The tree.—On favorable sites in British Guiana, tauroniro becomes a heavy, round-crowned canopy tree without buttresses. It is commonly 20 to 28 inches, and occasionally up to 48 inches in diameter and 90 to 120 feet tall with a long, cylindrical bole clear of branches for 60 to 70 feet.

The wood.—The wood has the general appearance and properties of balata (*Manilkara* sp.) but is coarser in texture and considered inferior to that species. The sapwood is about 1½ to 2 inches wide, light brown, and poorly demarcated from a light brown to reddish-brown heartwood. The grain varies from straight to interlocked, the latter producing a light striping on the tangential surface. Growth rings are indistinct. The wood is of medium luster and texture and when seasoned is without odor or taste.

Weight.—The specific gravity of tauroniro is reported at 0.66 based on ovendry weight and green volume. Specific gravity of air-dry wood averages about 0.80, based on the weight and volume of wood in that condition. The wood averages 50 pounds per cubic foot when air-dry and 67 pounds when green according to tests at Yale University (*250*). This is somewhat below bulletwood's average air-dry weight of 64 pounds. Fanshawe (*82*) reports somewhat higher average weight of 53 to 57 pounds per cubic foot for air-dry tauroniro from British Guiana.

Seasoning.—The timber, which is moderately difficult to season, will air-dry at a rapid rate, accompanied by slight surface and end checking, some warping, moderate crook, and slight twist. Some casehardening also occurs in rapid drying but, along with other defects, can be reduced if the timber is seasoned at a moderate rate.

Shrinkage.—Tauroniro undergoes greater shrinkage than many tropical American hardwoods but compares favorably with equally dense United States hardwoods. Its radial shrinkage is considerably above the average for both tropical and temperate zone hardwoods of similar density. Shrinkage amounts to 7.2 percent radially, 9.7 percent tangentially, and 15.7 percent volumetrically from green to ovendry as compared to 5.3, 9.0, and 15.8 percent, respectively, for white oak (*242*, *250*). Shrinkage from green to air-dry would amount to about half these values. The ratio of tangential to radial shrinkage is very favorable; under mild drying conditions the wood should season without developing internal and surface stresses.

Mechanical properties.—Unseasoned timber is about as strong as other woods of comparable density, except that it falls slightly below the average in crushing strength, cleavage, and toughness. In this condition it is clearly superior to white oak in static bending except in work to maximum load (shock resistance). It is also superior to oak in stiffness, hardness, shear, and crushing strength. It falls below oak in cleavage resistance and shock resistance and is about equal to that species in bearing strength.

In the air-dry condition, tauroniro is only slightly superior to oak in resistance to shear but is 20 to 40 percent stronger in all other properties except bearing strength in which it is only three-quarters as strong as that species (*250*).

Working properties.—The wood is moderately difficult to work. Straight-grained material saws and planes smoothly, but wood with interlocked grain is susceptible to considerable chipped grain in planing. Inclined to be splintery, the wood does not turn well but can be bored satisfactorily.

Durability.—Tauroniro and other species of *Humiria* have the reputation of being highly durable in the American tropics. Pure culture tests at Yale University rated the wood very durable to a white-rot fungus and durable to moderately durable to a brown-rot fungus. Tauroniro from British Guiana was found to have little resistance to teredo in Hawaiian waters (*76*). Wolcott (*263*) found the wood resistant to damage by the dry-wood termite of the West Indies, rating slightly above Honduras mahogany in this respect.

Uses.—The timber is used for heavy construction in place of balata (*Manilkara bidentata*) in British Guiana and is considered suitable for fresh water piling, bridge timbers, house framing, and heavy joinery in that country. The rich color of the wood and its modest but attractive figure suggest its use for face veneer and furniture. It is considered superior to Demerara greenheart for wheel spokes and has been recommended for sugar barrels, agricultural implements and vehicles, and flooring. It is one of ten woods acceptable for siding and flooring and structural timbers in the government housing program of British Guiana. In general, it is useful wherever a wood of high strength properties is required (*227*).

Supply.—British Guiana and possibly French Guiana and Surinam can supply tauroniro in exportable quantities.

TEAK

Tectona grandis

Teak is one of the world's best known and most highly valued timbers. It is native to southeastern Asia and Malaya and is planted extensively in many other tropical regions, including the Philippines, West Africa, continental tropical America, and the West Indies. Commercial supplies of the timber come largely from the tropical forests of Burma; small amounts also originate from India and Java. Teak is also indigenous to Indo-China but is seldom exported from there. Timber from the different sources is usually sold as Moulmein teak, Rangoon teak, and so forth, according to its port of export or place of origin. Though not indigenous to Java, teak was originally planted near temples and shrines and now forms pure forests over extensive areas. This is in contrast to its usual occurrence in mixed forests in its native habitat (*118*, *135*, *237*, *105*).

Nomenclature.—Teak, *Tectona grandis* L. f., harvested from plantation-grown trees in the Caribbean area, has been marketed in relatively small volumes as plantation-grown teak or simply as teak. The timber is somewhat unique in not having numerous other common names as do most other tropical timbers. However, other timbers are often erroneously called teak. The Spanish name is teca, and the French is teck. (Verbena family, Verbenaceae.)

Distribution and habitat.—Teak is planted extensively in British Guiana, Puerto Rico, Cuba, Haiti, Jamaica, and other West Indies islands and countries in the Caribbean region but is best known from Trinidad, Honduras, and British Honduras. It has been grown most successfully in Trinidad and other areas on deep, well-drained soils with a rainfall of 50 to 120 inches, but it also does well on a variety of soils and geographical formations provided that there is good subsoil drainage. Plantations are thriving in Trinidad on areas formerly occupied by semideciduous forests and rain forests.

Teak is also apparently well established on lands carrying second-growth brush, on former cocoa estate lands, and on other areas of heavy clay soil with good drainage (*165*, *162*, *38*). However, Castens' (*52*) experience in Burma indicates teak should only be planted in the alluvial valley soil and on areas of deep loamy sand and loam on the lower ridges. He further concludes that teak planted on clay soils in Burma is not expected to do well, and that trees planted on narrow ridges and moderate to steep slopes will almost surely die some time after reaching 25 years of age.

The tree.—Teak is a very large deciduous tree in its native habitat. The bark is up to three-fourths of an inch thick, grayish brown, flaky, and somewhat shallowly fissured. Trees growing 100 feet high and 3 feet in diameter are not unusual, and occasional trees reach a height of 150 feet and a diameter of 5 feet or more. Trees of this size are usually 100 to 200 years old (*135*, *46*, *165*). In favorable locations teak has a clean cylindrical bole, which is sometimes fluted at the base or often buttressed in old trees (*165*). The tree varies greatly in size according to climatic and soil conditions with much shorter and more fluted stems and greater branching in the drier and hotter regions. Trees cut for the export market are usually 2 to 2½ feet in diameter and clear of branches for 30 to 35 feet above the stumps.

In dry forests the growth rate is slow; 5 to 8 years are required to grow 1 inch in diameter. In moist forests and cultivated plantations under very favorable conditions, teak may grow as much as 1 inch or more in 2 years, and the trees may attain diameters of 30 inches or more in 60 years (*46*). Saw-log-size trees have been produced in Honduras in 20 years under extremely favorable conditions. Plantations in other tropical areas have shown similar results (*71*), but in general, plantation-grown trees require up to twice this period to reach economic maturity.

In Burma and Siam the trees are always girdled in the forest to allow the timber to dry out before felling. Logs from green trees will not float, but those from trees girdled 2 to 3 years prior to cutting can be rafted or floated down rivers. This is important as virtually all Burma teak is extracted by water.

The wood.—Teak is a moderately hard, oily timber of medium weight. The heartwood of plantation-grown teak is olive green when freshly cut, becoming golden brown and eventually almost black upon exposure and seasoning. The 1- to 2-inch wide yellowish to white-colored sapwood is sharply demarcated from the heartwood. Growth rings are distinct and, except for occasional false rings, are of annual occurrence. Teak is considered a typically ring porous wood in India but shows much variation in the width of the pore zone. Terminal growth varies from a band of 2 or 3 layers of large pores to a few scattered large pores touching the initial parenchyma layer but not forming a definite band. The growth layers are distinguished on side-grain surfaces by narrow brown lines darker than the rest of the heartwood. Plantation grown teak is usually straight grained and of uniform fine texture. The wood has an oily feel and a strong fragrant odor when freshly cut. Seasoned wood retains its oily feel but possesses only a faint fragrance and has no detectable taste (*71*, *46*, *143*, *135*, *56*).

Weight.—Plantation-grown teak from Honduras is reported by Dickinson (*71*) to be some-

what lower in density than Burma-grown teak, with an average specific gravity of 0.56 (0.52 to 0.62) based on ovendry weight and green volume. The specific gravity of air-dry wood averaged 0.64, based on weight and volume in that condition. Air-dry wood weighed 40 pounds per cubic foot and green wood 60 pounds per cubic foot.

A comparison of forest-grown Burma and Indonesian teak with plantation-grown teak from Trinidad by the Central Secretariat of the Caribbean Commission (*50*), using data by Smathers (*205*) and Pfeiffer (*175*), gave Trinidad-grown teak an air-dry specific gravity value of 0.695 as compared to 0.679 for the forest-grown teak. Weight of air-dry (12 percent moisture content) wood from Trinidad was listed at 43.4 pounds per cubic foot as compared to 42.3 pounds for wood from Burma. These studies and others have dispelled the belief that plantation-grown teak is always lower in density than forest-grown wood. Teak is similar in weight to sugar maple of the United States (44 pounds air-dry) and is somewhat lighter than white oak (48 pounds air-dry) (*160*).

Seasoning.—Teak is easily air-seasoned or kiln-dried with a minimum of degrade. In tests at Yale University, plantation-grown stock from Honduras air-seasoned rapidly with no appreciable defect. The Forest Products Research Laboratory in England reports that teak air-seasons or kiln-seasons well but slowly with little tendency to check, split, or warp, and that lumber from girdled trees dries with the same results as other material. However, material from green logs requires more initial protection against rapid drying than that from girdled trees. There is liable to be considerable variation in the drying rate of individual boards, because differences between the initial and final moisture contents are occasionally great.

The timber is very liable to change color during kiln-seasoning, but the uniform coloring is restored within a reasonable time after drying (*105*). Kiln Schedule 6 of the Forest Products Research Laboratory (*222*) has been recommended, although more severe kiln schedules have been tried with good results (*140*).

Shrinkage.—Teak is well known for its exceptionally low shrinkage and excellent stability in use (*241*), being quite similar to mahogany and white pine in these characteristics. Forest-grown Burma teak shrinks 2.3 percent radially, 4.2 percent tangentially, and 6.8 percent volumetrically from green to ovendry (*236*). Plantation-grown teak from Honduras has comparable shrinkage rates, according to studies at Yale University (*71*), in which the teak shrank 2.1 percent radially, 4.6 percent tangentially, and 5.1 percent volumetrically from green to ovendry. Shrinkage from green to air-dry would amount to about half these values.

Teak is highly regarded for its stability in response to atmospheric changes, undergoing a radial movement of 0.8 percent and tangential movement of 1.3 percent from equilibrium in a 60-percent relative humidity to equilibrium in a 90-percent humidity. This amounts to a movement (swelling) of $\frac{3}{32}$ and $\frac{5}{32}$ inch per foot, respectively (*108*). Plantation-grown teak is comparable to forest-grown wood in its high resistance to water absorption (*71*, *236*, *198*).

Mechanical properties.—Teak has good strength properties. Green wood is reported by the Forest Products Research Laboratory (*105*) to equal white oak in hardness and resistance to impact loads, and to exceed that wood by 30 to 40 percent in stiffness and bending strength. When air-dry, teak becomes 10 to 20 percent inferior to oak in hardness and resistance to impact loads, but becomes only 10 to 20 percent stronger in bending and stiffness. Under heavy use it has a tendency to break down by short brittle splintering on edge-grain surfaces and for the surface of flat-sawed material to disintegrate rapidly.

Tests of the mechanical properties of air-dry plantation-grown teak from Trinidad showed it equal or superior to forest-grown Burma teak in static bending, compression parallel to the grain, tension parallel to the grain, and hardness and toughness properties. In similar tests of air-dry Honduras-grown teak, it was slightly superior to Burma-grown teak in compression across the grain, shear, cleavage, and toughness; slightly lower in stiffness, crushing strength, and tension across the grain; and similar in the other properties. Studies by the Indian Forest Research Institute at Dehra Dun, India, also showed no essential difference in strength properties between planation-grown and forest-grown material (*202*, *205*, *175*, *71*, *249*).

Working properties.—Plantation-grown teak is easily worked with both hand and machine tools (*71*, *46*). Its dulling effect on cutting edges can be overcome by using special carbide or other high-quality steel. Reduced spindle speeds are recommended when using ordinary, good-quality, high-speed steel knives or cutters. A very smooth finish is obtained when tools are kept sharp, but some care is required to prevent roughness on end grain due to the brittle nature of the wood.

Teak takes nails and screws fairly well (*123*) and glues moderately well despite its oily nature (*240*). Its bending properties vary from poor to good. In general, it is a moderately good bending wood but is liable to buckle on the concave face if bent to small radii of curvatures. It can be varnished and polished with good results.

Durability.—Teak is recognized throughout the world as a timber of excellent durability to decay, termites, and marine borers (*237*, *71*, *12*, *46*, *241*). But controlled tests of untreated, 10-year-old, plantation-grown teak in Trinidad indicated that the wood is only moderately durable to fungus

attack (rot) and definitely susceptible to attack by subterranean termites (*39*). However, pure culture tests with 20-year-old, plantation-grown teak from Honduras showed the wood to be somewhat variable but generally very durable to damage by both a white-rot and brown-rot fungus (*71*). The sapwood is not durable.

Wolcott (*263*) rates the heartwood of East Indian teak resistant to damage by the dry-wood termite of the West Indies, the same as West Indies mahogany, but found the sapwood had little resistance to termite damage. The sapwood is also susceptible to attack by powder-post beetles and other insects (*105*). The heartwood is generally considered to be highly resistant but not immune to marine borer attack. Amos' report that teak contains up to 1.4 percent silica by weight would indicate a considerable resistance to marine organisms (*14*). Yet, teak was found to have no appreciable resistance to marine borers in recent exposure tests at Wrightsville, N.C., where the timber was rated 23d in resistance to marine borers of 37 woods tested (*58*).

Plantation-grown teak possesses excellent weathering characteristics. Unpainted wood is almost entirely free from warp and checking when exposed to the weather (*55*).

Preservation.—Teak is considered very difficult to impregnate with preservatives; only the vessels absorb preservative in pressure treatments. Although the heartwood is extremely resistant to preservatives, it is a common practice in Trinidad to treat plantation-grown teak posts by the open-tank process. This treatment is reported to add considerable life to the thick sapwood in small posts.

Uses.—Plantation-grown teak is suitable for the same uses as forest-grown material, including shipbuilding (particularly decking), flooring, high-class joinery, interior trim, durable outdoor structural work, door and window frames, carvings, furniture, doors, interior paneling, and fancy turned items. Figured wood is cut into both laminated and solid veneer. The timber's low shrinkage, as well as its stability and durability, make teak well adapted for use in tanks and vats. It is used in laboratories and chemical plants for benches and other fixtures because of its high resistance to acids. Because of its resistance to moisture, teak is frequently used for kitchens and bathroom fittings.

One of the principal uses for imported wood is in decking for ships and in general boatbuilding of all kinds. Many other woods have been tried, but no substitute has been found for teak decking on naval vessels.

Thinnings from plantation-grown teak in Trinidad are split and used in wire fencing, squared and sold for house framing, or sawed into lumber for furniture, boats, and other uses. Considerable plantation material is also used, both treated and untreated, for posts and small poles.

Supply.—The supply of plantation-grown teak is not large—only Trinidad is in a position to offer even a small volume for export. Other areas may soon have exportable surpluses when plantations reach merchantable size.

TONKA

Dipteryx odorata

About four species of the tonka-bean tree in the genus *Dipteryx* (formerly *Coumarouna*) supply the scented tonka beans of commerce, which are valued for coumarin, a fragrant chemical. Coumarin is used principally for flavoring snuff and in manufacture of perfume and, to some extent, in confectionary. For many years, the export of tonka beans has been an important industry in Brazil and Venezuela.

Nomenclature.—Tonka is the preferred trade name for wood of the common species, *Dipteryx odorata* (Aubl.) Willd. (*Coumarouna odorata* Aubl.). The name tonka wood is also frequently used in the trade. It is locally known as tonka or koemaroe in Surinam; tonka, tonka bean, or kumaru in British Guiana; tonka in Trinidad; gaïac de cayenne in French Guiana; cumary or cumarú in Brazil; and sarrapia and cumarú in Venezuela and Colombia. The name tonquin is also sometimes used in Spanish-speaking countries. (Legume family, Leguminosae.)

Distribution and habitat.—The tonka tree grows in the Guianas, Venezuela, Colombia, and the Amazon region of Brazil. It is also cultivated for its fruit (tonka beans) in Trinidad. The tree is of frequent occurrence in Brazil, Venezuela, and French Guiana (*73*); rare in the rain and high savanna forests of Surinam (*231*); rare in the rain and seasonal forest areas of British Guiana, though of general distribution (*82*). The tree thrives on many types of soil but reaches its best development on well-drained gravelly or sandy sites. Heavy waterlogged soil and impervious clay are unsuitable for its growth. It will stand a certain amount of drought but is reported to require a minimum annual rainfall of 50 to 60 inches (*117*).

The tree.—This species is a rather large, unbuttressed overstory tree with a small rounded crown. The trees are most frequently 18 to 30 inches in diameter and 80 to 120 feet in height, although on the best sites they sometimes reach 40-inch diameters and 160-foot heights. Their clean cylindrical boles are generally 60 to 80 feet long. Under cultivation and in second-growth forests, the tree is generally small to medium in size (*72, 82*).

The wood.—Tonka is an exceptionally attractive timber. The fresh heartwood is a reddish-brown or purplish-brown color with attractive light yellowish-brown or purplish streaks. It seasons to a variegated reddish and yellowish brown but after exposure to light gradually be-

comes a uniform yellowish brown or light brown. The sapwood is distinct from the heartwood, brownish yellow or yellowish brown and about 1 to 2 inches thick. The wood is characterized by rather prominent vessel lines and by a consistent narrow stripe on radial surfaces caused by the closely interlocked grain. A waxy or oily feel is also a characteristic of this wood. The texture is fine, luster medium, and grain irregular to often interlocked. The wood has no distinctive taste but a faint vanillalike or rancid odor. It is an extremely hard and heavy wood, similar to lignumvitae in this respect (*127*, *143*, *82*, *231*).

Weight.—The specific gravity of tonka averages 0.89 (0.79 to 0.97), based on green volume and ovendry weight. The specific gravity of air-dry wood averages about 1.08. Weight per cubic foot averages about 81 pounds green and 67 pounds air-dry (*231*, *127*).

Seasoning.—The wood is relatively easy to season considering its density. Material has been air-dried under cover at Yale University in less than 120 days with some surface checking occurring; seasoning at a moderate to slow rate would likely reduce the occurrence of this defect.

Shrinkage.—The shrinkage rates of tonka are unusually low for a wood of its high density. It compares favorably in this respect with woods of much lower density. A radial shrinkage of 5.0 percent, tangential shrinkage of 7.6 percent, and volumetric shrinkage of 12.0 percent are below those of white oak. Tonka's longitudinal shrinkage of 0.13 percent is also very moderate (*127*). Because of the high density of tonka, this wood undergoes relatively large movement in response to changes in atmospheric conditions and is thereby relatively unstable in use. However, it resists water absorption and does not react quickly to changes in the atmosphere, being in this respect superior to teak but somewhat inferior to lignumvitae.

Mechanical properties.—Tonka is a very strong, tough wood. Green wood closely resembles Demerara greenheart in all mechanical properties, but it is slightly inferior to that species in all properties except tension across the grain and side hardness. It is much more dense than white oak, but it is also much stronger, except in cleavage and work to maximum load (shock resistance) (*127*), in which white oak is nearly its equal.

Air-dry tonka is much stronger than green wood in nearly all properties except for an appreciable reduction in cleavage resistance and tensile strength across the grain. However, in this condition it is clearly superior to white oak in all properties but cleavage resistance.

Working properties.—Tonka is difficult to work because of its high density and hardness. It is hard to saw and bore, but if sawed or bored clean edges and holes result. When severely interlocked grain is not present, the wood planes and finishes to a smooth surface (*231*). It glues poorly (*240*), as do many other woods of very high density, but takes a high polish (*82*).

Durability.—This species is very resistant to decay in contact with the ground (*132*, *82*, *231*). Untreated railway ties are reported to last 10 to 22 years in well-drained sites in Belem, Brazil, where they were considered superior to ties of creosoted oak (*133*). The high density of the wood may provide considerable resistance to damage by termites and marine borers, but no specific information is available on this. When unpainted wood is exposed to the elements (*55*), tonka weathers well as to surface smoothness and freedom from warp and checking.

Uses.—Tonka is used extensively for cogs and shafts, heavy construction, turnery, fishing rods, paving blocks, barge and dock fenders, and flooring. The wood is particularly well adapted for use in tool handles, agricultural implements, sporting goods, and other uses utilizing its high bending strength and good shock resistance qualities. The somewhat oily nature of the wood and its hardness allow its use for bearings, cogs, shafts, and other uses in place of lignumvitae, where friction wear is a problem. It makes excellent wood for railway crossties and posts, for it is durable and does not split when exposed to the elements.

This wood should also do exceptionally well as boat keels and frames, ice sheathing, industrial flooring, and specialty items requiring a strong durable wood. Small quantities have been shipped into the United States for high-grade face veneer (*132*).

Supply.—Tonka is available from British and French Guiana, Surinam, and possibly Trinidad.

WACAPOU

Vouacapoua americana

Nomenclature.—Timber of *Vouacapoua americana* Aubl. is generally known as wacapou, épi de bleu, and bois angelin in French Guiana, bruinhart or wakapoe in Surinam, and acapú and sometimes wacapou in Brazil. It is also known in the trade by the English names of brownheart and partridgewood and has been exported to Europe under the name of acapú or Amazon wood. (Legume family, Leguminosae.)

Distribution and habitat.—Wacapou is common in French Guiana and Surinam. It is a very important commercial timber tree in its Brazilian range (*132*), attaining its best development in the State of Para, Brazil, but apparently does not extend westward into the State of Amazonas (*190*). According to Bertin (*23*) this species produces the best timber of French Guiana but is of infrequent occurrence. In Surinam the tree occurs often in the rain forests and tends to grow in groups. According to the Surinam Forest Service (*231*), large-size trees are becoming somewhat

scarce in the presently accessible forests of that country. In general, the trees grow only in the upland rain forests where they occupy the higher lands close to the rivers.

Two other closely related species are known. *Vouacapoua pallidior* Ducke occurs in Brazil, where it is also called acapú. The other species, *V. macropetala* Sandw., known as sara in British Guiana, is covered separately in this work. The wood of both species is similar except in color, that of *V. pallidior* being dull chestnut brown with some narrow streaks of dark brown and fine pencil-striping of light-colored vessel lines.

The tree.—The trees are tall, slender, and unbuttressed, with a clear bole 50 to 75 feet long, and usually not more than 24 inches in diameter but at times reaching 36 inches.

The wood.—Wacapou is a hard, heavy dense wood. The heartwood is dark olive to dark chocolate and is clearly demarcated from the ¾- to 1¼-inch-wide, cream-colored sapwood (*248*). Numerous fine lines of parenchyma, which are initially lighter brown in color but which eventually turn nearly black, make the wood unusually attractive. Pfeiffer (*175*) refers to this wood as one of the finest growing in Surinam. The grain is straight to slightly roey; texture is uniformly coarse; the luster is low. No distinctive odor or taste is present in seasoned wood (*143*, *73*).

Weight.—The specific gravity of air-dry wood based on the weight and volume of wood in that condition is listed from 0.87 to 1.07 in reports from Surinam, French Guiana, and Brazil. On the basis of these reports, wacapou apparently averages about 0.95 in specific gravity, based on air-dry volume and weight, and weighs about 59 pounds per cubic foot air-dry and 75 pounds per cubic foot when green. Surinam wood averaged 0.79 (0.73 to 0.85) in specific gravity based on ovendry weight and green volume in tests at Yale University (*248*).

Seasoning.—The wood is considered moderately difficult to air-season, which it does at a moderate rate with slight warping in the form of cup and twist. Slight end and surface checking and casehardening are also liable to occur.

Shrinkage.—The dimensional and volumetric shrinkages exhibited by wacapou are low in comparison to the high density of the wood. Its shrinkage values from green to ovendry of 4.9 percent radially, 6.9 percent tangentially, and 13.0 percent in volume are less than comparable values for white oak, and about the same as those for black locust except in volumetric shrinkage, where black locust is considerably below wacapou. Shrinkage from green to air-dry would be about half the above values. Wacapou is a relatively stable wood undergoing only moderate changes in volume in response to atmospheric changes.

Mechanical properties.—Tests of mechanical properties have been made on wacapou from Surinam by Yale University (*248*) and Pfeiffer (*175*) and on wood from French Guiana by the Centre Technique Forestier Tropical in France (*50*).

In the most recent tests at Yale, green wacapou was found to be equal or superior to other tropical woods of similar high density in all mechanical properties except hardness, shear, cleavage resistance, and tension across the grain. It is inferior to greenheart, which is also considerably heavier, in all mechanical properties except work to proportional limit and shock resistance.

When air-dry, the wood is about average for its density in most static-bending and compression parallel to the grain properties. It is above average in elastic resilience but below average in shock resistance, hardness, shear, and cleavage resistance, and particularly low in compression and tension across the grain. It is also generally inferior to the heavier greenheart when air-dry, except in elastic resilience and shearing strength in which both woods are about equal.

Wacapou is much superior to white oak (*Quercus alba*) in bending and compression parallel to the grain, shock resistance, and side hardness. It is surpassed by oak in compression and tension across the grain, in cleavage resistance, and very slightly in shearing strength.

Working properties.—The wood is considered, despite its high density, only moderately difficult to work and is generally said to have good working qualities. Smooth surfaces are obtained in sawing and planing, but the coarse grain causes some rough and torn grain in boring and mortising (*231*).

Durability.—Wacapou is reputed to be highly resistant to decay and insect attack. It was found to be very durable upon exposure to both a white-rot and a brown-rot fungus in pure culture tests (*248*). Untreated wacapou ties have remained sound for 6 to 8 years in poorly drained soil in Brazil, and for 18 to 20 years in well-drained soils. In South Africa untreated ties were good for 8 to 9 years in wet locations and 18 years in dry locations (*133*).

Heartwood of wacapou is rated by Wolcott (*263*) as resistant to the dry-wood termite of the West Indies. It is comparable in this respect to West Indies mahogany (*Swietenia mahagoni*) and greatly superior to Honduras mahogany (*S. macrophylla*).

According to Edmondson (*76*), wacapou has little resistance to marine borer attack in Hawaiian waters. However, two series of tests at Wrightsville, N.C., showed the wood to have a high resistance to teredo. In the first test there was no evidence of attack in 16 months, whereas greenheart was moderately damaged in the same period; and greenheart was destroyed in 30 months, while wacapou showed only moderate damage in 33 months. In the second test, only slight marine borer activity was noted on wacapou after a year of exposure (*58*).

Wacapou is currently rated the fifth most teredo-resistant wood of 37 tested at Wrightsville, with *Licania macrophylla*, *Parinari rodolphii*, *P. campestris*, and *Eschweilera subglandulosa* bettering wacapou in the order listed (*58*). Silica content of wacapou is 0.002 percent and ash content 0.51, eliminating the possibility that silica content is an important factor in the wood's teredo resistance (*247*).

Uses.—Wacapou, one of the most highly regarded woods of Brazil, Surinam, and French Guiana, has been exported only in small quantities to the United States. It is used in the Guianas for furniture, cabinetmaking, flooring, wheelwright's work, beams, general construction, railway crossties, and posts. Horn (*132*) states that it is used in the Amazon Valley for flooring, cabinetwork, interior trim, piling, rising and gunwales of boats, crossties, and general construction. The timber's natural resistance to marine borer attack and termite damage and its relatively high price make it best adapted for all types of marine and civil construction, as well as for high-class furniture, interior trim, and parquet flooring and cabinetwork.

Supply.—Wacapou is available in limited quantities but can be secured for export from French Guiana and Surinam in the Caribbean area.

WALLABA

Eperua falcata, Eperua grandiflora, Eperua jenmanii, Eperua schomburgkiana

Wallaba is one of the most abundant good-quality timbers in the Guianas, where it is used extensively for many purposes. Despite its high resin content, which causes some difficulty in machining, the wood may soon become an established timber on the world market. Wallaba utility poles and heavy timbers are presently gaining in popularity on the export market.

Nomenclature.—Species commonly marketed under the trade name wallaba are *Eperua falcata* Aubl., *E. grandiflora* (Aubl.) Benth., *E. jenmanii* Oliver, and *E. schomburgkiana* Benth. Legume family, Leguminosae.)

Eperua falcata is commonly known as soft wallaba, water wallaba, yoboko and ituri wallaba in British Guiana, generally walaba ituri walaba, or bijlhout in Surinam, and wapa or ituri wallaba in French Guiana. The other species are most commonly known as ituri wallaba in the Guianas. The timber is called palo machete or uapa tabaco in Venezuela and aipe or apa in Brazil. Other common names by countries are as follows: bie-iehoehoe, bili-hoedoe (biri hoedoe), hariraro walaba, pallewie (parrewe), roode walaba, tamoene, toto amate (waapa), and wouapa in Surinam; awapa, bois de sabre, eperu, wapa blanc, wapa gris, and wapa huileaux in French Guiana.

Distribution and habitat.—The species discussed in this report are centered in the Guianas but extend into Venezuela and the Amazon region of northern Brazil. The wallabas generally occur in pure stands or as dominants in the wallaba type, an edaphic climax on acid, white sandy soils, and locally are frequent in rain forests. The wallaba type covers large areas of country, mostly flat plateaus and flat tops of ridges and hills, sometimes extending for many miles (*81*). The wallabas also occur as riparian or swamp trees in other areas and in the mora forests of the far interior of British Guiana. They are also found on one of the driest soils in that country and may be present in almost any forest type. The white sandy soils have no agricultural value but are capable of supporting wallaba stands averaging 600 cubic feet of merchantable trees per acre. Under good conditions, a wallaba forest can be recut 30 years after the initial harvest, indicating that these otherwise poor sites afford good growing conditions for the wallabas. Caribbean pine or pitch pine (*Pinus caribaea*) is presently planted with some success on the white wallaba sands in Surinam and British Guiana.

The tree.—The four species marketed as wallaba are very similar in appearance and wood structure. Fanshawe (*81*) describes the trees of *Eperua falcata* and *E. grandiflora* as follows:

> Semideciduous canopy trees reach 32 inches diameter breast height and 100 feet high, usually 16 to 24 inches diameter breast height and 80 to 90 feet high, bole 40 to 60 feet, basally swollen or with low buttresses; stem form good, cylindrical with little taper; branches erect, slender; crown light, rounded or oval.

The trees make rather rapid growth but develop heart rots at a fairly early age. Many trees are defective, resulting in an average cull of 15 to 20 percent in merchantable stands. Round logs 16 to 28 inches in diameter and 20 to 25 feet long are obtainable. Transmission poles are available up to 60 feet long with butt diameters of 8 to 12 inches after being fashioned.

The wood.—Typical logs have 1 to 2 inches of dirty white or gray colored, resin-streaked sapwood that is sharply defined from the full red or reddish-purple heartwood. The surface of the wood is streaked in concentric rings with gummy exudations. Concentric zones of denser wood marked by gummy exudations also occur in the heartwood at irregular intervals. Growth rings are distinct, marked by parenchyma. Pores are distinct to the naked eye, evenly distributed, and occasionally contain gum. Rays are very distinctive on the radial surface. Intercellular canals are filled with gum associated with the terminal parenchyma.

The wood has uniformly straight grain and medium to coarse texture. It is hard, heavy, stiff, and strong but not difficult to cut. The wood is not lustrous, but quartersawed lumber shows a pleasing fleck as a result of resinous deposits (*27*).

It is tasteless and is either odorless or has a slight odor described as rancid, sour, or like creosote by different observers (*143*).

Weight.—The four species in this group are considered to have very similar density. However, detailed information is available only for *Eperua falcata*. Specific gravity, based on green volume and ovendry weight, is reported at 0.78 for this species. Air-dry wood averages 0.93 in specific gravity and weighs 58 pounds per cubic foot. Green wood weighs 76 pounds per cubic foot (*149*).

Seasoning.—Wallaba dries slowly with a marked tendency to warp and split. An initial period of air-seasoning prior to kiln-drying is required to avoid heavy degrade. Otherwise severe distortion, checking, and honeycombing will occur. Kiln Schedule 3 of the Forest Products Research Laboratory in England has been used successfully (*222*).

Shrinkage.—The following tabulation lists shrinkage values determined by three independent tests. It illustrates that wallaba, although heavier than white oak, shrinks much less in radial, tangential, and volumetric proportions.

	Shrinkage (green to ovendry)			
Species and source	*Radial (percent)*	*Tangential (percent)*	*Longitudinal (percent)*	*Volumetric (percent)*
Wallaba (*Eperua falcata*):				
French Guiana (*50*)	------	------	------	9. 10
British Guiana (*175*)	3. 0	6. 0	0. 17	. 35
French Guiana (*149*)	4. 3	7. 8	------	11. 70
Average	3. 6	6. 9	. 17	10. 0
White oak (*Quercus alba*), United States (*160*)	5. 3	9. 0	------	15. 8

Mechanical properties.—The wood's hardness, bending strength, and stiffness under gradually applied loads and its compressive strength along the grain are in proportion to its density. However, its resistance to shock loads and splitting are somewhat below the average for tropical hardwoods of similar density. According to tests in the United States (*149*) and in England (*15, 105*), wallaba in comparison to white oak in the green state is 40 percent heavier, 40 percent harder, and 75 percent stronger and stiffer in bending under gradually applied loads. Air-dried wallaba is clearly superior to white oak in all properties except tension perpendicular to the grain and shear. It is superior to pitch pine from Honduras in all properties except impact bending and toughness but is considerably below that wood in toughness and slightly lower in impact bending.

Working properties.—Wallaba is hard but works easily with machine and hand tools except that gum collects on the cutting edges of the tools. During conversion of logs the saw teeth are also often clogged with gum. This has been satisfactorily overcome by using saws with 3½-inch pitch and generous gullet space, or by applying a mixture of kerosene and water or a steady stream of water to the blade during sawing. Radial splits and cup shakes may also occasionally occur during conversion.

A recent study of wallaba at the Forest Products Research Laboratory in England (*77*) illustrated one system by which the timber can be successfully worked to control the detrimental effects of the resinous exudations. Logs from British Guiana were converted into lumber using a saw with 3½-inch pitch and large gullet space, plus the application of kerosene and water. After an initial period of air-drying, the lumber was kiln-dried. It was next planed on a Woods 501–B four-cutter planer using high-speed steel cutters with cutter angle of 25 degrees backed to 15 degrees. A feed speed of 75 feet per minute was used. Machine finish was good without grain pickup, and little gum was left on the cutters, which stood up well to the run.

Immediately after planing the wood was treated with filler and wax polish. This finish essentially stopped all further exudation of resin and gave the author reason to conclude that the high gum content has little, if any, detrimental effect on the appearance of the wood after polishing. No difficulty was experienced in crosscutting or end grooving the wood, which gave a good clean and accurate finish. Abrasion tests showed the wood to be equal to hard maple, Rhodesian teak, and East African olive.

The wood polishes reasonably well after filling, stains readily with both oil and spirit stains, and turns well. It usually splits straight and clean but does not take nails satisfactorily.

Durability.—The heartwood of wallaba is generally considered resistant to insects and very resistant to decay. The sapwood is not durable and is heavily attacked by pinhole borers and termites soon after logging. The General Post Office in British Guiana reports the average life of untreated transmission poles to be 20 years; some poles are sound after 30 years. In British Guiana untreated heartwood stakes of *Eperua falcata*, 1 by 4 inches by 2 feet driven 8 inches in the ground, were highly resistant to decay, lasting 8 to 9 years in the ground. Wolcott (*263*) rates wallaba as resistant to the dry-wood termites of the West Indies, comparing wallaba with Honduras mahogany in this respect. Edmondson (*76*) found *E. falcata* to have low resistance to marine borers in Hawaiian waters.

Uses.—Wallaba is exceptionally well suited for use as transmission poles, flagpoles, and posts. Its good strength and durability qualify the timber for railway ties, shoring, bridge timbers, and mine timbers. In building construction it is used for foundations, sills, joists, framing, roofing, siding,

and veranda posts. It is also used in British Guiana for vat staves, shingles, and paling. The high resin content of the wood makes it an excellent flooring material in chemical factories, mills, and warehouses, and it is currently exported to Martinique as sawed beams. The wood has a relatively high caloric value as fuelwood or charcoal, ovendry heartwood having a caloric value of 9,260 B.t.u. and sapwood 8,980 B.t.u. as compared to 12,000 B.t.u. for coal. Charcoal made from *Eperua falcata* has a caloric value of 13,200 to 13,800 B.t.u. (7,300 calories) per pound (*114*).

Rather extensive tests on the pulping characteristics of wallaba at the Imperial Institute in London proved with certain reservations the practicability of making paper from this wood. Wallaba (*Eperua falcata*) when treated by the soda process gave a good yield of pulp, which was of good quality but not easily bleached. It furnished paper of satisfactory strength and character, suitable for book or writing paper but not kraft paper for it lacked strength for this class of paper and the beating costs would be unusually high. The wood is not considered suitable for the sulphite process because of its high resin content (*83*, *115*).

Samples of hardboard of good quality have been made from semichemical pulps in conjunction with the extraction of resin. A process patented by Fleck and Schuler (*264*) in England isolates wallaba resin, which is reacted with aldehydes in situ to form thermoplastic or thermosetting resins, giving a cheap molding powder. This promises the development of a wet-forming or dry-forming process for making fiberboard from wallaba.

In 1951 wallaba was second to greenheart in exports from British Guiana. Wallaba transmission poles are being shipped in increasing numbers to the West Indies islands and the United Kingdom, and limited quantities are exported to the United States.

Supply.—Wallaba is one of the more common and accessible woods in the Guianas. Large areas of merchantable timber are located along navigable rivers and near docking and other shipping facilities. Most information on available supplies comes from British Guiana, where the volume of merchantable timber in the accessible forests is estimated at 17,000,000 tons or 850,000,000 cubic feet.

In one 214,500-acre tract in British Guiana, wallaba averages more than 1,800 board feet per acre over an area of 10,345 acres. It is predominant on 81,500 acres of the total, averaging more than 3,400 board feet per acre in sound trees 16 inches and over. Many stands contain 500 to 600 cubic feet of wallaba per acre in merchantable trees. The wallaba forest type when cut for firewood down to 4 inches in dimeter averages from a low of 1,000 to a high of 3,600 cubic feet per acre (*121*).

WAMARA

Swartzia leiocalycina, Swartzia benthamiana

Nomenclature.—The genus *Swartzia* contains more than 90 species of shrubs and trees native mostly to tropical America but also found in tropical Africa. The timber of two very similar species, *Swartzia leiocalycina* Benth. and *S. benthamiana* Miq., of British Guiana and French Guiana is marketed under the trade names of wamara in British Guiana and montouchi in French Guiana. The wood of *S. benthamiana* is also known locally in British Guiana as itikiboroballi. Other species of *Swartzia* are described under Parakusan. (Legume family, Leguminosae.)

Distribution and habitat.—Both species grow in British Guiana but only *Swartzia benthamiana* is reported in commercial quantities in French Guiana, although the other may also grow there in limited quantities. Both species may also occur elsewhere in the American tropics.

Swartzia benthamiana is found as an occasional tree in the wallaba and rain forest of British Guiana and is of general distribution in the near interior. *S. leiocalycina* grows throughout the country except in the northwest district. It occurs as a frequent to dominant species in the seasonal forest and as an occasional to frequent tree in the rain forest.

The tree.—Both species providing wamara timber are small-crowned canopy trees usually with low buttresses. Mature trees are generally 16 to 20 inches, sometimes up to 28 inches, in diameter and 90 to 110 feet high. Boles are clear of branches for 50 to 70 feet above the low buttresses and may often be flat or somewhat flanged in shape. In general, *Swartzia leiocalycina* is slightly larger than *S. benthamiana.*

The wood.—The sapwood of wamara, according to Ducke (*73*), is very wide and only the largest trees contain heartwood. Nearly white in color, it is reputed to be one of the most beautiful woods of the Amazon Valley. The heartwood varies from a chocolate brown to a pale reddish purple or purplish brown, occasionally marked by dark olive or purplish-brown colored stripes. The texture is very fine and the grain is generally straight but may be variable. It is extremely heavy, hard, compact, and resilient, and usually has good luster. The pores are small but are made readily visible by the soft pale-colored parenchyma tissue surrounding them. Very fine ripple marks are visible but not conspicuous on surfaced slash-sawed boards. Odor or taste is not distinctive in dry wood (*82*, *190*, *10*).

Weight.—Wamara is a very dense, heavy wood. *Swartzia leiocalycina* is reported to have an air-dry specific gravity of 1.06, based on volume and weight in that condition, and to weigh 66 pounds per cubic foot (*16*). Green wood weighs 75 pounds per cubic foot. *S. benthamiana* is some-

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what lighter, with a specific gravity of 0.80 to 0.96, averaging 0.88, based on air-dry volume and weight. It weighs 50 to 60 pounds per cubic foot (*82*, *10*).

Seasoning.—Information on seasoning is lacking for this wood except for Horn's reference (*132*) that *Swartzia tomentosa* DC. of Brazil (probably the same as *S. benthamiana*) checks considerably in drying. Bannia, *S. bannia* Sandw., a somewhat heavier species of British Guiana and Surinam is also moderately difficult to air-dry (*250*). It is reasonable to assume that wamara has similar seasoning characteristics.

Shrinkage.—Information on directional shrinkage is lacking for this timber. The French Tropical Forest Technical Center reports shrinkage of *Swartzia benthamiana* in volume from green to ovendry (expressed as a percent of the green volume) amounts to 13.3 percent (*50*). This is a moderately high value, about double the shrinkage that would occur from green to air-dry. Volumetric shrinkage of West Indies mahogany (*Swietenia mahagoni*) was determined in two different tests by the same Center to be 7.8 and 9.0 from green to ovendry. Shrinkage is equal to that for white ash and below that for white oak.

Pfeiffer (*175*) found *Swartzia* spp. from Surinam to have a high movement value in response to changes in atmospheric conditions. Material tested increased in volume between ovendry and equilibrium with relative humidities of 40, 70, and 100 percent by 8.4, 11.3, and 20.2 percent, respectively, based on the original ovendry volume. This is considerably above the average for most woods tested but can be partially attributed to the high density (1.25) of the wood used in the tests. The extreme density of the wood used by Pfeiffer suggests bannia (*S. bannia*) was tested.

Mechanical properties.—Mechanical tests of *Swartzia benthamiana* by the French Tropical Forest Center (*50*) indicate wamara possesses very high strength properties. Compared to woods of similar density, it is above average in stiffness and maximum bending stresses but somewhat below in resistance to splitting. As compared to kopie (*Goupia glabra*) and purple heart (*Peltogyne venosa*), it is intermediate in hardness on the radial surface and resistance to impact bending. It is superior to these species in maximum bending stress parallel to the grain and stiffness, but inferior to both species in resistance to splitting. However, its overall strength properties are very high, fitting it for most uses where good strength is needed.

Working properties.—Wamara is variously reported as very difficult to moderately difficult to work with either hand or machine tools, for it is a hard, high-density wood. But there is general agreement that the wood finishes smoothly, turns very satisfactorily (as do many other very dense woods), and polishes well. It takes nails badly and needs preboring for the use of nails or screws (*10*, *132*, *142*).

Durability.—The heartwood is generally reported to be very resistant to decay. For example, in graveyard tests in British Guiana (*50*), the heartwood of *Swartzia leiocalycina* lasted an average of 8 to 9 years in both wet and dry locations. The sapwood, which makes up the bulk of the lumber produced, is not durable. The wood is rated resistant to damage by the dry-wood termite but less resistant than West Indies mahogany and slightly more resistant than Honduras mahogany (*263*). *S. leiocalycina* was found to have little resistance to marine-borer damage in Hawaiian waters (*76*). The silica content of the wood is reported as only 0.01 percent of the ovendry weight (*14*).

Uses.—Wamara heartwood is one of the most attractive woods on the export market. The dark heartwood is used for inlay, walking sticks, bagpipes, parquet flooring, and bows, and is recommended as a substitute for ebony for it polishes to a high luster. The whitish sapwood is used in some localities for implement frames and spokes of wheels; the heartwood for posts, articles of turnery, furniture, cabinetwork, and heavy and durable construction. The sapwood has been recommended as a substitute for hickory (*Carya*) for those purposes requiring very strong, tough, and resilient material (*193*).

The wood is used for structural timber, scantlings, and so forth in the government housing program in British Guiana. It should be well fitted for many other uses requiring a heavy, hard wood having high bending and compression strength, abrasion resistance, and durability.

Supply.—British Guiana and French Guiana have exportable quantities of wamara.

YEMERI

Vochysia hondurensis

Nomenclature.—Yemeri is the preferred trade name in British Honduras for timber of *Vochysia hondurensis* Sprague, a species of southern Mexico and Central America. The timber is known also as emeri, emory, and yemoke in British Honduras and San Juan in Honduras, and as palo de chancho in Costa Rica. South American species of *Vochysia* are treated under the trade name kwarie. (Vochysia family, Vochysiaceae.)

Distribution and habitat.—*Vochysia hondurensis* is one of the few species of the genus occurring outside of South America. It is distributed in the tropical zone from southern Mexico and British Honduras to Costa Rica (*215*, *265*, *150*). *V. guatemalensis* Donn. Smith occurs at higher elevations in the subtropical zone in southern Mexico, Guatemala, and Honduras.

Yemeri is found throughout British Honduras both on silt soils along river banks and on sandy

soils. It attains its best development on the coastal plain where it grows in almost pure stands. It occurs extensively in the "buamil," or second growth, on abandoned farmlands on soils of the poorer type but will not grow on very swampy land and is rare on limestone and marl sites (*224*). In Honduras, it occurs in the intermediate forest on medium- to well-drained clayey soil (*223*).

The tree.—Yemeri trees are medium to large unbuttressed, canopy trees. Diameters of 2 to 3 feet and heights of 90 to 130 feet are common, and trees are reported to occasionally grow to 6 feet in diameter and 190 feet high. The boles are straight, clear, cylindrical, and usually 50 to 60 feet long. The outer bark is smooth, gray, and rather papery in texture (*127*).

The wood.—Yemeri is similar in some respects to Spanish cedar (*Cedrela*), especially in color. Freshly cut heartwood varies from a light brown to pinkish yellow turning a dull uniform pink or pinkish brown when dry, sometimes with a distinct golden cast. The heartwood is distinct but not always sharply demarcated from the whitish 3½- to 5½-inch-wide band of gray or buff sapwood.

Vertical traumatic gum ducts, filled with orange-brown gum, may occur sporadically and are sometimes large enough to be considered an objectionable defect. The luster is medium to high. It is a typically straight-grained wood, but interlocked grain may occur in layers 1 to 2 inches thick. These layers of interlocked grain produce an unpretentious stripe figure on quartersawed surfaces. Texture of the wood is coarse to medium and of a rather fibrous nature. No distinctive odor or taste is present in seasoned wood (*241*, *150*, *103*, *217*).

Weight.—The wood is reported to vary somewhat in density, apparently from local growing conditions. The specific gravity averages about 0.37 (0.29 to 0.45) based on ovendry weight and green volume. The specific gravity of air-dry wood based on weight and volume in that condition ranges from around 0.42 to 0.47. Air-dry wood weighs about 26 to 29 pounds per cubic foot and green wood about 67 pounds per cubic foot (*127*, *103*, *50*).

Seasoning.—Yemeri is moderately difficult to air-season and kiln-dry. It air-seasons at a rapid rate with moderate twist and slight checking, crook, bow, and cup. Collapse is also liable to occur in stock 1¼ inches or more in thickness (*249*). The wood can be kiln-seasoned fairly rapidly with very little tendency to check or split but with a marked tendency to distort, particularly in the form of twist and cup. Some collapse may occur in thicker stock. Reconditioning kiln-distorted stock is only partially effective. In order to minimize warping, a sticker spacing of not more than 18 inches is recommended with all stickers in vertical alinement and the top of the pile weighted down (*148*). Forest Products Research Laboratory Kiln Schedule 1 (*222*) and U.S. Forest Products Kiln Schedule TD–42 (*238*) are recommended, the latter for 4/4 stock.

Shrinkage.—Reported shrinkage values for yemeri do not always agree. Hess (*127*) reports shrinkage from green to ovendry at 2.0 percent radially, 9.0 percent tangentially, and 9.8 percent in volume. This compares well with a radial shrinkage of 2.8 percent and tangential shrinkage of 6.5 percent reported by U.S. Forest Products Laboratory (*68*).

The Forest Products Research Laboratory in England (*222*) reports the radial and tangential shrinkage at 2.0 and 6.0 percent, respectively, from green to air-dry (12 percent moisture content), which is usually about half the shrinkage from green to ovendry. This amounts to about ¼ inch per foot in the radial direction and ¾ inch per foot in the tangential direction.

British Honduras (*150*) reports shrinkage values of ⅛ inch and 9/16 inch per foot in the radial and tangential directions, respectively, from green to air-dry (14 percent moisture content). This would amount to about 1.0 percent in the radial plane and about 4.7 percent in the tangential plane.

All these values indicate a moderate rate of shrinkage but show a high ratio of tangential to radial shrinkage, possibly the principal cause for the distortion that occurs during seasoning. The low radial shrinkage indicates the advantages of using quartersawed stock where stability is desirable.

Mechanical properties.—The average strength properties of yemeri in both the green and air-dry condition are equal to and, in several properties, greater than those of most woods of similar low density.

Green yemeri is considerably harder than most woods of similar weight and is somewhat superior in stiffness and toughness. It is quite similar to yellow-poplar (*Liriodendron tulipifera*) in most properties and decidely superior in hardness. In general, it is inferior to white oak, which is also of much higher density.

Upon seasoning, yemeri increases in most properties, retaining its close similarity to yellow-poplar and Scotch pine (*Pinus sylvestris*) in most strength properties, but is 40 to 50 percent harder than either species and 40 percent superior to Scotch pine in resistance to splitting (*150*, *127*, *103*).

Working properties.—Although it is easily worked by either hand or machine tools, yemeri has relatively poor machining qualities. The timber is fibrous, coarse in texture, hard, and fairly tough. It resembles a coarse grade of mahogany in machining properties but, unlike mahogany, has a tendency to blunt cutting edges. Sawing along the grain is done without difficulty, but wooly surfaces are common on end grain in crosscutting. A fairly wide tooth-pitch is necessary for best results. Raised grain is a common

defect in planing, molding, and similar operations as well as rough end grain. Sharp cutters will considerably alleviate the problem of raised grain, and sanding will provide a satisfactory finish on the roughened end grain.

The wood is not suited for turnery because of its open texture; the finish is rough, and poor detail results from the tendency for feather edges to break off (*241*). The open texture also necessitates a considerable amount of filling before polishing. Yemeri takes glue, paint, and nails well and polishes to a good finish, although wood with water stains should not be used as they cause considerable grain raising. It is fair wood for steam bending.

The U.S. Forest Products Laboratory found yemeri to be considerably below the average for 15 tropical American species tested in planing, boring, and turning, and slightly below the average in shaping, sanding, and mortising. However, it was found to be a better wood to shape, sand, and mortise than the average of 25 hardwoods of the United States (*68*).

Durability.—The different species of *Vochysia* are known to vary in their resistance to decay, and yemeri is no exception. The heartwood is rated durable to very durable to a white-rot fungus and moderately durable to nondurable to a brown-rot fungus. Two classes of timber are recognized after felling in British Honduras: "white" and "red." The "white" yemeri is considered to be nondurable and the "red" yemeri to be slightly less durable than santa-maria (moderate durability).

Six- by 7½- or 8-inch yemeri railway ties with 5 to 6 inches of heartwood were reported to last 3½ to 4 years in the hinterland of British Honduras without treatment, and 4 to 5 years when given a brush application of preservative. In the less humid coastal area, they lasted 4½ to 5 years untreated and 5 to 6 years when treated (*86*). Graveyard tests in England found yemeri from British Honduras to be variable in decay resistance; heartwood lasted 3.9, 11.0, and 12.0 years on three different sites (*206*).

Specific tests have not been conducted with yemeri, but other species of *Vochysia* are reported by Wolcott (*263*) to vary from resistant to susceptible to attack by the dry-wood termite of the West Indies and according to Edmondson (*76*) have little resistance to marine-borer attack in Hawaiian waters. Unpainted yemeri weathers well, showing only moderate surface roughness and slight surface checking upon exposure (*249*, *224*).

Preservation.—Both the heartwood and sapwood are readily impregnated with preservatives; the vessels and not the fibers take up most of the preservative (*150*).

Uses.—Yemeri is used for general carpentry, exterior siding, interior construction, and dugout canoes. It is occasionally used for house siding in British Honduras and is reported to be superior to imported second-growth pine from the United States for this purpose. It is considered promising for use in boxes and crates, inexpensive furniture, and for numerous articles requiring a painted finish. Because it resembles Spanish cedar (*Cedrela* spp.), yemeri may be suitable for general utility plywood, core stock, and possibly high-grade face panels in furniture. However, the successful use of this timber will depend largely on the care given in conversion and seasoning.

Supply.—Yemeri is available in quantity from British Honduras.

YOKEWOOD

Catalpa longissima

Nomenclature.—Yokewood is one of the important timbers of Jamaica and Haiti. The tree and timber of *Catalpa longissima* (Jacq.) Sims are known also as French oak, mast wood, Jamaica oak, Haitian oak, chêne Haitien, bois chêne, radegonide, chêne d' Amérique, chêne noir, and pois doux marron. A synonym is *Macrocatalpa longissima* (Jacq.) Britton. (Trumpet-creeper family, Bignoniaceae.)

The three small-leaved evergreen species of *Catalpa* in the West Indies are placed by some authors in the segregate genus *Macrocatalpa*. Two other species, *C. speciosa* Warder and *C. bignonioides* Walt., are native in southeastern United States and are grown as ornamentals. The first was widely cultivated in plantations at one time.

Distribution and habitat.—Yokewood is common in Jamaica and Haiti and occurs also in Dominican Republic and Cuba. It has been introduced also in Guadeloupe and Grenada of the Lesser Antilles. In Jamaica the tree grows in the dry coastal plains of the south and southeast sides of the island and along sandy river banks but is rarely found above 1,000 feet in elevation. Yokewood has also been planted with considerable success in Jamaica on rocky and degraded sites at low elevations (below 1,500 feet) in arid areas receiving less than 40 inches of rainfall. The tree reproduces exceptionally well on the gravelly detrital flood fans along the St. Thomas River. This natural regeneration is used to reforest other areas and has a high degree of tolerance to unfavorable site conditions. Planted trees tend to be bushy when young, but later a dominant leader takes over, developing into long straight stems at maturity (*48*, *229*).

The tree.—Yokewood is a large tree growing to 80 feet in height and 3 feet in diameter.

The wood.—The heartwood is grayish to light brown in color in contrast to the distinctly lighter

sapwood. The texture is medium to coarse, the luster fairly high, and the grain generally straight. Seasoned wood has an odor suggesting kerosene but no distinctive taste (*229*, *190*).

Weight.—The weight of air-dry wood is given at 37 to 50 pounds per cubic foot by Stehlé (*218*) and at 70 pounds (probably green wood) by Swabey (*229*). The specific gravity of air-dry wood will average from 0.60 to 0.80 on the basis of the weight given by Stehlé.

Seasoning.—No data are available.

Shrinkage.—No data are available.

Mechanical properties.—Detailed tests of strength properties have not been made on yokewood. It is reported by Stehlé (*218*) to be medium hard, tightly knit, and elastic.

Working properties.—No other information is available on the working qualities of yokewood other than it saws easily (*229*).

Durability.—The Forest Department of Jamaica reports that the timber is considered durable in contact with the weather but does not include the timber in the list of woods durable in contact with the ground (*229*). Other sources report the wood as durable or very durable (*50*, *218*). Wolcott (*263*) rates yokewood only moderately resistant to the dry-wood termite of the West Indies.

Uses.—Yokewood is one of the most useful native timbers in Jamaica for boatbuilding and in general construction for sills, shingles, framing, boarding, and flooring. It is also made into the bodies of carts and wagons. In Haiti the timber is used principally for furniture and house construction.

Supply.—The supply is presently limited in Jamaica and Haiti with only small volumes available for export.

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APPENDIX

TABLE 10.—*Strength properties of Caribbean*

[Air-dry strength properties

Species	Source	Moisture content	Weight per cubic foot [1]	Specific gravity: Green volume and ovendry weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Angelique							
Dicorynia guianensis [2a]	Surinam	78. 7	67	0. 60	7, 650	11, 410	1, 840
Baboen							
Virola surinamensis [2b]	Brazil	93. 8	51	. 42	3, 580	5, 600	1, 640
Bagasse							
Bagassa guianensis [2a]	Brazil	58. 0	67	. 68	10, 340	14, 510	2, 300
Balata							
Manilkara bidentata [2a]	Surinam, British Guiana, Puerto Rico	47. 6	78	. 85	11, 120	17, 310	2, 700
Banak							
Virola koschnyi [3]	Central America	75. 0	48	. 44	----	6, 200	1, 470
Baromalli							
Catostemma fragrans [4]	British Guiana	154. 5	70	. 50	5, 200	8, 100	1, 610
Catostemma sp. [2c]	British Guiana	62. 6	61	. 60	6, 860	10, 670	2, 300
Bethabara							
Tabebuia serratifolia [2b]	Surinam, Brazil	31. 2	75	. 92	14, 220	22, 560	2, 920
Bustic							
Dipholis salicifolia [5]	United States	44. 0	77	. 86	5, 800	12, 400	1, 860
Cedar, Central American							
Cedrela sp. [5]	Nicaragua	73. 0	37	. 34	3, 360	5, 220	870
Courbaril							
Hymenaea courbaril [2a]	Honduras, Puerto Rico, Surinam, Panama	60. 8	71	. 71	7, 910	12, 940	1, 840
Hymenaea davisii [2a]	British Guiana	64. 8	70	. 67	8, 230	12, 440	2, 080
Crabwood							
Carapa guianensis [2c]	Brazil	72. 4	60	. 56	7, 190	11, 110	1, 560
Carapa guianensis [6]	British Guiana	58. 0	51	. 52	----	9, 900	1, 960
Determa							
Ocotea rubra [2a]	Surinam, British Guiana	83. 2	61	. 52	5, 420	7, 820	1, 460
Ocotea rubra [3]	Brazil	41. 0	*49	----	----	8, 100	1, 420
Gommier							
Dacryodes excelsa [7]	Puerto Rico	56–65	38	----	6, 480	9, 330	1, 200
Greenheart, Demerara							
Ocotea rodiaei [4]	British Guiana	42. 7	78	. 88	13, 250	19, 550	2, 970
Ocotea rodiaei [6]	British Guiana	41. 0	*76	----	----	19, 300	2, 970
Gronfoeloe							
Qualea albiflora [2a]	Surinam	150. 9	79	. 49	5, 660	8, 640	1, 630
Qualea rosea [2c]	Surinam	82. 5	60	. 53	6, 190	10, 510	2, 030
Gumbo-limbo							
Bursera simaruba [5]	United States	99. 0	38	. 30	2, 000	3, 300	560
Hura							
Hura crepitans [2a]	Venezuela, Panama, Surinam	67. 2	40	. 38	3, 930	6, 310	1, 040
Kopie							
Goupia glabra [2b]	Brazil, Surinam	65. 7	73	. 70	8, 180	11, 480	1, 810

See footnotes at end of table.

timbers in the green condition

are given in table 11]

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
1. 78	12. 0	4, 810	5, 590	2, 180	1, 100	1, 100	1, 000	700	1, 340	340	151. 2
. 46	4. 1	1, 740	2, 390	1, 900	430	320	200	260	720	180	60. 6
2. 84	11. 3	6, 060	7, 900	2, 510	1, 620	1, 670	1, 200	650	1, 670	370	195. 5
2. 51	13. 6	7, 030	8, 690	3, 060	2, 160	2, 230	2, 480	990	1, 900	480	264. 8
---	5. 3	---	3, 050	---	590	440	---	---	660	245	---
. 94	6. 7	2, 710	3, 840	1, 800	570	520	280	610	810	260	---
1. 14	7. 3	3, 330	4, 280	2, 680	590	630	360	210	750	180	165. 7
4. 55	27. 6	8, 890	10, 350	3, 110	2, 630	3, 060	2, 300	1, 340	2, 120	620	403. 8
1. 00	17. 1	3, 750	5, 330	---	---	---	1, 700	---	---	---	---
---	7. 4	---	2, 760	---	380	350	310	---	720	---	---
1. 87	14. 6	4, 260	5, 800	1, 960	1, 780	1, 970	1, 640	1, 220	1, 770	540	230. 5
1. 62	8. 5	4, 260	5, 540	2, 450	1, 480	1, 610	1, 120	890	1, 680	410	187. 8
1. 92	11. 4	3, 980	4, 930	1, 170	1, 150	1, 060	960	500	1, 320	350	129. 9
---	---	---	5, 120	---	1, 020	830	---	---	---	320	---
1. 18	4. 8	3, 040	3, 760	1, 740	450	520	550	620	860	280	75. 0
---	6. 1	---	4, 560	---	620	610	---	---	900	275	---
2. 00	10. 9	3, 260	4, 530	1, 700	840	690	730	---	1, 120	270	---
3. 31	13. 4	7, 580	10, 160	3, 580	2, 260	2, 320	2, 040	1, 070	1, 730	610	---
---	35. 3	---	10, 500	---	2, 160	2, 110	---	---	1, 320	500	---
1. 18	6. 8	3, 640	4, 840	1, 950	600	510	630	590	1, 070	300	98. 8
1. 07	9. 3	3, 800	5, 200	2, 300	1, 030	930	560	480	1, 250	320	155. 9
. 45	3. 5	930	1, 510	---	290	230	290	380	590	170	---
. 89	5. 9	1, 960	2, 790	1, 170	520	440	420	430	830	220	70. 3
2. 08	7. 6	4, 880	6, 170	2, 140	1, 400	1, 380	1, 050	980	1, 550	430	131. 9

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TABLE 10.—*Strength properties of Caribbean*

[Air-dry strength properties

Species	Source	Moisture content	Weight per cubic foot [1]	Specific gravity: Green volume and ovendry weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Kurokai							
Protium decandrum [8]	British Guiana	72. 0	50	0. 53		10, 450	1, 560
Protium schomburgkianum [4]	British Guiana	99. 0	56	. 48	5, 800	9, 300	1, 510
Kwarie							
Vochysia guianensis [2a]	Brazil	119. 4	59	. 43	4, 600	6, 730	1, 380
Vochysia guianensis [2a]	Surinam	230. 4	74	. 36	3, 820	6, 050	1, 230
Mahogany, Honduras							
Forest-grown							
Swietenia macrophylla [4]	Mexico	92. 2	54	. 45	5, 000	8, 900	1, 480
Swietenia macrophylla [4]	Nicaragua	110. 3	59	. 45	5, 200	8, 700	1, 440
Swietenia macrophylla [4]	Peru	106. 8	58	. 51	5, 800	9, 800	1, 470
Swietenia macrophylla [9]	Central America	58. 0	44	. 45	6, 120	9, 240	1, 290
Swietenia macrophylla [2b]	Brazil	56. 8	44	. 45	6, 070	8, 960	1, 280
Plantation-grown							
Swietenia macrophylla [2a]	Honduras	50. 7	40	. 42	5, 080	8, 350	1, 140
Mahogany, West Indies							
Swietenia mahagoni [4]	Dom. Republic	95. 2	68	. 56	6, 300	9, 700	1, 170
Swietenia mahagoni [9]	Cuba	48. 0	59	. 57	4, 560	8, 250	1, 070
Manbarklak							
Eschweilera subglandulosa [2b]	Surinam	42. 9	78	. 87	10, 010	17, 110	2, 700
Manni							
Symphonia globulifera [3]	British Honduras	97. 0	*55			11, 900	2, 020
Symphonia globulifera [2c]	Surinam, British Guiana	85. 4	67	. 58	7, 140	11, 180	1, 960
Marish							
Licania buxifolia [2b]	British Guiana	37. 3	75	. 88	10, 570	17, 070	2, 930
Licania macrophylla [2b]	Brazil, Surinam	49. 8	71	. 76	9, 560	14, 380	2, 320
Mora							
Mora excelsa [2c]	British Guiana, Surinam	60. 0	78	. 78	9, 040	12, 630	2, 330
Mora excelsa [3]	British Guiana	59. 0	*71			12, 900	2, 290
Nargusta							
Terminalia amazonia [2a]	British Honduras, British Guiana, Panama	67. 3	67	. 64	7, 710	12, 130	2, 010
Terminalia amazonia [6]	Trinidad	51. 0	66	. 70		14, 200	2, 200
Terminalia amazonia [3]	British Honduras	67. 0	*60			13, 000	2, 010
Pine, Caribbean							
Pinus caribaea [10]	Nicaragua			. 61	5, 080	8, 550	1, 600
Pinus caribaea [3]	British Honduras	41. 0	57	. 65		9, 000	1, 610
Pinus caribaea [2c]	British Honduras	35. 4	57	. 68	6, 090	11, 190	1, 880
Podocarp							
Podocarpus coriaceus [3]	British Honduras	44. 0	*41			8, 700	1, 250
Purpleheart							
Peltogyne pubescens [3]	British Guiana	62. 0	75	. 74		14, 400	2, 170
Peltogyne pubescens [4]	British Guiana	42. 1	81	. 92	12, 700	21, 100	4, 260
Peltogyne venosa var. *densiflora* [4]	Brazil	64. 3	77	. 75	11, 400	16, 200	2, 610

See footnotes at end of table.

timbers in the green condition—Continued

are given in table 11]

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
	10. 6		5, 080			970			1, 340	345	
1. 23	9. 2	3, 210	4, 370	1, 740	800	430	310	550	1, 070	310	
. 91	5. 2	1, 900	2, 780	1, 650	590	620	400	440	750	220	121. 6
. 68	5. 8	2, 300	2, 890	1, 490	900	810	390	420	770	190	95. 6
. 99	8. 2	3, 300	4, 540	1, 610	750	850	780	780	1, 070	370	
1. 05	8. 6	3, 200	4, 520	1, 530	870	800	620	760	1, 080	320	
1. 36	8. 8	3, 830	4, 990	1, 580	1, 130	1, 120	750	790	1, 280	370	
	10. 2		4, 540		750	650	710		1, 310		
1. 70	9. 0	3, 830	4, 340	1, 370	770	790	670	630	1, 140	320	82. 4
1. 14	7. 3	2, 730	3, 500	1, 040	1, 160	1, 090	1, 090	750	1, 500	280	84. 3
1. 19	10. 6	3, 750	4, 810	1, 250	1, 300	1, 310	1, 010	1, 080	1, 620	450	
	8. 6		4, 170		990	980	980		1, 540		
2. 14	17. 4	5, 350	7, 340	2, 710	2, 120	2, 280	1, 350	1, 020	1, 630	420	365. 9
	12. 3		5, 810		1, 290	1, 210			1, 310	450	
1. 60	11. 2	4, 130	5, 160	2, 320	900	940	620	610	1, 140	320	157. 0
2. 27	13. 4	6, 190	7, 580	3, 230	2, 050	2, 250	1, 430	750	1, 620	360	213. 3
2. 23	10. 2	5, 580	6, 720	2, 460	1, 720	1, 720	940	840	1, 320	380	207. 6
2. 04	13. 5	4, 800	6, 400	2, 660	1, 340	1, 450	1, 040	570	1, 400	380	228. 5
	10. 2		6, 900		1, 610	1, 690			1, 610	470	
1. 70	12. 2	4, 440	5, 530	2, 230	1, 360	1, 320	1, 060	850	1, 440	400	187. 1
			7, 330		1, 610	1, 580			1, 750	490	
	14. 6		6, 430		1, 430	1, 350			1, 600	480	
. 92	8. 0	3, 230	4, 130		700	780	830				
	10. 8		4, 600		670	720			1, 180	240	
1. 11	10. 7	3, 560	4, 900	2, 230	840	980	700	340	1, 170	240	250. 7
	10. 0		4, 320		800	650			1, 080	265	
	12. 4		7, 890		2, 040	2, 060			1, 910	520	
2. 27	16. 4	9, 250	10, 970	3, 790	3, 000	3, 290	3, 010		1, 830		
2. 67	17. 0	7, 070	9, 020	2, 790	2, 040	2, 090	2, 120	920	1, 640	525	

TABLE 10.—*Strength properties of Caribbean*

[Air-dry strength properties

Species	Source	Moisture content	Weight per cubic foot [1]	Specific gravity: Green volume and ovendry weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Roble							
Tabebuia rosea [4]	Venezuela	107. 8	58	0. 45	6, 000	9, 600	1, 620
Tabebuia rosea [2a]	Panama, British Honduras, Honduras	68. 2	55	. 52	6, 600	10, 770	1, 450
Rosewood							
Dalbergia sp.[2c]	Brazil			. 80	7, 970	14, 140	1, 840
Saman							
Pithecellobium saman [2b]	Venezuela			. 48	4, 880	8, 100	910
Santa-maria							
Calophyllum brasiliense var. *rekoi* [2c]	British Honduras	62. 0	52	. 52	5, 560	10, 490	1, 590
Calophyllum spp.[11]	British Honduras, Panama				6, 310	9, 910	1, 535
Calophyllum brasiliense [3]	Central America	62. 0	54	. 55		10, 500	1, 570
Simarouba							
Simarouba amara [2a]	Surinam	69. 2	40	. 38	3, 900	6, 310	1, 140
Sterculia							
Sterculia pruriens [4]	British Guiana	93. 9	53	. 44	5, 800	9, 000	1, 890
Suradan							
Hyeronima laxiflora [2c]	Surinam	82. 6	74	. 65	6, 510	10, 680	1, 880
Tabebuia, white							
Tabebuia insignis var. *monophylla* [4]	British Guiana	89. 8	65	. 55	9, 700	13, 700	2, 300
Tatabu							
Diplotropis purpurea [2b]	Surinam, Brazil	61. 2	78	. 78	12, 380	17, 400	2, 680
Tauroniro							
Humiria balsamifera [2c]	Surinam	62. 7	67	. 66	7, 820	11, 720	2, 060
Teak							
Plantation-grown							
Tectona grandis [2a]	Honduras	72. 3	60	. 56	6, 160	9, 940	1, 350
Forest-grown							
Tectona grandis [2a]	Burma			. 57	7, 410	11, 330	1, 480
Tectona grandis [12 6]	Burma	52. 0	57	. 60	7, 090	11, 440	1, 670
Tonka							
Dipteryx odorata [2a]	Brazil	49. 2	81	. 91	12, 530	19, 290	2, 690
Wacapou							
Vouacapoua americana [2b]	Surinam	47. 9	73	. 79	12, 450	15, 850	2, 620
Wallaba							
Eperua falcata [4]	British Guiana	57. 2	76	. 78	12, 500	16, 000	2, 550
Eperua spp. [3]	British Guiana	58. 0	73			14, 300	2, 330
Wamara							
Swartzia leiocalycina [8]	British Guiana	38. 0	75	. 87		20, 380	2, 650
Yemeri							
Vochysia hondurensis [2a]	Nicaragua	226. 4	67	. 33	3, 500	5, 580	1, 040
Vochysia hondurensis [3]	British Honduras	165. 0	*36			6, 000	1, 070

See footnotes at end of table.

timbers in the green condition—Continued

are given in table 11]

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
1. 24	7. 2	4, 410	5, 030	1, 650	910	670	610	670	1, 100	320	-----
1. 66	11. 7	4, 040	4, 910	1, 510	1, 030	910	790	790	1, 250	380	147. 0
2. 05	13. 2	3, 490	5, 510	1, 980	2, 210	2, 440	1, 830	920	2, 360	430	150. 7
1. 51	10. 4	2, 720	3, 760	1, 000	800	750	600	470	1, 100	260	99. 4
1. 10	12. 7	3, 040	4, 560	1, 700	1, 010	890	570	580	1, 260	330	180. 4
1. 46	-----	4, 850	5, 160	1, 507	990	860	640	560	1, 060	320	-----
-----	10. 0	-----	5, 290	-----	1, 170	1, 040	-----	-----	1, 310	390	-----
. 76	4. 5	2, 340	2, 970	1, 240	510	390	380	560	790	230	65. 8
1. 13	6. 6	2, 590	4, 350	2, 120	600	640	370	440	860	230	-----
1. 30	8. 3	3, 300	4, 960	2, 100	1, 280	1, 220	760	740	1, 200	380	186. 6
2. 34	12. 0	5, 870	6, 200	2, 610	1, 390	1, 230	600	650	1, 160	-----	-----
3. 30	13. 0	5, 860	8, 020	2, 940	1, 880	1, 980	1, 290	700	1, 800	420	201. 1
1. 69	10. 0	4, 060	5, 810	2, 470	1, 240	1, 320	870	880	1, 460	380	145. 9
1. 59	10. 9	3, 960	4, 780	1, 350	1, 140	1, 290	1, 290	940	1, 730	390	116. 2
2. 08	10. 7	4, 160	5, 110	1, 580	890	920	1, 030	960	1, 490	420	84. 4
1. 70	9. 3	4, 080	5, 870	1, 940	920	1, 040	1, 060	-----	1, 110	-----	-----
3. 27	12. 3	7, 420	9, 020	2, 700	2, 000	2, 200	2, 280	1, 160	1, 990	480	265. 3
3. 44	14. 5	7, 280	9, 170	2, 750	1, 580	1, 610	1, 860	860	1, 510	380	202. 6
3. 39	14. 4	5, 990	8, 270	2, 860	1, 770	1, 980	1, 520	950	1, 550	330	-----
-----	9. 8	-----	8, 070	-----	1, 590	1, 540	-----	-----	-----	365	-----
-----	21. 6	-----	10, 140	-----	-----	2, 560	-----	-----	2, 140	555	-----
. 67	4. 6	2, 050	2, 610	1, 170	510	410	420	440	700	230	73. 5
-----	4. 5	-----	3, 090	-----	630	540	-----	-----	710	280	-----

TABLE 10.—*Strength properties of Caribbean*

[Air dry strength properties

Species	Source	Moisture content	Weight per cubic foot [1]	Specific gravity: Green volume and ovendry weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SELECTED TIMBERS FOR COMPARATIVE PURPOSES							
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Ash, white *Fraxinus americana* [5]	United States	42. 0	48	0. 55	5, 100	9, 600	1, 460
Beech, European *Fagus sylvatica* [3]	United Kingdom	88. 0	*52			8, 900	1, 520
Hickory, shagbark *Carya ovata* [5]	United States	60. 0	64	. 64	5, 900	11, 000	1, 570
Douglas-fir (coast type) *Pseudotsuga menziesii* [12]	United States	36. 0	39	. 45	4, 500	7, 600	1, 570
Oak *Quercus* spp.[3]	United Kingdom	89. 0	*52			8, 100	1, 290
Oak, white *Quercus alba* [5]	United States	68. 0	62	. 60	4, 700	8, 300	1, 250
Pine, Scotch *Pinus sylvestris* [3]	United Kingdom	79. 0	*41			6, 000	1, 240
Pine, slash *Pinus elliottii* [12]	United States	66. 0	58	. 56	5, 100	8, 900	1, 580

[1] Weight per cubic foot at moisture content listed in column 3 except where designated (*), in which case weight is based on 50 percent moisture content.

[2] Tropical Woods. Nos. 98 (2a), 99 (2b), 103 (2c).

[3] Armstrong, F. H. The strength properties of timber. [Gt. Brit.] Dept. Sci. and Ind. Res. Forest Prod. Res. Bul. 28. 1953.

[4] Kynoch, William, and Norton, Newell, A. Mechanical properties of certain tropical woods, chiefly from South America. Mich. Univ. School Forestry and Conserv. Bul. 7. 1938.

[5] Markwardt, L. J., and Wilson, T. R. C. Strength and related properties of woods grown in the United States. U.S. Dept. Agr. Tech. Bul. 479. 1935.

[6] [Gt. Brit.] Department of Scientific and Industrial Research. A handbook of Empire timbers. Rev. ed. Forest Prod. Res. Lab. 1945.

timbers in the green condition—Continued

are given in table 11]

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
1. 04	16. 6	3, 190	3, 990	-------	1, 010	960	810	590	1, 380	-------	-------
-------	13. 2	-------	3, 860	-------	1, 080	960	-------	-------	1, 210	490	-------
1. 28	23. 7	3, 430	4, 580	-------	-------	-------	1, 040	-------	1, 520	-------	-------
. 75	7. 6	3, 130	3, 860	-------	570	500	440	300	930	-------	-------
-------	11. 1	-------	3, 850	-------	1, 120	1, 050	-------	-------	1, 170	430	-------
1. 08	11. 6	3, 090	3, 560	-------	1, 120	1, 060	830	770	1, 250	420	144. 9
-------	5. 6	-------	3, 020	-------	450	440	-------	-------	750	215	-------
1. 02	9. 5	3, 040	4, 340	-------	600	630	680	400	1, 000	-------	-------

[7] Wellwood, R. W. The physical-mechanical properties of certain West Indies timbers. I. Caribbean Forester 7 (2): 151–173. 1946.

[8] Armstrong, F. H. The strength properties of timber. The 2-cm. standard for tests of small clear specimens. [Gt. Brit.] Dept. Sci. and Ind. Res. Forest Prod. Res. Bul. 34. 1955.

[9] Heck, George E. Average strength and related properties of five foreign woods tested at the Forest Products Laboratory. U.S. Forest Serv. Forest Prod. Lab. Rpt. R1139. [Processed.] 1937.

[10] Fahnestock, G. R., and Garratt, George A. Nicaraguan pine (*Pinus caribaea* Mor.). Tropical Woods 55: 1–16. 1938.

[11] Greene, Edward C., Jr. Santa Maria, a neotropical timber of the genus *Calophyllum*. Tropical Woods 30: 9–16. 1932.

[12] U.S. Forest Service Forest Products Laboratory. Wood handbook. U.S. Dept. Agr. Handb. 72. 1955.

TABLE 11.—*Strength properties of Caribbean*

Species	Source	Moisture content	Weight per cubic foot	Specific gravity: Oven-dry volume and weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Angelique							
Dicorynia guianensis [2a]	Surinam	11. 8	45	0. 72	11, 610	17, 390	2, 190
Baboen							
Virola surinamensis [2b]	Brazil	11. 4	32	. 51	6, 900	10, 950	2, 040
Bagasse							
Bagassa guianensis [2a]	Brazil	12. 0	50	. 76	13, 900	20, 050	2, 580
Balata							
Manilkara bidentata [2a]	Surinam, British Guiana, Puerto Rico	13. 2	66	1. 02	15, 030	27, 280	3, 450
Balsa							
Ochroma spp.[3]	Central America						
Heartwood		12. 0	12			2, 800	470
Sapwood		12. 0	17			5, 300	710
Banak							
Virola koschnyi [4]	Central America	12. 0	33	. 51		10, 800	1, 720
Baromalli							
Catostemma commune [4]	British Guiana	12. 0	37			11, 200	1, 820
Catostemma sp.[2c]	British Guiana	9. 5		. 74	10, 750	15, 450	2, 880
Bethabara							
Tabebuia serratifolia [2b]	Surinam, Brazil	12. 3	69	1. 06	16, 600	25, 360	3, 140
Bustic							
Dipholis salicifolia [5]	United States	12. 0	62				
Cedar, Central American							
Cedrela sp.[5]	Nicaragua	12. 0	25	. 38	5, 940	7, 860	1, 010
Courbaril							
Hymenaea courbaril [2a]	Honduras, Puerto Rico, Surinam, Panama	12. 6	53	. 81	11, 900	19, 400	2, 160
Hymenaea davisii [2a]	British Guiana	12. 1		. 79	10, 720	19, 290	2, 950
Crabwood							
Carapa guianensis [2a]	Brazil	13. 5	41	. 61	9, 650	15, 620	1, 850
Carapa guianensis [3]	British Guiana	12. 0	39			14, 600	2, 120
Determa							
Ocotea rubra [2a]	Surinam, British Guiana	12. 8	41	. 58	7, 640	10, 470	1, 820
Ocotea rubra [6]	British Guiana	12. 0			7, 980	13, 070	2, 010
Gommier							
Dacryodes excelsa [7]	Puerto Rico	14. 1		. 61	8, 600	13, 030	1, 530
Gronfoeloe							
Qualea albiflora [2c]	Surinam	14. 8	37	. 56	10, 090	14, 020	1, 960
Qualea rosea [2c]	Surinam	12. 8	39	. 58	9, 720	14, 610	2, 200
Greenheart, Demerara							
Ocotea rodiaei [8]	British Guiana	14. 8	*66	1. 06	*16, 200	*25, 500	*3, 700
Ocotea rodiaei [3]	British Guiana	12. 0	62			30, 500	3, 400
Ocotea rodiaei [9]	British Guiana	12. 0	62			26, 580	2, 970
Gumbo-limbo							
Bursera simaruba [5]	United States	12. 0	21	. 32	3, 300	4, 800	740
Hura							
Hura crepitans [2a]	Venezuela, Panama, Surinam	11. 9	28	. 41	5, 380	8, 710	1, 170
Kopie							
Goupia glabra [2b]	Brazil, Surinam	12. 2	52	. 80	10, 380	15, 300	2, 150

See footnotes at end of table.

timbers in the air-dry condition[1]

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
3. 32	15. 2	6, 810	8, 770	2, 490	1, 700	1, 290	1, 280	*560	1, 660	360	----
1. 40	10. 0	3, 330	5, 140	2, 130	560	510	270	360	980	200	----
4. 18	14. 4	9, 670	11, 560	2, 850	2, 140	1, 730	1, 690	740	1, 940	*290	----
3. 76	28. 5	8, 050	11, 640	3, 360	2, 650	3, 190	*2, 320	1, 100	2, 500	*330	----
----	----	----	1, 680	----	----	----	----	----	----	----	----
----	----	----	3, 730	----	----	----	----	----	----	----	----
----	8. 1	----	5, 720	----	950	640	----	----	1, 300	245	----
----	8. 4	----	6, 730	----	860	710	----	----	870	240	----
2. 27	----	6, 260	8, 340	2, 960	830	830	510	280	900	180	----
4. 98	*22. 0	9, 000	13, 010	3, 260	3, 180	3, 680	2, 300	*500	*2, 060	*380	----
----	----	4, 950	9, 540	----	----	----	----	----	----	----	----
----	5. 6	----	4, 450	----	580	500	710	----	----	----	----
3. 72	17. 6	6, 500	9, 510	2, 240	2, 520	2, 350	1, 880	*960	2, 470	*470	----
2. 30	19. 3	6, 430	9, 400	3, 170	2, 070	1, 760	1, 230	*860	2, 130	*390	----
2. 85	13. 4	5, 810	7, 900	2, 030	1, 670	1, 220	*850	550	1, 680	*280	----
----	----	----	8, 590	----	1, 550	1, 130	----	----	----	440	----
2. 00	6. 4	4, 420	5, 800	1, 810	590	660	640	*440	980	*220	----
----	----	----	8, 940	----	*550	*610	----	----	----	*215	----
2. 70	9. 7	4, 890	7, 150	2, 100	1, 350	900	1, 290	----	1, 910	390	----
3. 07	8. 0	7, 050	8, 670	2, 320	1, 430	900	700	*330	1, 400	*250	----
2. 41	12. 5	5, 940	7, 570	2, 650	1, 370	1, 050	860	*430	1, 800	*250	----
*4. 02	*22. 0	*10, 000	*12, 920	*4, 160	*2, 140	*2, 630	*1, 970	*1, 020	*1, 830	----	----
----	----	----	14, 940	----	----	2, 650	----	----	2, 830	485	----
----	21. 6	----	13, 350	----	----	2, 400	----	----	----	----	----
. 85	3. 0	1, 720	3, 080	----	370	270	560	360	800	200	----
1. 34	6. 7	3, 300	4, 800	1, 290	790	550	630	*350	1, 080	320	----
2. 80	9. 5	5, 200	8, 350	2, 460	1, 740	1, 700	1, 210	*570	1, 600	*380	----

TABLE 11.—*Strength properties of Caribbean*

Species	Source	Moisture content	Weight per cubic foot	Specific gravity: Oven-dry volume and weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Kurokai							
Protium decandrum [9]	British Guiana	12. 0	40			15, 980	1, 870
Protium schomburgkianum [8]	British Guiana	12. 2	*33	0. 50	6, 600	*11, 800	*1, 650
Kwarie							
Vochysia guianensis [2a]	Brazil	15. 0		. 48	6, 930	10, 330	1, 570
Vochysia guianensis [2a]	Surinam	10. 6		. 42	6, 540	9, 050	1, 440
Lignumvitae							
Guaiacum officinale [3]	Central America	12. 0	76				
Mahogany, Honduras							
Forest-grown							
Swietenia macrophylla [8]	Mexico	10. 5	*31	. 50	*8, 600	*12, 400	*1, 560
Swietenia macrophylla [8]	Nicaragua	10. 7	*33	. 50	*7, 700	*12, 000	*1, 510
Swietenia macrophylla [8]	Peru	12. 0	37	. 58	7, 600	12, 400	1, 540
Swietenia macrophylla [10]	Central America	12. 0	32	. 50	8, 810	11, 140	1, 430
Swietenia macrophylla [4]	British Honduras	12. 0	31			11, 500	1, 370
Swietenia macrophylla [2a]	Brazil	11. 9	33	. 49	8, 360	11, 590	1, 420
Plantation-grown							
Swietenia macrophylla [2a]	Honduras	13. 4	31	. 46	7, 620	10, 310	1, 150
Mahogany, West Indies							
Swietenia mahagoni [10]	Cuba	12. 0	41	. 61	7, 100	9, 600	1, 200
Manbarklak							
Eschweilera subglandulosa [2b]	Surinam	12. 7	67	1. 04	14, 000	26, 470	3, 140
Manni							
Symphonia globulifera [4]	British Honduras	12. 0	43			18, 000	2, 200
Symphonia globulifera [2c]	Surinam; British Guiana	12. 1	44	. 68	10, 920	16, 860	2, 460
Symphonia globulifera [11]	British Honduras	12. 7	44	. 66	11, 200	18, 450	2, 640
Marish							
Licania buxifolia [2b]	British Guiana	12. 5	68	1. 07	19, 440	27, 660	3, 340
Licania macrophylla [2b]	Brazil-Surinam	11. 5	58	. 90	13, 550	20, 650	2, 530
Mora							
Mora gonggrijpii [4]	British Guiana	12. 0	64			25, 500	3, 180
Mora excelsa [2c]	British Guiana; Surinam	11. 6	62	. 97	13, 040	22, 100	2, 960
Mora excelsa [4]	British Guiana	12. 0	62			23, 100	2, 970
Nargusta							
Terminalia amazonia [2a]	British Honduras; British Guiana; Panama	12. 9		. 73	11, 310	17, 750	2, 300
Terminalia amazonia [3]	Trinidad	12. 0	54			18, 800	2, 470
Terminalia amazonia [4]	British Honduras	12. 0	49			18, 200	2, 270
Pine, Caribbean							
Pinus caribaea [12]	Nicaragua	12. 0	49		9, 450	15, 880	2, 130
Pinus caribaea [4]	British Honduras	12. 0	48			14, 700	1, 950
Pinus caribaea [2c]	British Honduras	13. 1	51	. 78	9, 850	16, 690	2, 240
Podocarp							
Podocarpus coriaceus [4]	British Honduras	12. 0	31			11, 800	1, 380
Purpleheart							
Peltogyne pubescens [4]	British Guiana	12. 0	54			20, 200	2, 580
Peltogyne pubescens [8]	British Guiana	13. 9	*68	1. 05	16, 300	25, 100	3, 640
Peltogyne venosa var. *densiflora* [8]	Brazil	13. 1	*54	. 75	13, 300	20, 100	2, 550
Rosewood							
Dalbergia sp. [2c]	Brazil	11. 5		. 88	11, 850	18, 970	1, 880

See footnotes at end of table.

timbers in the air-dry condition [1]—Continued

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
	17. 6		8, 860			1, 160			2, 130	330	
1. 46	*13. 1	*5, 400	*6, 960	*1, 950	*1, 000	*720	*630	*450	*1, 410		
1. 73	7. 3	4, 950	6, 230	1, 690	*500	740	620	*360	1, 220	240	
1. 67	*5. 2	5, 790	7, 160	1, 790	*710	*460	530	*280	*680	*140	
			11, 400		3, 600	4, 500				450	
*2. 38	*9. 4	*4, 880	*7, 180	*1, 560	*1, 140	*770	*1, 000	*700	*1, 290	*340	
2. 20	*9. 2	*5, 170	*1, 350	*1, 500	*1, 080	*810	*870	*720	*1, 270	*370	
2. 13	8. 8	5, 170	7, 130	1, 610	1, 180	930	900	640	1, 300	340	
	6. 8		6, 430		880	760	1, 210		1, 050		
	9. 9		6, 170		980	700			1, 630	315	
2. 77	*7. 8	5, 170	6, 470	1, 500	960	970	900	*610	1, 250	*300	
2. 52	7. 5	4, 210	5, 680	1, 200	*1, 000	*980	1, 250	*620	1, 510	280	
	6. 2		6, 240		1, 350	1, 330	1, 170		1, 480		
3. 72	33. 3	6, 000	11, 210	3, 150	2, 750	3, 480	2, 480	*540	2, 070	*260	
	16. 8		9, 280		1, 650	1, 290			1, 590	390	
2. 72	*16. 5	4, 840	8, 820	2, 860	1, 280	1, 120	800	*350	1, 420	*220	
2. 69	14. 1	7, 850	10, 040	2, 490	1, 680	1, 320	1, 530	650	1, 770	400	
6. 49	14. 2	10, 050	13, 390	3, 360		3, 570	2, 230	*250	1, 750	*220	
4. 09	15. 4	8, 160	11, 010	2, 680	2, 640	2, 560	1, 590	*400	1, 850	*240	
	24. 7		13, 660		3, 170	2, 950			2, 650	550	
3. 22	18. 5	6, 320	11, 840	3, 840	2, 210	2, 300	1, 280	660	1, 900	380	
	21. 4		12, 240		2, 610	2, 460			2, 560	555	
3. 16	16. 4	6, 950	9, 540	2, 520	1, 990	1, 610	1, 230	*670	1, 950	*270	
			10, 600		2, 550	2, 100			2, 280	260	
	17. 8		9, 990		2, 220	1, 740			2, 090	310	
2. 35	12. 0	5, 980	8, 390		1, 180	1, 230	1, 680		1, 750		
	15. 0		7, 830		1, 140	1, 120			1, 830	315	
2. 43	17. 3	4, 960	8, 540	3, 010	1, 180	1, 240	1, 210	470	2, 090	340	
	9. 3		6, 980		1, 280	710			1, 690	250	
	16. 6		10, 960		2, 750	2, 510			2, 420	590	
4. 07	24. 9	9, 970	13, 270	4, 540	3, 350	3, 640	2, 370	880	2, 070		
3. 97	18. 6	8, 790	10, 770	2, 730	2, 460	2, 140	1, 780	670	2, 150	350	
4. 24		6, 370	9, 600	2, 200	2, 970	2, 720	1, 900	*620	*2, 110	*330	

TABLE 11.—*Strength properties of Caribbean*

Species	Source	Moisture content	Weight per cubic foot	Specific gravity: Oven-dry volume and weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Roble							
Tabebuia rosea [8]	Venezuela	14. 6	*35	0. 50	*7, 300	*12, 500	*1, 750
Tabebuia rosea [2a]	Panama, British Honduras, Honduras	13. 5	37	. 57	9, 480	13, 780	1, 600
Saman							
Pithecellobium saman [2b]	Venezuela	12. 4	35	. 51	6, 080	8, 860	1, 100
Santa-maria							
Calophyllum brasiliense var. *rekoi* [2c]	British Honduras	13. 1	39	. 60	9, 000	14, 640	1, 830
Calophyllum spp.[2c]	British Honduras, Panama	12. 0	36	. 55	8, 740	12, 650	1, 695
Calophyllum brasiliense [4]	Central America	12. 0	40			14, 900	1, 830
Simarouba							
Simarouba amara [2a]	Surinam	12. 2	27	. 40	6, 280	8, 930	1, 240
Sterculia							
Sterculia pruriens [8]	British Guiana	13. 2	*37	. 50	*6, 100	*9, 700	*1, 930
Sterculia pruriens [4]	British Guiana	12. 0	33			11, 900	1, 720
Suradan							
Hyeronima laxiflora [2c]	Surinam	9. 7	49	. 75	11, 110	18, 200	2, 270
Tabebuia, white							
Tabebuia insignis var. *monophylla* [8]	British Guiana	14. 3	*42	. 63	*10, 600	*14, 900	*2, 260
Tatabu							
Diplotropis purpurea [2b]	Surinam, Brazil	12. 0	58	. 89	13, 660	20, 560	2, 870
Tauroniro							
Humiria balsamifera [2c]	Surinam	14. 2	50	. 78	11, 050	18, 770	2, 510
Teak							
Plantation-grown							
Tectona grandis [2a]	Honduras	12. 6	40	. 59	8, 430	13, 310	1, 390
Tectona grandis [13]	Trinidad	12. 0	43	. 62		15, 860	1, 576
Forest-grown							
Tectona grandis [2a]	Burma	10. 4		. 61	8, 160	13, 240	1, 490
Tectona grandis [3]	Burma	12. 0	43	. 64		14, 300	1, 850
Tonka							
Dipteryx odorata [2a]	Brazil	12. 0	67	1. 04	19, 130	27, 270	3, 030
Wacapou							
Vouacapoua americana [2b]	Surinam	12. 7	59	. 91	13, 720	21, 640	*2, 530
Wallaba							
Eperua falcata [8]	British Guiana	13. 1	*58	. 88	*13, 700	*22, 000	*2, 880
Eperua spp.[4]	British Guiana	12. 0	56			19, 200	2, 270
Wamara							
Swartzia leiocalycina [9]	British Guiana	12. 0	66			30, 960	3, 430
Yemeri							
Vochysia hondurensis [2c]	Nicaragua	11. 9	28	. 37	4, 930	7, 900	1, 160
Vochysia hondurensis [4]	British Honduras	12. 0	29			9, 600	1, 270
SELECTED TIMBERS FOR COMPARATIVE PURPOSES							
Ash, white							
Fraxinus americana [5]	United States	12. 0	42	. 64	8, 900	15, 400	1, 770
Beech, European							
Fagus sylvatica [4]	United Kingdom	12. 0	43			16, 200	1, 950
Hickory, shagbark							
Carya ovata [5]	United States	12. 0	50	. 78	10, 700	20, 200	2, 160
Oak, European							
Quercus spp.[4]	United Kingdom	12. 0	43			13, 300	1, 560

See footnotes at end of table.

timbers in the air-dry condition [1]—Continued

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
*1. 70	*9. 4	*4, 630	*6, 010	*2, 230	*1, 040	*700	*1, 000	-------	810	-------	-------
3. 18	12. 5	5, 890	7, 340	1, 740	1, 310	*960	940	*560	1, 450	270	-------
1. 97	*7. 8	3, 920	5, 070	1, 110	900	850	830	*460	1, 280	*240	-------
2. 50	16. 1	4, 860	6, 910	2, 010	1, 410	1, 150	890	*520	*2, 080	330	-------
2. 20	-------	5, 060	6, 670	1, 619	1, 370	870	1, 210	330	1, 480	340	-------
-------	12. 4	-------	8, 410	-------	1, 680	1, 250	-------	-------	1, 900	410	-------
1. 78	5. 8	3, 690	4, 840	1, 360	690	440	600	*390	1, 160	250	-------
*1. 09	*8. 0	*6, 230	*8, 230	*3, 020	*910	*770	*590	*450	*1, 080	-------	-------
-------	10. 6	-------	6, 860	-------	1, 020	790	-------	-------	1, 090	250	-------
3. 14	12. 0	4, 510	9, 620	2, 630	2, 140	1, 700	1, 160	*670	1, 720	*280	-------
*2. 77	*11. 4	*6, 670	*8, 240	*2, 690	1, 350	1, 160	*980	*520	*1, 380	*290	-------
3. 66	*14. 8	9, 100	12, 140	*2, 920	2, 030	2, 140	*1, 200	*500	1, 960	*300	-------
2. 66	19. 6	5, 480	8, 950	2, 990	1, 870	1, 610	980	1, 000	2, 140	600	-------
2. 92	*10. 3	5, 300	6, 770	1, 510	1, 140	1, 110	1, 340	*770	*1, 600	470	-------
-------	14. 2	-------	8, 600	-------	339	347	-------	-------	-------	-------	-------
2. 51	*9. 3	5, 180	6, 710	*1, 500	950	1, 080	1, 190	980	*1, 380	*340	-------
-------	-------	8, 320	-------	1, 070	1, 130	-------	-------	1, 350	-------	-------	-------
6. 74	26. 1	11, 720	13, 720	3, 190	2, 490	3, 540	2, 740	*710	2, 100	*420	-------
4. 23	17. 0	9, 590	11, 480	*2, 740	1, 600	1, 730	*1, 220	*550	1, 890	*335	-------
*3. 60	*20. 1	*7, 130	*10, 230	*2, 870	*1, 660	*1, 760	*1, 240	*560	*1, 590	-------	-------
-------	17. 7	-------	10, 800	-------	2, 260	2, 040	-------	-------	-------	440	-------
-------	32. 0	-------	15, 980	-------	-------	4, 260	-------	-------	3, 580	950	-------
1. 20	5. 8	3, 350	4, 140	*1, 160	670	*400	450	*410	1, 030	*190	-------
-------	9. 5	-------	4, 860	-------	930	700	-------	-------	1, 120	300	-------
2. 60	17. 6	5, 790	7, 410	-------	1, 720	1, 320	1, 410	940	1, 950	-------	-------
-------	17. 4	-------	7, 870	-------	1, 820	1, 440	-------	-------	2, 030	525	-------
3. 01	25. 8	-------	9, 210	-------	-------	-------	2, 170	-------	2, 430	-------	-------
-------	9. 4	-------	7, 210	-------	1, 460	1, 230	-------	-------	1, 760	430	-------

TABLE 11.—*Strength properties of Caribbean*

Species	Source	Moisture content	Weight per cubic foot	Specific gravity: Ovendry volume and weight	Static bending		
					Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SELECTED TIMBERS FOR COMPARATIVE PURPOSES							
		Percent	*Lbs.*		*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*
Oak, white *Quercus alba* [5]	United States	12. 0	48	0. 71	8, 200	15, 200	1, 780
Douglas-fir *Pseudotsuga menziesii* [14]	United States	12. 0	34		7, 800	12, 200	1, 950
Pine, Scotch *Pinus sylvestris* [4]	United Kingdom	12. 0	32			12, 000	1, 590
Pine, slash *Pinus elliottii* [14]	United States	12. 0	43	. 61	9, 800	15, 900	2, 060

[1] All values determined or adjusted to 12 percent moisture content except where designated (*) where moisture content in column 3 applies.

[2] Tropical Woods. Nos. 98 (2a), 99 (2b), 103 (2c).

[3] [Gt. Brit.] Department of Scientific and Industrial Research. A handbook of Empire timbers. Rev. ed. Forest Prod. Res. Lab. 1945.

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[6] Hohenkirk, L. S. Report on tests of woods from British Guiana by the Forest Products Laboratories of Canada. Jour. Board Agr. Brit. Guiana. Georgetown. 1920.

[7] Wellwood, R. W. The physical-mechanical properties of certain West Indies timbers. I. Caribbean Forester 7 (2): 151–173. 1946.

[8] Kynoch, William, and Norton, Newell A. Mechanical properties of certain tropical woods, chiefly from South

timbers in the air-dry condition [1]—Continued

Static bending—Continued		Compression parallel to grain			Hardness		Compression perpendicular to grain: Stress at proportional limit	Tension perpendicular to grain	Shear	Cleavage, per inch of width	Toughness, per specimen
Work to proportional limit	Work to maximum load	Fiber stress at proportional limit	Maximum crushing strength	Modulus of elasticity	End	Side					
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
In.-lb. per cu. in.	*In.-lb. per cu. in.*	*P.s.i.*	*P.s.i.*	*1,000 P.s.i.*	*Lb.*	*Lb.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*Lb.*	*In.-lb.*
2. 27	14. 8	4, 760	7, 440	----	1, 520	1, 360	1, 320	800	2, 000	450	----
1. 77	9. 8	5, 850	7, 430	----	900	710	870	340	1, 160	----	----
----	11. 2	----	6, 640	----	800	680	----	----	1, 400	295	----
2. 76	12. 6	6, 280	9, 100	----	1, 080	1, 010	1, 390	570	1, 730	----	----

America. Mich. Univ. School Forestry and Conserv. Bul. 7. 1938.

[9] Armstrong, F. H. The strength properties of timber. The 2-cm. standard for tests of small clear specimens. [Gt. Brit.] Dept. Sci. and Ind. Res. Forest Prod. Res. Bul. 34. 1955.

[10] Heck, George E. Average strength and related properties of five foreign woods tested at the Forest Products Laboratory. U.S. Forest Serv., Forest Prod. Lab. Rpt. R1139 [Processed]. 1937.

[11] Garratt, George A. The wood of *Symphonia globulifera*. Tropical Woods 45: 1–15. 1936.

[12] Fahnestock, G. R., and Garratt, George A. Nicaraguan pine (*Pinus caribaea* Mor.). Tropical Woods 55: 1–16.

[13] Smathers, R. A comparative study of some of the more important mechanical properties of Trinidad and Burma grown teak. [Gt. Brit.] Imp. Forestry Inst. Paper 27. 1951.

[14] U.S. Forest Service Forest Products Laboratory. Wood handbook. U.S. Dept. Agr. Handb. 72. 1955.

TABLE 12.—*Maximum allowable stresses for*

(For use in designing

Botanical name	Trade name	Minimum allowable specific gravity for air-dried timber	Allowable compressive stress parallel to grain			Allowable compressive stress perpendicular to grain		
			Special constructions in small-sized timber	Air-dry constructions inside and outside buildings	For use in hydraulics and foundations	Special constructions in small-sized timber	Air-dry constructions inside and outside buildings	For use in hydraulics and foundations
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			P.s.i.	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*
Andira coriacea	Angelin	0. 80	2, 300	1, 800	1, 450	650	475	380
Carapa guianensis	Crabwood	0. 60	2, 000	1, 550	950	310	230	130
Cedrela odorata	Cedar, Central Am	0. 35	1, 100	850	575	230	170	110
Dicorynia paraensis	Angelique	0. 65	2, 200	1, 700	1, 250	575	425	280
Diplotropis purpurea	Tatabu	0. 75	4, 000	3, 100	2, 800	500	375	340
Dipteryx odorata	Tonka	1. 00	4, 000	3, 100	2, 500	1, 500	1, 100	900
Eperua falcata	Wallaba	0. 80	2, 600	2, 100	1, 350	700	525	340
Eschweilera longipes	Manbarklak	1. 00	3, 000	2, 300	1, 400	1, 250	950	525
Goupia glabra	Kopie	0. 75	2, 600	2, 000	1, 300	700	525	330
Hura crepitans	Hura	0. 40	1, 050	825	350	260	190	65
Hymenaea courbaril	Courbaril	0. 85	3, 400	2, 600	2, 100	1, 150	850	650
Manilkara bidentata	Balata	1. 00	4, 000	3, 100	2, 100	1, 200	900	575
Mora excelsa	Mora—red variety	0. 95	2, 800	2, 200	1, 350	850	650	360
Mora excelsa	Mora—white variety	0. 90	2, 600	2, 000	1, 350	700	525	300
Ocotea rodiaei	Greenheart, Demerara	1. 00	4, 000	3, 100	2, 400	1, 000	750	575
Ocotea rubra	Determa	0. 55	1, 850	1, 400	850	300	230	120
Ocotea spp	Kereti silverballi	0. 47	2, 000	1, 550	1, 100	310	230	160
Peltogyne pubescens	Purpleheart	0. 70	2, 600	2, 000	1, 300	925	675	380
Platonia insignis	Pakuri	0. 70	2, 100	1, 650	1, 300	575	425	320
Qualea rosea	Gronfoeloe	0. 55	2, 000	1, 550	1, 000	400	300	180
Quercus spp	Oak	0. 60	1, 500	1, 150	700	400	300	115
Simarouba amara	Simarouba	0. 37	1, 100	850	575	230	170	110
Swartzia spp	Parakusan, Wamara	1. 05	5, 100	4, 000	2, 800	1, 550	1, 150	775
Symphonia globulifera	Manni	0. 60	2, 400	1, 900	1, 050	360	260	130
Tabebuia serratifolia	Bethabara	1. 00	4, 400	3, 400	2, 800	1, 150	850	700
Tectona grandis	Teak (Indonesian)	0. 60	1, 850	1, 400	1, 150	425	320	220
Vochysia and *Qualea* spp	Kwarie & Yemeri	0. 50	1, 550	1, 200	750	240	180	100
Vouacapoua americana	Wacapou	0. 85	3, 400	2, 600	2, 000	925	675	500

[1] This table has been taken from pages 192–193, v. 2, of J. Ph. Pfeiffer's "De Houtsoorten van Suriname" (Surinam Timbers), published in Amsterdam, Holland, in 1927. Certain botanical names have been changed to conform with later corrections in the nomenclature of Surinam Timbers. Conversion from kg/cm² to p.s.i. was done by

tropical timbers under different circumstances

timber structures) [1]

Allowable bending stress			Modulus of elasticity		Allowable shearing stress			Allowable tension stress perpendicular to grain under all circumstances
Special constructions in small-sized timber	Air-dry constructions inside and outside buildings	For use in hydraulics and foundations	Special constructions and air-dry constructions inside and outside buildings	For use in hydraulics and foundations	Special constructions in small-sized timber	Air-dry constructions inside and outside buildings	For use in hydraulics and foundations	
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
P.s.i.	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*	*P.s.i.*
3, 500	2, 600	2, 200	1, 493, 000	1, 209, 000	400	340	340	7
2, 500	1, 850	1, 150	1, 422, 000	1, 209, 000	260	210	180	20
1, 650	1, 250	850	711, 000	569, 000	150	110	85	17
3, 100	2, 300	1, 800	1, 493, 000	1, 209, 000	280	240	210	16
4, 000	3, 000	2, 800	2, 062, 000	1, 706, 000	380	330	340	20
4, 300	3, 200	2, 700	2, 204, 000	1, 849, 000	500	450	370	33
2, 000	1, 500	1, 000	1, 280, 000	1, 067, 000	360	300	260	11
3, 300	2, 500	1, 500	2, 133, 000	1, 777, 000	550	475	380	23
3, 500	2, 600	1, 700	1, 635, 000	1, 351, 000	400	340	300	16
1, 650	1, 250	500	640, 000	427, 000	150	110	71	18
5, 200	3, 900	3, 100	1, 706, 000	1, 422, 000	450	390	360	11
4, 500	3, 400	2, 300	2, 062, 000	1, 706, 000	625	525	470	26
3, 300	2, 500	1, 500	1, 706, 000	1, 422, 000	450	380	310	33
3, 000	2, 300	1, 650	1, 777, 000	1, 493, 000	600	500	430	33
3, 800	2, 800	2, 200	2, 275, 000	1, 920, 000	280	230	210	10
2, 200	1, 700	1, 000	1, 138, 000	1, 067, 000	140	130	100	20
2, 000	1, 500	1, 050	1, 067, 000	853, 000	170	140	120	24
3, 700	2, 800	1, 850	1, 351, 000	1, 138, 000	450	370	330	26
2, 500	1, 900	1, 500	1, 564, 000	1, 280, 000	310	260	260	9
2, 500	1, 900	1, 200	1, 138, 000	1, 067, 000	330	280	140	26
2, 000	1, 500	850	1, 209, 000	995, 000	170	140	100	33
1, 150	875	575	782, 000	640, 000	150	110	85	17
6, 300	4, 800	3, 300	2, 773, 000	2, 275, 000	650	525	470	11
2, 500	1, 850	1, 000	1, 351, 000	1, 138, 000	190	160	110	9
4, 700	3, 600	3, 100	2, 275, 000	1, 920, 000	550	450	370	17
2, 400	1, 800	1, 400	1, 138, 000	995, 000	240	200	140	14
1, 900	1, 450	850	853, 000	711, 000	200	170	140	21
3, 700	2, 800	2, 100	1, 706, 000	1, 422, 000	300	240	230	20

the Secretariat, Caribbean Commission. After conversion, the latter figures were rounded off as follows: 0–100 rounded off to the unit; 100–400 rounded off to 10 units; 400–1,000 rounded off to 25 units; and above 1,000 rounded off to 100 units. Figures for elasticity modulus (p.s.i.) were rounded off to the nearest thousand.

INDEX TO THE TIMBERS

The preferred trade names and scientific names of timbers discussed in detail in the text are indicated by boldface type.

A

B

C

D

E

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