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NUMBER 95 June 1, 1949

A technical magazine devoted to the furtherance of knowledge of tropical woods and forests and to the promotion of forestry in the Tropics.

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PROPERTIES AND USES OF TROPICAL WOODS, I.[1]

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To a great extent, the users of wood are still bound by tradition to favor the wood of certain species for numerous specific applications. Undoubtedly the original selection of these particular woods was largely the result of a process of trial and error, the success of which is best indicated by the degree to which the requirements of service have been met over the years. The demand for a limited number of favored woods, however, has led to a growing scarcity of the more

[1]This is the first published technical report based on work conducted at the Yale School of Forestry in cooperation with the Office of Naval Research and the Bureau of Ships, United States Navy Department, under Contract N6 ori-44, Task Order XV (Project Designation No. NR-033-020).

popular domestic and imported species, and to an increasing difficulty in obtaining supplies of lumber, timbers, veneer, and other wood products, particularly in the higher grades of hardwoods.

A vast amount of technical data on the properties of domestic woods has been accumulated. These data permit comparison of the properties of readily obtainable but little-used woods with those of the woods that are traditionally more favored, and thus the establishment of a basis for determination of their adaptability to structural and industrial uses. Many of the use requirements for wood, however, remain unsatisfied by the limited group of domestic woods that are available.

The extensive forests of the tropics comprise the largest and, from the standpoint of their composition and diversity, the most complex stands of timber in the world. These forests contain a large number of timber species that appear to possess desirable properties, but adequate technical data are available for very few of them. The known general characteristics of certain of these tropical species indicate the possibility that they may be superior in many respects to the woods now used for many special purposes.

The School of Forestry at Yale University has been actively engaged in research in the field of tropical woods for more than twenty-five years, during which time it has built up a collection that now contains over 45,000 specimens of wood, mostly tropical in origin. At various times in the past certain woods or groups of woods have been subjected to mechanical and physical tests. In April 1947 the scope of these activities was expanded to meet the growing need for technical data relating to the properties of tropical woods. Under the sponsorship of the Navy Department through the Office of Naval Research, studies were initiated to determine the basic properties of a selected group of tropical American timbers and to evaluate each species with regard to its potentialities for specific types of use.

In this study direct comparisons are made with well-known species of proved serviceability. Although immediate large-scale commercial acceptance is not anticipated on the basis of these tests, data of this type should serve to arouse the interest of potential producers and consumers. These data should also stimulate further tests and trials to demonstrate the performance of the wood in actual use.

The scope of the tests being conducted under this research program is indicated by the following:

I. *Mechanical Properties*

Representative material from each log is tested in the green and air-dry conditions to determine properties in (1) static bending; (2) compression parallel to grain; (3) compression perpendicular to grain; (4) hardness (side and end); (5) shear; (6) tension perpendicular to grain; (7) cleavage, and (8) toughness.

II. *Physical Properties*

Representative material from each log is tested to determine specific gravity and shrinkage. Decay resistance is determined by means of an accelerated laboratory test method. Tests to determine rate of moisture absorption, gluing, weathering, and paint-holding characteristics are conducted on material selected from stock available from several logs of each species. The cooperation of other laboratories has been obtained in conducting tests of the resistance of selected species to fire, abrasion, and marine-borer attack.

III. *Seasoning Properties*

Test specimens obtained from each log are used to determine rate of drying and seasoning characteristics (including the development of seasoning defects) under air-drying conditions.

IV. *Machining Properties*

Observations are made and recorded with regard to the general characteristics of each species when subjected to the sawing, planing, shaping, and boring operations involved in the preparation of specimens for mechanical testing.

V. *Steam-bending Properties*

Those species that appear from other tests to be adapted to steam bending, are compared directly with white oak of bending quality.

Accurate identification of all test material is provided through the selection of representative standing trees in the forest by botanists, foresters, or lumbermen. Herbarium specimens consisting of leaves, flowers, or fruit from the same tree are collected to document the field identification. From each tree, an 8-foot log representing the upper half of the first 16-foot log taken above the butt swell is marked and shipped to New Haven where it is sawed into test blanks under close supervision. Further assurance of correct identification is provided by direct comparison of the wood with authentic specimens from the Yale collections. A minimum of three trees is sought for each species studied, and an attempt is made to secure representative material from various portions of its geographic range.

Field notes describing the material are made by the collector. Tree number, species, locality of growth, date cut, site, elevation, tree height, tree diameter, length of clear bole, vigor, age (second growth or old growth), diameter of log, length of log (or flitch), type of herbarium material collected, and date of shipment are included in the field notes.

The first shipment of logs received under this project arrived in New Haven in April 1947. Since that time nearly 250 logs representing 95 different species have been received. To date, tests to determine the basic physical and mechanical properties of these woods have been conducted on material representing 43 species. Mechanical test data collected thus far are largely limited to the properties of the unseasoned wood. For 25 of these species sufficiently representative data have now been obtained to warrant publication.

It is the purpose of this report to present the results of those phases of the over-all study relating to the basic mechanical properties of the unseasoned wood, and such physical properties as specific gravity, shrinkage, decay resistance, and air-seasoning characteristics of these 25 tropical woods. In addition to these experimental findings, information relative to its source, availability, and characteristics, together with an evaluation of the wood from the standpoint of present and potential use, is presented for each of the species covered in this report.

FIG. 1
Tropical forest in Panama from which test logs of Vaco and Cedro Granadino were obtained

Further results for additional species and on other phases of the study, including mechanical properties of seasoned wood, machining, gluing, moisture absorption, weathering, and paint-holding characteristics will be presented in subsequent reports.

Selection of Material for Test

Test material is selected following in general the methods outlined in American Society for Testing Materials Specification D-143.[1] As soon as possible after arrival in New Haven, all logs are photographed and cut into 2½ by 2½-inch by 4-foot sticks and ⁵⁄₄-inch lumber according to the pattern shown in Figure 2. The lower 4-foot section of each log is designated as Bolt C and the upper section as Bolt D. Each stick is identified as to its position in the bolt.

Specimens for mechanical testing are cut from the 2½ by 2½-inch sticks, and the ⁵⁄₄-inch boards are reserved for shrinkage, toughness, gluing, weathering, and other tests.

The moisture content of each log is ascertained by cutting a moisture content sample 2 inches long from the mid-length of each of three 8-foot sticks at the time of cutting into 4-foot lengths. These sticks are selected from the center, median, and outer portions of the cross section of the log.

At the same time sections 6 inches long are cut in a similar manner from a complete series of sticks extending in one of the cardinal directions from pith to the bark, for example, N1, N3, N5, etc., for subsequent use in decay resistance tests.

From each quadrant of Bolt D the most nearly representative quarter-sawed or plain-sawed board is reserved for shrinkage and toughness test specimens. Other boards are air dried for subsequent testing.

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[1]The current edition of this specification was adopted in 1948 and published in the 1948 Book of Standards of A.S.T.M. as D143-48, "Standard Methods of Testing Small Clear Specimens of Timber."

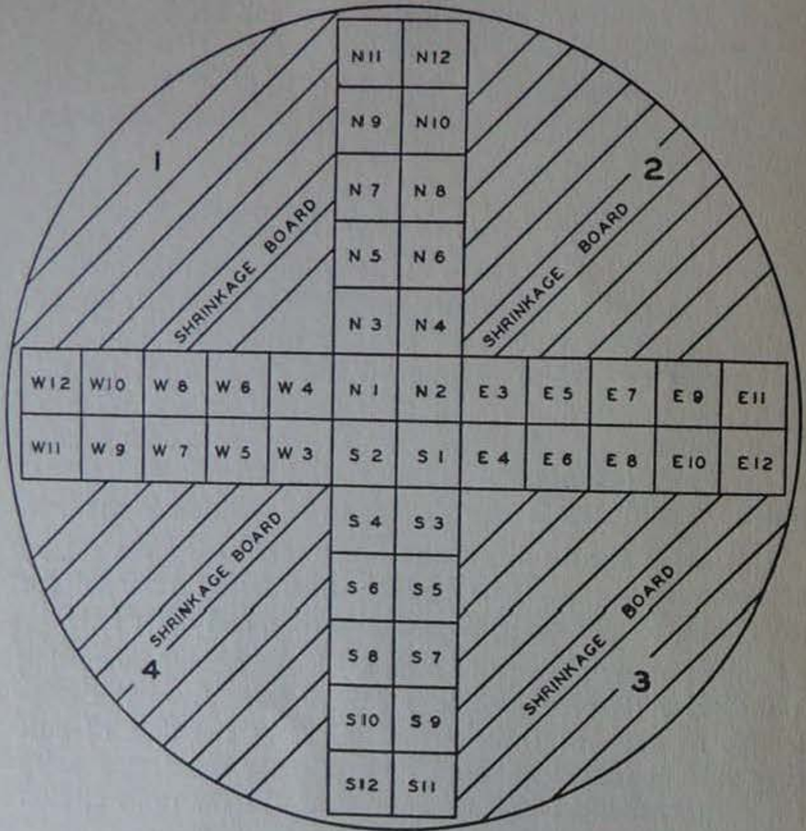

FIG. 2
Cutting diagram showing the distribution of test specimens on a cross section of a log

Mechanical Properties

Specimens for mechanical testing are selected in general accordance with the methods described in A.S.T.M. D-143. An equal number of sticks are prepared for testing in the green and air-dry conditions to provide a direct comparison of the effect of air drying upon the properties of the wood. All tests on green material are conducted as soon as possible after sawing the log. While awaiting testing, the 2½ by 2½-inch by 4-foot sticks are stored in water. As re-

quired for test, these sticks are surfaced to 2 by 2-inch cross-sectional dimensions from which standard size specimens are prepared.

Material to be tested in the air-dry condition is handled as described in the section on air seasoning. When thoroughly air-dried to a uniform moisture content of approximately 12 percent, the 4-foot sticks are surfaced to 2 by 2-inch cross-sectional dimensions and cut to standard size shortly before testing. If necessary, surfaced specimens are held in a humidity-controlled chamber until the time of testing to avoid changes in moisture content.

In addition to the 2 by 2-inch specimens required for testing to determine standard mechanical properties, 15 toughness test blanks, approximately ¾-inch square and 10 inches long, are sawed from the shrinkage boards (Fig. 2) for testing in the green condition, and an equal number of longitudinally matched specimens are selected for testing in the air-dry condition. Immediately prior to testing, these specimens are planed to exact ⅝ ($.625 \pm .02$)-inch square cross-sectional dimensions. After the removal of these test specimens, the remaining portions of the shrinkage boards are air-seasoned together with the balance of the 5/4-inch stock from the same log.

In general, the mechanical test methods outlined in American Society for Testing Materials Specification D-143 have been followed and, with a few exceptions noted here, detailed description is unnecessary.

From each static-bending and compression parallel to grain specimen tested in the green condition, a cross-sectional wafer approximately one inch in length is cut near the failure after test for the purpose of determining specific gravity. After drying slowly under room conditions, these wafers are dried to constant weight in an oven at 100° C. and specific gravity determined on the basis of oven-dry weight and oven-dry volume. In addition, for each log, four of these specimens—selected from the undamaged portion of static-bending specimens so as to obtain one near

TABLE 1. MECHANICAL PROPERTIES OF TWENTY-FIVE TROPICAL AMERICAN WOODS IN THE GREEN CONDITION

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending					Compression Parallel to Grain			Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness[1]
						Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load	Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity							
			per-cent	oven-dry vol.	green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit-lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Bulletwood (*Manilkara bidentata*)	Surinam, British Guiana, Puerto Rico	7	47.6	1.03	0.85	11,120	17,310	2,700	2.51	13.6	7,030	8,690	3,060	2160	2230	2480	990	1900	480	264.8
Guayacán (*Tabebuia guayacan*)	Honduras	3	35.4	1.00	0.85	11,060	18,480	2,580	2.71	18.7	7,730	9,740	2,910	2820	3140	2390	990	2230	510	286.3
Gonçalo Alves (*Astronium graveolens*)	Honduras, Venezuela	4	46.2	0.95	0.84	8,510	12,140	1,940	2.28	6.7	4,620	6,580	2,230	1640	1910	1840	1000	1760	420	139.0
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	50.7	0.98	0.82	10,680	17,780	2,910	2.28	13.4	6,170	7,780	2,880	2000	2480	1580	560	1790	390	264.5
Piquiá (*Caryocar villosum*)	Brazil	3+	61.3	0.84	0.72	8,260	12,450	1,820	2.17	8.4	4,990	6,290	2,210	1450	1720	2080	990	1604	430	150.5
Mylady (*Aspidosperma cruentum*)	British Honduras	3	57.2	0.82	0.71	9,070	14,100	2,500	1.83	8.9	5,360	6,650	2,840	1500	1470	1100	760	1500	420	152.8
Courbaril (*Hymenaea courbaril*)	Honduras, Surinam, Puerto Rico	6	59.9	0.80	0.70	6,890	12,180	1,640	1.62	14.1	3,820	5,340	1,770	1780	1970	1810	1290	1800	570	214.6
(*Hymenaea Davisii*)	British Guiana	3	64.8	.079	0.67	8,230	12,440	2,080	1.62	8.5	4,260	5,540	2,450	1480	1610	1120	890	1680	410	187.8
Tatajuba (*Bagassa guianensis*)	Brazil	2+	58.0	0.76	0.68	10,340	14,510	2,300	2.84	11.3	6,060	7,900	2,510	1620	1670	1200	650	1670	370	195.5
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	60.5	0.80	0.67	7,600	12,380	1,650	1.96	10.0	4,230	5,460	1,730	1740	1760	960	1230	1700	590	222.8
Nargusta (*Terminalia amazonia*)	British Guiana, British Honduras	6	72.3	0.76	0.66	8,140	12,720	2,160	1.79	11.4	4,700	5,960	2,460	1460	1440	1260	880	1500	420	198.4
Angélique (*Dicorynia paraensis*)	Surinam	2	78.7	0.69	0.60	7,650	11,410	1,840	1.78	12.0	4,810	5,590	2,180	1100	1100	1000	700	1340	340	151.2
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	3	65.1	0.66	0.60	6,330	10,050	1,460	1.62	8.8	3,790	5,130	1,570	1350	1230	1070	800	1340	440	122.8
Hububalli (*Loxoptery-*	British Guiana																			

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			per cent	oven-dry vol.	green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	60.4	0.62	0.56	4,920	8,190	1,200	1.11	9.2
Determa (*Ocotea rubra*)	Surinam	2	75.2	0.62	0.56	6,360	8,810	1,650	1.42	5.2
Teak (plantation-grown) (*Tectona grandis*)	Honduras	3	72.3	0.59	.056	6,160	9,940	1,350	1.59	10.9
Flor Azul (*Vitex Kuylenii*), Rajate Bién (*Vitex Cooperi*)	Honduras, Guatemala	4	98.8	0.60	0.53	5,860	9,420	1,490	1.29	7.7
Roble Blanco (*Tabebuia pentaphylla*)	British Honduras, Honduras	6	67.8	0.58	0.52	6,140	10,460	1,370	1.54	11.2
Cedro Espino (*Bombacopsis quinata*)	Honduras	3	86.0	0.58	0.51	4,650	8,060	1,380	0.95	7.8
Vaco (*Magnolia sororum*)	Panama	3	84.8	0.56	0.50	4,950	8,560	1,690	0.84	6.5
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	3	50.7	0.46	0.42	5,080	8,350	1,140	1.14	7.3
Laurel Blanco (*Cordia alliodora*)	British Honduras, Honduras, Nicaragua	10	122.2	0.46	0.42	5,350	8,720	1,170	1.46	9.8
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	67.4	0.46	0.41	4,520	7,510	1,310	0.94	7.1
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	3	56.2	0.44	0.40	4,170	7,180	990	0.99	7.2

[1]Toughness values are the average of tests of green and air-dry specimens 5/8 × 5/8 × 10

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness[1]
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit-lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Frijolillo	2,790	3,930	1,410	1060	1030	960	710	1270	310	130.3
Determa	3,620	4,380	2,070	540	600	700	640	910	320	74.9
Teak	3,960	4,780	1,350	1140	1290	1290	940	1730	390	116.2
Flor Azul, Rajate Bién	3,700	4,780	1,780	1050	1050	1180	650	1280	320	108.0
Roble Blanco	3,860	4,720	1,520	1100	960	860	800	1290	410	152.3
Cedro Espino	2,790	3,690	1,520	840	790	660	760	1110	340	116.9
Vaco	2,610	3,590	2,060	880	860	740	860	1120	410	118.3
Mahogany	2,730	3,500	1,040	1160	1090	1090	750	1500	280	84.3
Laurel Blanco	3,370	3,910	1,310	820	740	700	520	1090	270	131.7
Cedro Granadino	2,770	3,370	1,330	650	550	600	430	990	260	106.2
Primavera	2,850	3,510	1,050	810	700	800	720	1030	320	74.8

inches loaded on the tangential face over an 8-inch span.

the pith, one near the periphery, and two that are representative of average growth—are also used for the purpose of determining specific gravity on an oven-dry weight and green volume basis. In both instances volume is determined by the immersion method.

The mechanical properties of twenty-five Tropical American woods tested in the green condition are shown in Table 1.

Shrinkage

Volumetric shrinkage is determined using the regular green-volume specific gravity specimens previously described as having been selected from the undamaged portion of four static-bending specimens from each log so as to obtain one near the pith, one near the periphery, and two that are representative of average growth. These specimens are selected only from sticks tested in the green condition. Volumetric shrinkage is computed as the difference between green and oven-dry volume expressed as a percentage of the original green volume.

Two radial shrinkage, two tangential shrinkage, and two longitudinal shrinkage specimens are obtained from each D bolt from shrinkage boards designated on the cutting diagram (Fig. 2). One radial shrinkage specimen is prepared from each of two opposite quadrants, and one tangential specimen from each of two opposite quadrants remaining after sawing the diametral planks and before seasoning. Shrinkage specimens are cut to a size of approximately 1 by 1 by 4 inches. Two longitudinal shrinkage specimens of the same size are cut from the same boards. If necessary, to obtain a 4-inch width having a true radial or tangential aspect, two narrow pieces are edge glued using a resorcinol-type glue.

Shrinkage specimens are soaked and carefully sawed to size prior to measurement of the 4-inch dimension. Specimens are weighed green and slowly dried to constant weight under room conditions, then reweighed and remeasured.

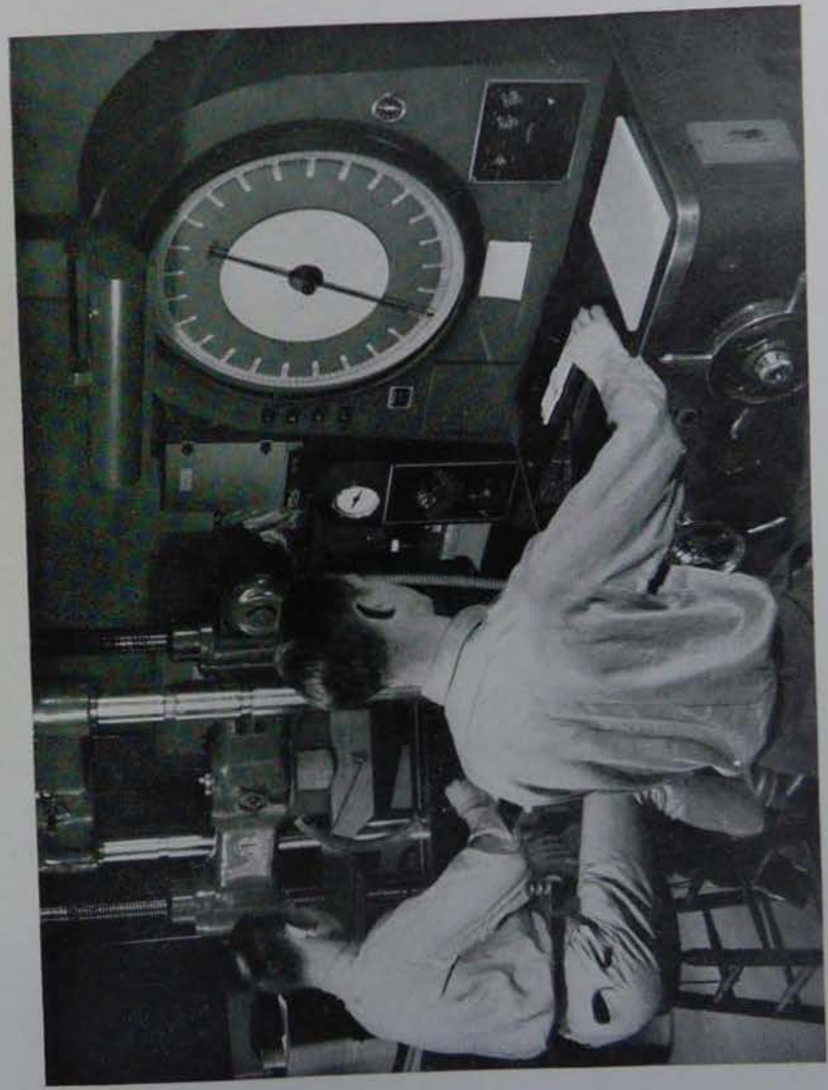

Fig. 3

Testing a beam to determine the properties of wood in static bending

They are then dried to constant weight in an oven at 100° C., reweighed and remeasured. From these data the shrinkage is determined as follows:

$$\text{Shrinkage (percent)} = \left(\frac{\text{green dimension} - \text{oven-dry dimension}}{\text{green dimension}}\right) 100$$

The relationship between volumetric shrinkage and specific gravity is shown for a representative group of domestic hardwoods and for a group of tropical hardwoods in Figure 4. Although increasing density is commonly asso-

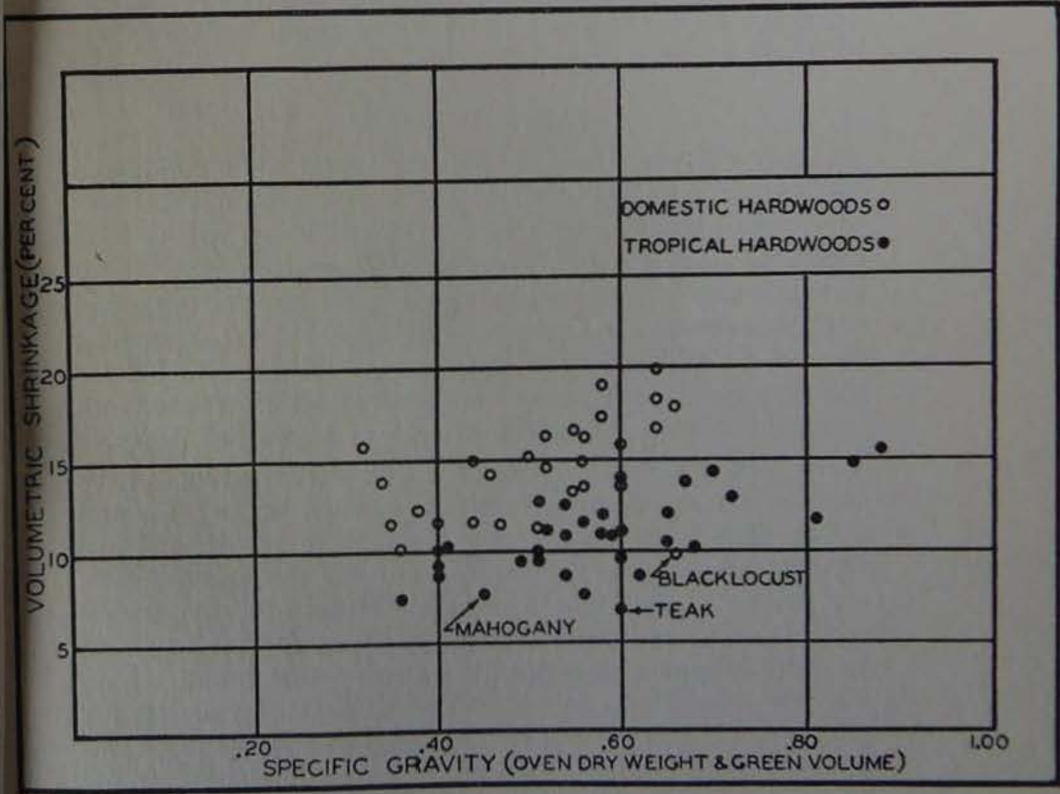

Fig. 4

Relationship between volumetric shrinkage and specific gravity for representative groups of Tropical American and domestic hardwoods ciated with greater shrinkage in both groups, it is evident that most of the tropical woods are characterized by lower shrinkage values than temperate hardwoods of comparable density. Even the extremely dense tropical woods (specific gravity of 0.80-0.90) show appreciably less shrinkage than is commonly displayed by domestic woods only three-fourths as heavy. The widely recognized dimensional stability of Mahogany and Teak is substantiated by their position on the graph, but it is also evident that a number of other tropical woods approach these two species in this respect.

Values for radial, tangential, longitudinal, and volumetric shrinkage from the green to oven-dry condition are shown in Table 2.

Decay Resistance[1]

Decay resistance tests are patterned after those conducted by Scheffer and Duncan[84] at the Forest Products Laboratory. Small blocks 1 by 1 inch in cross section and ¼ inch measured along the grain are subjected to attack at 77° F. by pure cultures of *Polyporus versicolor*, a white-rot organism, and *Poria monticola*, causing a brown rot. Insofar as possible, three zones of heartwood and the sapwood are sampled for each log tested. Specimens are removed after a four-month interval to determine loss of weight as a result of decay.

All weight determinations are made after the blocks have attained an equilibrium moisture content at 40° C., and weight loss is expressed as a percentage of the original equilibrium weight. Results of four-month exposure tests are presented in Table 3. Actual weight-loss percentages and indicated resistance classes are given for each species. In some instances considerable variation was found within a single species and in others the amount of material for which results are available was limited to a single log. Consequently the results shown are not equally significant for all species included in the table.

[1]Decay resistance tests have been conducted under the direction of Prof. J. S. Boyce, Yale School of Forestry.

Table 2. Shrinkage Properties of Twenty-five Tropical American Woods[1]

Species	Source	Specific Gravity green volume basis	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Bulletwood (*Manilkara bidentata*)	Surinam, British Guiana, Puerto Rico	0.85	6.3	9.4	0.23	16.9
Guayacán (*Tabebuia guayacan*)	Honduras	0.85	6.8	8.5	0.18	14.8
Gonçalo Alves (*Astronium graveolens*)	Honduras	0.84	4.0	7.6	0.43	10.0
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	0.82	4.9	10.5	0.34	14.4
Piquiá (*Caryocar villosum*)	Brazil	0.72	5.0	8.0	0.20	13.0
Mylady (*Aspidosperma cruentum*)	British Honduras	0.71	5.2	8.7	0.18	14.3
Courbaril (*Hymenaea courbaril*)	Honduras, Surinam, Puerto Rico	0.70	4.4	8.6	0.29	12.6
(*Hymenaea Davisii*)	British Guiana	0.67	4.1	7.6	0.51	14.8
Tatajuba (*Bagassa guianensis*)	Brazil	0.68	5.2	6.6	0.09	10.2
Masa (*Tetragastris balsamifera*)	Puerto Rico	0.67	4.4	8.5	0.18	13.9
Nargusta (*Terminalia amazonia*)	British Guiana, British Honduras	0.66	5.0	8.0	0.18	12.8
Angélique (*Dicorynia paraensis*)	Surinam	0.60	4.6	8.2	0.16	14.0
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	0.60	2.8	5.7	0.32	9.6
Hububalli (*Loxopterygium Sagotii*)	British Guiana, Surinam	0.56	3.4	7.2	0.34	11.1

TABLE 2—*Continued*

Species	Source	Specific Gravity green volume basis	Shrinkage (percent)[1] Radial	Tangential	Longitudinal	Volumetric
Frijolillo (*Pseudosamanea guachapele*)	Honduras	0.56	2.9	4.5	0.37	7.6
Determa (*Ocotea rubra*)	Surinam	0.56	4.0	7.7	0.30	11.6
Teak (plantation-grown) (*Tectona grandis*)	Honduras	0.56	2.1	4.6	0.37	5.1
Flor Azul (*Vitex Kuylenii*) Rajate Bién (*Vitex Cooperi*)	Honduras, Guatemala	0.52	3.2	6.4	0.16	10.4
Roble Blanco (*Tabebuia pentaphylla*)	British Honduras, Honduras	0.52	3.6	6.0	0.16	9.1
Cedro Espino (*Bombacopsis quinata*)	Honduras	0.51	4.1	7.6	0.10	12.8
Vaco (*Magnolia sororum*)	Panama	0.50	3.6	7.0	0.23	11.2
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	0.42	2.4	4.2	0.42	6.6
Laurel Blanco (*Cordia alliodora*)	British Honduras, Honduras, Nicaragua	0.42	3.1	6.7	0.14	8.7
Cedro Granadino (*Cedrela Tonduzii*)	Panama	0.41	4.2	6.3	0.16	10.3
Primavera (*Tabebuia-Donnell-Smithii*)	Honduras	0.40	3.1	5.1	0.24	9.1

[1]Shrinkage values represent shrinkage from the green to oven-dry conditions expressed as a percentage of the green dimension.

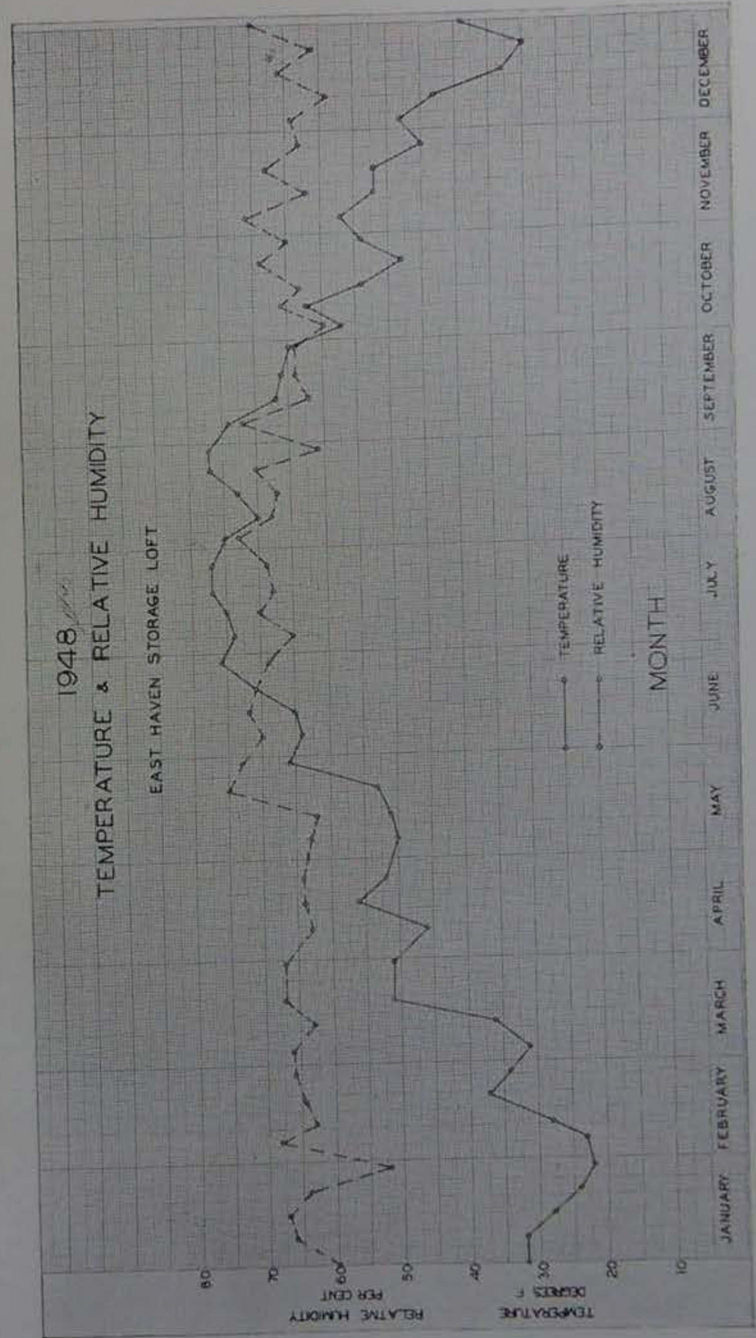

FIG. 5

Temperature and relative humidity conditions in the air-seasoning loft. The active seasoning period extends from April 1 to November 1.

FIG. 6
The progress of air seasoning is determined by weighing sample boards

Fig. 7
Decay resistance of wood is determined in pure-culture tests involving brown-rot and white-rot fungi

TABLE 3. WEIGHT LOSS AND DECAY RESISTANCE OF TROPICAL AMERICAN WOODS IN PURE CULTURE TESTS

Species	Source	No. of Logs	Specific Gravity	White Rot[1] Average Weight Loss	White Rot[1] Average Resistance Class[2]	White Rot[1] Maximum Weight Loss	White Rot[1] Maximum Resistance Class[2]	Brown Rot[1] Average Weight Loss	Brown Rot[1] Average Resistance Class[2]	Brown Rot[1] Maximum Weight Loss	Brown Rot[1] Maximum Resistance Class[2]
			green vol. basis	percent		percent		percent		percent	
Bulletwood (*Manilkara bidentata*)	Puerto Rico, British Guiana, Surinam	7	0.85	5.1	A	19.3	B	0.5	A	2.2	A
Guayacán (*Tabebuia guayacan*)	Honduras	1	0.85	0.4	A	0.5	A	0.3	A	0.4	A
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	0.82	1.5	A	7.9	A	1.4	A	2.8	A
Mylady (*Aspidosperma cruentum*)	British Honduras	1	0.71	2.0	A	2.4	A	1.4	A	2.1	A
Courbaril (*Hymenaea courbaril*)	Honduras, Puerto Rico	5	0.70	3.3	A	17.3	B	10.8	B	38.5	C
(*Hymenaea Davisii*)	British Guiana	3	0.67	20.6	B	59.8	D	11.4	B	52.2	D
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	0.67	4.0	A	7.7	A	11.4	B	54.3	D
Nargusta (*Terminalia amazonia*)	British Guiana	3	0.66	7.1	A	26.4	C	4.8	A	28.0	C
Angélique (*Dicorynia paraensis*)	Surinam	1	0.60	16.2	B	42.4	C	7.5	A	17.3	B
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	3	0.60	1.4	A	2.8	A	1.5	A	4.7	A
Hububalli (*Loxopterygium Sagotii*)	British Guiana	3	0.56	20.6	B	62.6	D	7.8	A	56.1	D
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	0.56	5.0	A	36.9	C	3.8	A	22.2	B

TABLE 3—*Continued*

Species	Source	No. of Logs	Specific Gravity	White Rot[1] Average Weight Loss	White Rot[1] Average Resistance Class[2]	White Rot[1] Maximum Weight Loss	White Rot[1] Maximum Resistance Class[2]	Brown Rot[1] Average Weight Loss	Brown Rot[1] Average Resistance Class[2]	Brown Rot[1] Maximum Weight Loss	Brown Rot[1] Maximum Resistance Class[2]
			green vol. basis	percent		percent		percent		percent	
Determa (*Ocotea rubra*)	Surinam	1	0.56	7.6	A	15.5	B	0.3	A	2.7	A
Teak (plantation-grown) (*Tectona grandis*)	Honduras	3	0.56	3.3	A	31.8	C	3.7	A	34.0	C
Roble Blanco (*Tabebuia pentaphylla*)	Honduras, British Honduras	4	0.52	37.4	C	70.7	D	6.8	A	21.5	B
Cedro Espino (*Bombacopsis quinata*)	Honduras	4	0.51	7.5	A	17.2	B	4.0	A	7.9	A
Flor Azul (*Vitex Kuylenii*)	Honduras	2	0.51	3.2	A	4.6	A	2.4	A	7.3	A
Vaco (*Magnolia sororum*)	Panama	3	0.50	5.8	A	24.3	B	1.3	A	14.4	B
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	3	0.42	9.4	A	37.5	C	—[3]	A	3.0	A
Laurel Blanco (*Cordia alliodora*)	Honduras, British Honduras	4	0.42	1.6	A	4.9	A	0.3	A	5.5	A
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	0.41	37.5	C	63.2	D	28.7	C	48.4	D
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	2	0.40	13.3	B	42.2	C	9.9	A	31.3	C

[1]White rot—*Polyporus versicolor;* Brown rot—*Poria monticola.*
[2]Resistance classes:
A—0-10 percent decay; very durable.
B—11-24 percent decay; durable.
C—25-44 percent decay; moderately durable.
D—more than 44 percent decay; nondurable.
[3]Weight loss was not appreciable.

Two values are used to portray the resistance of the heartwood of a given species to deterioration by a particular fungus. *Average decay* indicates the general resistance to decay found by averaging all of the weight losses throughout the heartwood. As mentioned earlier, the heartwood is sampled, where possible, in each of three zones so that any variation in decay resistance that may occur from zone to zone may be detected. Such a procedure makes possible the additional determination of *maximum decay* which represents the critical extreme in variation of the decay resistance of the wood sampled.

Decay resistance classes shown in Table 3 have been assigned as follows:

A = 0 to 10 percent decay: Very durable.
B = 11 to 24 percent decay: Durable.
C = 25 to 44 percent decay: Moderately durable.
D = More than 44 per cent decay: Non-durable.

For practical purposes, the condition of testing that results in the lowest decay resistance evaluation is the more important. Even though a wood may be very resistant to decay by a brown-rot fungus but only moderately resistant to a white rot, it will nevertheless be exposed to the latter in service and thus be limited in durability by its resistance to the white-rot organism.

Seasoning Characteristics

The air-seasoning characteristics of each species are observed in the course of air drying 2½ by 2½-inch squares, which are reserved for mechanical testing in the seasoned condition, and ⅝-inch boards remaining from each test log following the removal of material for shrinkage and toughness specimens. All of this stock is seasoned in 4-foot lengths in stickered piles located in a ventilated storage loft under cover. Air temperature and relative humidity records are maintained continuously. A record of such conditions based upon weekly averages for the year 1948 is shown in Figure 5.

Prior to piling, all pieces showing noticeable end checks and splits are trimmed. All other checks and splits are marked by crayon to show the extent of damage that may have occurred in the log. The ends of all pieces are coated with filled hardened gloss oil or paraffin. Boards and dimension are placed in separate piles and segregated by species.

Piles are approximately 4 feet square. The height is determined by the amount of material to be piled but in no instance exceeds 5 feet. In piling, stickers are placed at 1-foot intervals for the first course and at 2-foot intervals for all subsequent courses. Stickers are aligned vertically, flush with the ends of the boards and squares at the front of the pile, and overhang at the rear is kept at a minimum. A spacing between boards of ¼ to ½ inch is left for dense woods and a greater spacing for the less dense and more rapidly drying species.

The current moisture content for each species piled is determined by means of sample boards at the time of piling, and subsequently once each month during the seasoning period. At the time of cross-cutting and segregation of material for seasoning, two squares and two 5/4 boards (unless the logs exceed 24 inches in diameter in which event three of each are used) are selected from each log for moisture sample boards. Care is exercised in the selection to see that these samples are representative of the log cross-section. Sapwood is avoided unless a high proportion of the log is sapwood.

When the moisture content of the sample boards reaches 16 percent a core and shell wafer and a stress section are cut from each sample stick at least 7½ inches from the end of the piece and similar sections are cut from two other squares or boards in that pile from the same log. Care is taken in selecting these pieces so that they contain no sapwood unless the greater percentage of the log is sapwood. The freshly cut ends are coated. If, after determining the moisture content of the wafers, no core moisture content exceeds 20 percent and the average moisture content of the

four pieces does not exceed 18 percent, the material is considered to be seasoned.

If the squares or boards are not sufficiently dry, the oven-dry weights of the sample boards are recalculated on the basis of the new moisture content as determined from the freshly cut wafers and the drying period extended until the moisture conditions are not in excess of these limits.

Seasoning Defects

Following the completion of air seasoning, 15 pieces per log selected at random are examined for presence of any or all of the following defects, with the exception of honey-combing and casehardening. Defects occurring in the material before piling and which are indicated by crayon markings are not considered.

Casehardening. Casehardening is evaluated on the basis of severity as none, slight, severe, or reverse. Stress sections from the sample boards and two other selected pieces are used for the evaluation and photographed.

End Checking and Splitting. The number and maximum extent of checks and splits are recorded.

Surface Checking. Surface checks are considered in two categories:

1. Superficial checks–those which will surface out by the removal of 1/16 inch of wood and therefore are not important.
2. Non-superficial checks–those which because of their depth will still be present after normal surfacing.

Warping. Several specific defects are considered under warping. The amount of each is determined for all air-seasoned pieces.

Cup is measured by the deviation away from a straight edge held at right angles to the length of the piece.

Bow is measured by the lengthwise deviation of the face from a straight-edge.

Crook is measured as the lengthwise deviation of the edge of the piece from a straight-edge.

Twist is measured by the amount of spiraling that has taken place in the piece throughout its length.

Diamonding is the distortion of the cross section from the square. It is indicated as present or absent.

Honeycombing. As the squares are cut up for test specimens they are observed for honeycombing and, if present, the probable cause, whether the result of external checks or of severe internal drying stresses, is recorded.

Collapse. The exterior of all pieces is observed for the presence of collapse.

Air-seasoning characteristics of the species covered in this report are presented in Table 4. The bases for the evaluation of rate of drying and seasoning defects are explained in the footnotes of the table.

Each species has been further classified as to its ease of seasoning in Table 5. No significance should be attached to the relative position of a species within each group.

Use Classification for Tropical Woods

The purpose of this section is to present in summary form an evaluation of each of the woods included in this report from the standpoint of present use as well as potential uses for which the timber appears to be adapted on the basis of its properties as determined thus far in this study. It should be recognized that these suggested uses are largely based upon a study which is incomplete. The additional tests to be conducted and the dry strength data should permit improvement and expansion of these listings. Additional recommendations are included in the individual species descriptions.

TABLE 4. AIR-SEASONING CHARACTERISTICS OF TWENTY-FIVE TROPICAL AMERICAN WOODS

Species	No. of Logs	Source	Specific Gravity green volume basis	Rate of Drying[1]	Warp[2] Crook and Bow	Warp[2] Cup	Warp[2] Twist	Checking and Splitting[2] End	Checking and Splitting[2] Surface	Case-hardening[3]
Bulletwood (*Manilkara bidentata*)	5	Puerto Rico, Surinam, British Guiana	0.85	Fast to Slow	B	A-B	B	B-D	B-D	A-C
Guayacán (*Tabebuia guayacan*)	3	Honduras	0.85	Fast	B	B	A	C	C	B
Gonçalo Alves (*Astronium graveolens*)	3	Honduras	0.84	Moderate	C	B	C	C	B	A
Black Kakeralli (*Eschweilera Sagotiana*)	2	British Guiana	0.82	Moderate	B	A	A	B	A	A
Piquiá (*Caryocar villosum*)	2	Brazil	0.72	Moderate	B	B	B	B	B	A
Mylady (*Aspidosperma cruentum*)	1	British Honduras	0.71	Fast	B	A	A	C	A	A
Courbaril (*Hymenaea courbaril*)	7	Honduras, Surinam, Puerto Rico	0.70	Fast to Moderate	B-C	A-B	A-B	A-B	A-B	A-C
(*Hymenaea Davisii*)	3	British Guiana	0.67	Moderate	B	A	B	C	C	A
Tatajuba (*Bagassa guianensis*)	1	Brazil	0.68	Moderate	B	A	B	A	A	A
Masa (*Tetragastris balsamifera*)	2	Puerto Rico	0.67	Moderate	A	A	A	C	C	A
Nargusta (*Terminalia amazonia*)	1	British Honduras	0.63	Fast	B	A	A	A	A	A
	3	British Guiana	0.70	Moderate	B	A	A	B	B	A

TABLE 4—*Continued*

Species	No. of Logs	Source	Specific Gravity[green volume basis]	Rate of Drying[1]	Warp[2] Crook and Bow	Warp[2] Cup	Warp[2] Twist	Checking and Splitting[2] End	Checking and Splitting[2] Surface	Case-hardening[3]
Angélique (*Dicorynia paraensis*)	3	Surinam	0.60	Fast	B	B	A	A-C	C-D	C
Yellow Sanders (*Buchenavia capitata*)	3	Puerto Rico	0.60	Fast	B	A	A	B	B	A
Hububalli	3	British Guiana	0.54	Moderate	C	A	A	D	D	A
(*Loxopterygium Sagotii*)	3	Surinam	0.58	Fast	B	B	B	A	A	A
Frijolillo (*Pseudosamanea guachapele*)	3	Honduras	0.56	Moderate	C	A	A	A	A	A
Determa (*Ocotea rubra*)	1	Surinam	0.56	Moderate	B	A	A	B	B	C
Teak (plantation-grown) (*Tectona grandis*)	3	Honduras	0.56	Fast	A	A	A	A	A	A
Flor Azul (*Vitex Kuylenii*)	2	Honduras	0.51	Fast to Slow	B	A	A	B-D	B-D	A-C
Rajate Bién (*Vitex Cooperi*)	2	Guatemala	0.54	Moderate	B	A	B	A	A	A
Roble Blanco (*Tabebuia pentaphylla*)	5	Honduras, British Honduras	0.52	Fast	B	A-B	A	A	A-B	B
Cedro Espino (*Bombacopsis quinata*)	3	Honduras	0.51	Fast	A	A	A	A	B	B
Vaco (*Magnolia sororum*)	3	Panama	0.50	Fast	B	B	A	A	A	A

TABLE 4—*Continued*

Species	No. of Logs	Soucre	Specific Gravity[green volume basis]	Rate of Drying[1]	Warp[2] Crook and Bow	Warp[2] Cup	Warp[2] Twist	Checking and Splitting[2] End	Checking and Splitting[2] Surface	Case-hardening[3]
Mahogany (plantation-grown) (*Swietenia macrophylla*)	3	Honduras	0.42	Fast	B	B	B	A	A	A
Laurel Blanco (*Cordia alliodora*)	8	British Honduras, Honduras, Nicaragua	0.42	Fast	A-B	A-B	A-B	A-B	A-B	A
Cedro Granadino (*Cedrela Tonduzii*)	3	Panama	0.41	Fast	A	A	A	A	A	A
Primavera (*Tabebuia Donnell-Smithii*)	5	Honduras	0.40	Fast	B	A	B	A	A	A

[1]Rate of drying based on April to November air-seasoning conditions. New Haven, Conn.
Fast: Less than 120 days to dry from green condition to 16 percent moisture content.
Moderate: From 120 to 200 days to dry from green condition to 16 per cent moisture content.
Slow: Over 200 days from green condition to 16 percent moisture content.

[2]Warp, checking and splitting: Checking and splitting based on minimum utilization of 1 linear foot and surfacing to standard size; warp based on 4 foot length.
None (A) — none observed.
Slight (B) — less than 5 percent waste.
Moderate (C) — 5 to 25 percent waste.
Severe (D) — over 25 percent waste.

[3]Casehardening
None (A) — none observed.
Slight (B) — slight stress.
Severe (C) — fully casehardened.

TABLE 5. CLASSIFICATION OF TROPICAL AMERICAN WOODS AS TO THEIR EASE OF SEASONING

Group I
(Easy to season)

Species	Specific Gravity green volume basis
Yellow Sanders *(Buchenavia capitata)*	0.66
Nargusta *(Terminalia amazonia)* (Honduras)	0.63
Hububalli *(Loxopterygium Sagotii)* (Surinam)	0.58
Frijolillo *(Pseudosamanea guachapele)*	0.56
Teak (plantation-grown) *(Tectona grandis)*	0.56
Roble Blanco *(Tabebuia pentaphylla)*	0.52
Cedro Espino *(Bombacopsis quinata)*	0.51
Vaco *(Magnolia sororum)*	0.50
Shortleaf Pine ***(Pinus echinata)***	**0.46**
Laurel Blanco *(Cordia alliodora)*	0.42
Mahogany (plantation-grown) *(Swietenia macrophylla)*	0.42
Cedro Granadino *(Cedrela Tonduzii)*	0.41
Primavera *(Tabebuia Donnell-Smithii)*	0.40
Yellow Poplar ***(Liriodendron tulipifera)***	**0.38**

Group II
(Moderately difficult to season)

Species	Specific Gravity green volume basis
Guayacán *(Tabebuia guayacan)*	0.85
Black Kakeralli *(Eschweilera Sagotiana)*	0.82
Gonçalo Alves *(Astronium graveolens)*	0.70
Piquiá *(Caryocar villosum)*	0.72
Mylady *(Aspidosperma cruentum)*	0.71
Courbaril *(Hymenaea courbaril)*	0.70
Nargusta *(Terminalia amazonia)* (British Guiana)	0.70
Tatajuba *(Bagassa guianensis)*	0.68
Angélique *(Dicorynia paraensis)*	0.60
Determa *(Ocotea rubra)*	0.56
Rajate Bién *(Vitex Cooperi)*	0.54
Flor Azul *(Vitex Kuylenii)*	0.51
Walnut ***(Juglans nigra)***	**0.51**
Paper Birch ***(Betula papyrifera)***	**0.48**

Group III
(Difficult to season)

Species	Specific Gravity green volume basis
Bulletwood *(Manilkara bidentata)*	0.85
Courbaril *(Hymenaea Davisii)*	0.67
Masa *(Tetragastris balsamifera)*	0.67
White Oak ***(Quercus alba)***	**0.60**
Beech ***(Fagus grandifolia)***	**0.56**
Hububalli *(Loxopterygium Sagotii)* (British Guiana)	[illegible]

Boatbuilding

Uses for wood in boatbuilding are varied, including decking, planking, frames, keels, shaft logs, and numerous other specific components. The properties desired for several of these uses are discussed separately in the following paragraphs.

Decking—The characteristics desired in a decking wood include freedom from warp, low shrinkage, hardness, abrasion resistance, good weathering characteristics, low moisture absorption, durability, and moderate weight. Burma Teak is recognized as meeting these requirements to a high degree. The heartwood of the following species possesses characteristics that indicate suitability for decking.

Angélique	Nargusta	Tatajuba
Courbaril	Piquiá	Teak (plantation-grown)
Frijolillo	Rajate Bién	Yellow Sanders
Laurel Blanco	Roble Blanco	

Planking—The ideal planking wood is characterized by low shrinkage, high bending strength and shock resistance relative to its density, but not necessarily high stiffness; low moisture absorption, moderate hardness, good fastening characteristics, abrasion resistance, good weathering and paint-holding characteristics, durability and, in some waters, resistance to marine-borer attack. Central American Mahogany, Port Orford Cedar, Alaska Yellow Cedar, and Teak represent highly desirable woods for planking. The following woods appear to be adapted to this use:

Angélique	Laurel Blanco	Tatajuba
Courbaril	Nargusta	Teak (plantation-grown)
Determa	Primavera	Vaco
Frijolillo	Rajate Bién	Yellow Sanders

Frames—Boat frames require high strength in relation to density, particularly bending strength and impact resistance. Steam-bent frames require, in addition, ability to be bent to relatively sharp curvatures after steaming, with a maximum retention of strength. Good fastening characteristics and decay resistance are desirable.

Angélique	Mylady
British Guiana Courbaril	Nargusta (steam-bent)
Bulletwood (steam-bent)	Piquiá
Courbaril (steam-bent)	Tatajuba
Frijolillo	Teak
Guayacán (steam-bent)	Yellow Sanders
Laurel Blanco	

Keels and Under-water Structural Members—Strength without excessive stiffness, durability, low moisture absorption, and resistance to marine borers are the most important characteristics desired in keels and similar structural components of boats. Although it does not have all of the desired characteristics, White Oak is typical of the type of wood usually employed for this purpose.

Angélique	Determa	Tatajuba
Black Kakeralli	Gonçalo Alves	Teak (plantation-grown)
Bulletwood	Guayacán	Yellow Sanders
Courbaril	Piquiá	

Construction Timbers

High strength properties in relation to density are desired for structural uses. Stiffness and strength in static bending and in compression both along and across the grain, shear strength, and resistance to splitting are most important among these properties. Moderate or low shrinkage is desirable, as well as the ability to be seasoned in timber dimensions without excessive checking or splitting. Ease of fastening with nails, bolts, and mechanical connectors is another important consideration in the selection of a wood for use in construction. Structural timbers must, of course, be available in large cross-sectional sizes and in long lengths.

Construction timbers, based upon the decay hazard involved or the danger of deterioration by insect attack, are divided into two categories, *durable* construction and *general building* construction timbers. Those woods combining the properties listed above with resistance to decay or, in some cases, insect attack are included among the naturally durable construction timbers.

Angélique (durable)	Masa (durable)
Black Kakeralli (durable)	Mylady (durable)
Bulletwood (durable)	Nargusta (durable)
Courbaril (durable)	Piquiá (durable)
Determa (durable)	Rajate Bién (durable)
Flor Azul (durable)	Tatajuba
Gonçalo Alves (durable)	Vaco
Guayacán (durable)	Yellow Sanders (durable)
Hububalli	

Exterior Use

The principal characteristic considered in determining the suitability of a wood for exterior use is its ability to withstand weathering. This involves such factors as low shrinkage and either low moisture absorption or, at the opposite extreme, a high degree of permeability from the standpoint of both moisture absorption and loss. Furthermore, the wood should show little tendency to warp under the fluctuating moisture conditions associated with exposure to the elements. For protected surfaces good paint-holding characteristics are also involved. Unless the particular use also involves dampness that is continued over considerable periods or contact with soil, high decay resistance is not necessarily required for satisfactory outdoor use. Mahogany, White Pine, and Western Red Cedar exemplify woods that are adapted to exterior use.

Cedro Espino	Laurel Blanco	Primavera
Cedro Granadino	Mahogany (plantation-grown)	Teak (plantation-grown)
Frijolillo	Nargusta	Vaco
Gonçalo Alves		
Guayacán		

Flooring

Flooring requires a wood of moderately high to high density in order to obtain satisfactory hardness and abrasion resistance. Good appearance is also a factor in the selection of a wood for residential, store, and office flooring, but is superseded by the more strictly utilitarian requirement of exceptional wear resistance in the case of factory flooring. Flooring woods should machine smoothly, without excessive torn grain, in moulding machines and should be relatively free of warp. Low to moderate shrinkage is desired in any flooring but this is particularly true of flooring installations that involve only a partial protection from moisture.

Angélique	Guayacán	Rajate Bién
Black Kakeralli	Hububalli	Roble Blanco
Bulletwood	Masa	Tatajuba
Courbaril	Mylady	Teak (plantation-grown)
Frijolillo	Nargusta	Yellow Sanders
Gonçalo Alves	Piquiá	

Frame Construction

In temperate climates most woods can be used for this purpose and those possessing the characteristics of ease of nailing, ease of working with both hand and power tools, straight grain, stability, adequate size, and availability in quantity are most highly favored. Douglas Fir and Southern Pine are typical of the woods used in the United States. In the Tropics, where resistance to deterioration is a particularly important additional factor governing this type of use, the following woods appear to be suitable for frame construction:

Angélique	Guayacán	Rajate Bién
Cedro Espino	Hububalli	Roble Blanco
Cedro Granadino	Laurel Blanco	Tatajuba
Determa	Masa	Teak (plantation-grown)
Flor Azul	Mylady	Vaco
Frijolillo	Nargusta	
Gonçalo Alves	Piquiá	

Furniture and Cabinet Work

Among the characteristics that influence the choice of a particular wood for use in one or more furniture applications are suitable density and such mechanical properties as hardness, bending strength, compressive strength, shear strength, and resistance to cleavage. Low shrinkage properties are advantageous in most furniture uses. Appearance, including color, grain, texture, and figure, together with good machining and finishing characteristics, are among the important factors considered in the choice of woods used in exposed parts of furniture. Also included among the desirable characteristics for furniture are ease of gluing and mechanical fastening.

Angélique	Hububalli	Roble Blanco
Bulletwood	Laurel Blanco	Tatajuba
Cedro Espino	Mahogany (plantation-grown)	Teak (plantation-grown)
Cedro Granadino	Masa	Vaco
Courbaril	Nargusta	Yellow Sanders
Determa	Piquiá	
Gonçalo Alves	Primavera	
Guayacán		

Instruments

Professional and scientific instruments generally require a wood of uniform low shrinkage properties free from warp, and of uniform fine texture. Good machining and finishing characteristics are essential. Boxwood and Mahogany are among the favored woods for this type of use.

Laurel Blanco
Rajate Bién

Marine Piling and Construction

The characteristics of a timber suited for marine construction are those required for durable land construction and, in addition, resistance to attack by marine organisms such as *Teredo*, *Bankia*, and *Limnoria*. Marine piling requires the further characteristic of ability to withstand driving, and piling specifications are particularly exacting with respect to straightness. Long-boled, slender timber free of branches and branch stubs is particularly suitable for use as piling. Greenheart *(Ocotea Rodiaei)* is the best known of the marine construction timbers.

Angélique
Black Kakeralli
Determa
Guayacán
Piquiá
Tatajuba

Millwork

Millwork such as interior finish and doors is usually manufactured from woods with good machining and finishing characteristics. Low shrinkage and freedom from warp are also desired in a wood for millwork use. In addition to these requirements, exterior millwork should possess the qualities of durability and good weathering characteristics. From the standpoint of practical usage of tropical hardwoods, adaptability to millwork items is probably limited to high quality products calling for an attractive appearance in addition to the technical characteristics listed above.

Angélique	Laurel Blanco
Cedro Espino	Masa
Cedro Granadino	Mahogany (plantation-grown)
Courbaril	Primavera
Determa	Roble Blanco
Guayacán	Teak (plantation-grown)
Hububalli	Vaco

Patterns

Wood for pattern-making must satisfy exceptionally rigid requirements with respect to dimensional stability, uniform texture, and ease of working. The soft, slow-growth type of Eastern White Pine known as "Cork" Pine and Mahogany are highly favored for this use.

Cedro Granadino	Mahogany (plantation-grown)
Laurel Blanco	P...

Veneer and Plywood

The diversified uses of veneer and plywood require a wide range of wood properties and characteristics. The choice of species for use in plywood for construction or utility purposes is based largely upon strength properties, ease of gluing, and characteristics such as freedom from warping and surface checking of the wood. For rotary cutting, large diameter logs containing a high proportion of clear wood are preferred. Veneer for cross-bands and interior plies of furniture plywood or of decorative panelling should meet similar requirements, with particular emphasis upon uniformity of grain direction and freedom from warping tendencies. Attractive grain or figure in logs of either large or small size is the primary requirement of a species for furniture face veneer or decorative panelling. Smaller logs are acceptable for veneer cutting by the slicing method. All species to be used for veneer must be adaptable to rotary cutting or slicing and to the processing and drying operations involved in veneer production.

Utility	*Decorative*
Cedro Espino	Cedro Granadino
Cedro Granadino	Courbaril
Laurel Blanco	Frijolillo
Nargusta	Gonçalo Alves
Vaco	Primavera
Yellow Sanders	Yellow Sanders

Species Descriptions

The remainder of this paper consists of detailed descriptions of each of the species covered in Tables 1 to 4 including discussion of their occurrence, general characteristics, properties, and uses. The additional tests now in progress may alter or add to the uses recommended for each.

MYLADY *Aspidosperma cruentum* Woodson

Other names for this or closely related species are Colorado, Volador (Mexico); Canamito, Chichique (Guatemala);

Chaperno (Honduras), Alcarreto (Panama). The Costillo of Colombia may also be this tree. Mylady, or Malady, is the British Honduras name.

There are many species in this genus, a large number of which are small or grotesquely fissured ("paddle wood") trees. Some of the species are large well-formed trees, almost invariably with fine to rather fine textured, useful wood. Most of the species are found in the dry regions of South America.

The Mylady tree is tall and slender when it is young, sometimes reaching 80 to 90 feet in height while only 6 to 8 inches in diameter. In British Honduras few trees are larger than 18 inches in diameter, in other Central American countries the sizes are variously given as "large" or "giant" with diameters of 24 to 36 inches recorded for northern Petén. The clear trunk is commonly more than two-thirds the total height of the tree.

Heartwood bright orange-red to reddish brown when freshly cut in the unseasoned condition, becoming light pinkish brown or pale yellowish brown upon exposure and drying. Sapwood narrow, sharply demarcated in the log, white to yellowish when freshly cut becoming darker upon exposure and drying and then not clearly differentiated from the heartwood. Grain straight to irregular, texture medium, uniform; growth layers indistinct. Heartwood without pronounced odor or taste when seasoned. Very heavy, ranking slightly above Hickory in this respect, with an average specific gravity of 0.71 (0.61 to 0.77) based on oven-dry weight and green volume. Weight per cubic foot averages 70 pounds in the green condition and 53 pounds when air-dry.

Observations made on a limited sample of this material indicate that this wood should be air-dried at a moderate rate to avoid both end- and surface-checking. It is comparable in air-seasoning characteristics to Paper Birch (*Betula papyrifera*).

Species	Source	No. of Logs	Moisture Content	Specific Gravity: Oven-dry vol.	Specific Gravity: Green vol.	Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Mylady (*Aspidosperma cruentum*)	British Honduras	3	57.2	0.82	0.71	9,070	14,100	2,500	1.83	8.9
Persimmon[1] (*Diospyros virginiana*)	United States		58	0.78	0.64	5,600	10,000	1,370	1.35	13.0
White Oak[1] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Mylady (*Aspidosperma cruentum*) British Honduras	5,360	6,650	2,840	1500	1470	1100	760	1500	420	152.8
Persimmon[1] (*Diospyros virginiana*) United States	3,160	4,170	—	1240	1280	1110	770	1470	410	—
White Oak[1] (*Quercus alba*) United States	3,090	3,500	—	1120	1060	830	770	1250	420	—

[1]U. S. Dept. Agri. Tech. Bul. 479

The mechanical properties of *Aspidosperma cruentum* in the green condition exceed those of any widely used domestic timber. In comparison with other species of equivalent density, static-bending strength, stiffness, and crushing strength are notably high; elastic resilience, tension across the grain, and cleavage are approximately average; and shock resistance, hardness, compression perpendicular to grain, and shear are somewhat below average.

In the accompanying tabulation, the properties of Persimmon and White Oak are shown for comparison with Mylady. The higher strength of Mylady is evident in all properties with the exception of work to maximum load in static bending, compression across the grain, tension across the grain, and cleavage resistance. All three woods are comparable in the latter two properties. The greatest proportionate difference between *Aspidosperma cruentum* and the other two species is shown in modulus of elasticity (stiffness) in which White Oak is exceeded by a ratio of 2:1.

Species and Source	SHRINKAGE (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Mylady (*Aspidosperma cruentum*) British Honduras	5.2	8.7	0.18	14.3
White Oak[1] (*Quercus alba*) United States	5.3	9.0	—	15.8

[1]U. S. Dept. Agr. Tech. Bul. 479.

Shrinkage values of Mylady are relatively high as might be anticipated on the basis of its density. As shown in the tabulation, shrinkage is similar to that of White Oak both from the standpoint of magnitude and relative directional values. Volumetric shrinkage of 14.3 percent is slightly less than White Oak; radial and tangential values of 5.2 percent and 8.7 percent respectively are comparable to White Oak. Longitudinal shrinkage of 0.18 percent is within the limits recognized for normal, straight-grained wood.

Heartwood of *Aspidosperma megalocarpon*, suposedly similar to *A. cruentum*, is reported to be moderately resistant

to insect attack, decay, and marine borers.[48,79] On the basis of limited decay resistance tests conducted as a part of the present study, Mylady wood is rated very durable in its resistance to both white-rot and brown-rot fungi.

The wood of Mylady and closely related species of the genus *Aspidosperma* has been reported as not very difficult to work in spite of its high density. It turns and carves well, finishes very smoothly, and takes a high polish.

Locally, the long, straight, slender poles of Mylady are commonly employed for rural house framing, beams and rafters. Similar poles are used for scaffolding. Stems 2 to 3 inches in diameter are commonly used for raft or boat poles because of their strength and elasticity. Mature timber is used for house sills, house framing, heavy construction and hewn railway crossties. Because of its similarity in properties to Persimmon, Mylady might well be substituted for that species in its sporting goods, textile, and other specialty uses. It also is recommended for use in durable construction, as flooring, and as boat framing material.

References: 10, 48, 51, 79, 90, 94, 99, 115, 116.

GONÇALO ALVES *Astronium graveolens* Jacq.

The woods tested for this report were obtained from Honduras, where the common name is Ciruelillo, and Venezuela where the name Gateado is used. The Brazilian name Gonçalo Alves is given preference because the wood is known to the United States import trade by this name. Other names include Palo de Culebra (Mexico), Ciruelo, Ormigo (Guatemala), Ronroń (Salvador, Honduras, Costa Rica), Zorro (Panama), Gusanero (Colombia), and Guasango (Ecuador). The British Standards name is Zebrawood. Unfortunately this is frequently applied to several other unrelated woods.

The closely related species *Astronium fraxinifolium* Schott has similar wood and grows in the same regions. Further investigation is required to determine the practical feasibility of combining the woods of these two species.

Gonçalo Alves is a common tree in the upland forests of many regions from Mexico and Central America through Ecuador, Colombia, Venezuela, and Brazil. It is well known and frequently used locally throughout most of its range.

The tree of Gonçalo Alves attains diameters of 24 to 40 inches or more, and a maximum height of 120 feet. Except for narrow buttress flanges 4 to 6 feet tall, it has a clear, cylindrical trunk for two-thirds or more of its height. In some parts of its range trees over 24 inches in diameter are scarce. The logs are typically sound throughout.

The wood of Gonçalo Alves is variable in general color but usually can be recognized by its bold, irregular striping. When fresh, the heartwood is russet, brown, orange brown, or reddish brown to red with narrow to wide, irregular stripes of medium to very dark brown. After exposure it becomes brown, red, or dark reddish brown with nearly black stripes. The dingy grayish or brownish white sapwood is sharply demarcated, two to four inches wide. Grain variable, straight to roey, often producing a pleasing stripe on the quarter-sawed surface. Texture fine, uniform; growth layers indistinct. The wood often displays a striking figure as a result of the irregular occurrence of dark longitudinal bands. Odor and taste not distinctive. Exceedingly heavy, comparable in this respect to Greenheart with an average specific gravity of 0.84 (0.72 to 1.00) based on oven-dry weight and green volume. Weight per cubic foot averages 76 pounds in the green condition and 63 pounds when air dry.

Based on observation of a limited amount of material from Honduras, the wood should be seasoned at a moderate to slow rate to avoid excessive checking and warping.

The mechanical properties of Gonçalo Alves are considerably higher in most respects than those of any well known domestic species. In comparison with other species of equal density, however, the wood is below average in most properties including all static-bending properties, crushing strength, hardness, and toughness; slightly below

Species	Source	No. of Logs	Moisture Content	Specific Gravity Oven-dry vol.	Specific Gravity Green vol.	Static Bending: Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Gonçalo Alves (*Astronium graveolens*)	Honduras	1	49.2	0.93	0.81	7,680	11,640	2,040	1.90	5.4
	Venezuela	3	43.2	0.97	0.87	9,340	12,650	1,850	2.66	8.0
	Average	4	46.2	0.95	0.84	8,510	12,140	1,940	2.28	6.7
	Venezuela[1]	1	32.5	1.11	0.99	11,200	16,250	2,580	2.75	15.4
Dogwood[2] (*Cornus florida*)	United States		62	0.80	0.64	4,800	8,800	1,180	1.11	21.0
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	Hardness End	Hardness Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Gonçalo Alves (*Astronium graveolens*)										
Honduras	4,230	6,000	2,470	1430	1730	1530	840	1610	320	150.6
Venezuela	5,000	7,170	1,990	1850	2090	2140	1150	1920	530	127.4
Average	4,620	6,580	2,230	1640	1910	1840	1000	1760	420	139.0
Venezuela[1]	8,660	9,500	2,870	1690	2100	2490	940	1770	450	—
Dogwood[2] (*Cornus florida*) United States	—	3,640	—	1410	1410	1030	—	1520	—	—
White Oak[2] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—

[1]Kynoch and Norton (47). [2]U. S. Dept. Agr. Tech. Bul. 479.

average in shear; and average in compression and tension across the grain.

Previously published data on Gonçalo Alves from Venezuela are shown for direct comparison with the material tested in this study. The published Venezuela data, based upon a single log, are considerably higher in specific gravity and proportionately higher in nearly all strength properties. Except for work to maximum load, Gonçalo Alves is markedly stronger than Dogwood or White Oak in most properties for which comparable data are available.

Shrinkage of Gonçalo Alves is low, especially so in consideration of the high density of the wood.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Gonçalo Alves *(Astronium graveolens)*				
Honduras	4.2	7.1	0.55	11.1
Venezuela	3.7	8.2	0.31	8.9
Average	4.0	7.6	0.43	10.0
Venezuela[1]	3.2	8.6	—	10.4
Dogwood[2] *(Cornus florida)*				
United States	7.1	11.3	—	19.9
White Oak[2] *(Quercus alba)*				
United States	5.3	9.0	—	15.8
Black Locust[2] *(Robinia pseudoacacia)*				
United States	4.4	6.9	—	9.8

[1]Kynoch and Norton (47).
[2]U. S. Dept. Agr. Tech. Bul. 479.

Volumetric shrinkage of 10.0 percent is comparable to that of Black Locust and considerably less than that of White Oak and Dogwood. Radial shrinkage of 4.0 percent is especially low and tangential shrinkage of 7.6 percent is intermediate to that of Black Locust and White Oak. The ratio of tangential to radial shrinkage is relatively high, indicative of non-uniform shrinkage in these two directions. Longitudinal shrinkage of 0.43 percent is relatively high, probably the result of the characteristic interlocked grain.

The heartwood is reported to be highly durable.[79,112] It is not difficult to work in spite of its high density, turns readily, finishes very smoothly, and takes a high natural polish. The wood weathers well, is highly resistant to moisture absorption, and appears to be difficult to glue.

Gonçalo Alves has long been in demand both locally and in the export trade as a fine furniture and cabinet wood. The wood has been successfully cut for veneers and frequently a fine figure is produced. In addition Gonçalo Alves is used for flooring and general construction. Because of its figure and the beautiful polish which this wood will take, its greatest use will undoubtedly be in the furniture and cabinet industry both in solid and veneer construction. However, the similarity of many of the characteristics of this wood to those of Dogwood should make Gonçalo Alves a valuable substitute for this latter species in textile manufacture and turning. This timber can also be recommended for durable construction purposes and should be suitable for flooring. Its low shrinkage combined with high strength and durability indicate adaptability of Gonçalo Alves for insulator pins and other specialty uses of Black Locust *(Robinia pseudo-acacia)*.

References: 10, 13, 30, 34, 36, 44, 47, 51, 55, 58, 63, 64, 75, 79, 85, 90, 92, 94, 98, 99, 102, 111, 112, 113.

TATAJUBA *Bagassa guianensis* Aubl.

In French Guiana this tree is known as Bagasse, in Surinam as Gele Bagasse; in Brazil (the source of the material used in these tests) it is known as Tatajuba.

Tatajuba is a member of the Mulberry family, which includes the Iroko of West Africa, the Fig of world wide distribution in the tropical zone, Mulberry and Osage Orange of the United States, and Fustic, Satiné, and Letterwood of the American tropics. It is a large well-formed tree with a fibrous bark which yields large quantities of sweet, sticky latex on cutting. The heart-shaped leaves are entire, or 3-lobed, resembling Mulberry in this respect. The edible fruits are about the size and shape of an orange. It is found, generally scattered, in the low upland forests of the Guianas and lower Amazon region.

The unseasoned heartwood of Tatajuba is yellow, often streaked with brown, when freshly cut, becoming lustrous golden brown to russet from seasoning and exposure. The sapwood is narrow, sharply demarcated, pale yellow to yellowish white. Grain usually interlocked resulting in a rather broad stripe figure on the radial surface. Texture medium to coarse, moderately uniform; growth layers indistinct. Odor and taste not distinctive when seasoned. Very heavy, comparable to Hickory, with an average specific gravity of 0.68 (0.62 to 0.71) based on oven-dry weight and green volume. Weight per cubic foot averages 67 pounds in the green condition and 50 pounds when air-dry.

The wood air seasons at a moderate rate with very little tendency to warp or check, based on observations of a limited amount of material.

The strength properties of Tatajuba in the green condition exceed those of any well known domestic timber. Bending strength, crushing strength, and stiffness are exceptionally high among species of similar high density. On the same basis shock resistance, hardness, compression across the grain, and shear are average; and tension across the grain and cleavage resistance below average.

Although only slightly heavier than Hickory, Tatajuba 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. The superiority of *Bagassa guianensis* is even more evident in a general comparison with White Oak, although here the values for tension across the grain and cleavage are somewhat below those for Oak. Teak, with a green volume specific gravity identical to that of Oak, is also surpassed in

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Tatajuba (*Bagassa guianensis*)	Brazil	2+[1]	58.0	0.76	0.68	10,340	14,510	2,300	2.84	11.3
Shagbark Hickory[2] (*Carya ovata*)	United States		60	—	0.64	5,900	11,000	1,570	1.28	23.7
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
Teak[3] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,000	1,670	1.7	9.3

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Tatajuba (*Bagassa guianensis*) Brazil	6,060	7,900	2,510	1620	1670	1200	650	1670	370	195.5
Shagbark Hickory[2] (*Carya ovata*) United States	3,430	4,580	—	—	—	1040	—	1520	—	—
White Oak[2] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—
Teak[3] (*Tectona grandis*) Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—

[1]Based upon tests of one log and a shipment of plank representing an unknown number of trees.
[2]U. S. Dept. Agr. Tech. Bul. 479. [3]A. V. Thomas (105).

most properties by a margin greater than would ordinarily be anticipated on the basis of differences in density.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Tatajuba *(Bagassa guianensis)* Brazil	5.2	6.6	0.09	10.2
Teak[1] *(Tectona grandis)* Burma	2.3	4.2	—	6.8
White Oak[2] *(Quercus alba)* United States	5.3	9.0	—	15.8
Black Locust[2] *(Robinia pseudoacacia)* United States	4.4	6.9	—	9.8

[1]Handbook of Empire Timbers (32).
[2]U. S. Dept. Agr. Tech. Bul. 479.

Shrinkage of Tatajuba is exceptionally low among species of comparable high density. As shown in the tabulation, volumetric shrinkage of 10.2 percent is only two-thirds that of Oak and approximately the same as that of Black Locust, a slightly lighter species, noted for its dimensional stability. Values for radial shrinkage of 5.2 percent and tangential shrinkage of 6.6 percent are indicative of unusual uniformity in these two directions. Longitudinal shrinkage of 0.09 per cent is exceptionally low but probably of no particular significance.

The heartwood of *Bagassa guianensis* is reported to be fairly resistant to decay. The wood has been reported as easy to saw but difficult to split radially. It takes a smooth finish and holds its place well. The heartwood is highly resistant to moisture absorption, comparable to Teak in this respect.

Locally, Tatajuba is used for general building purposes, heavy construction timbers, marine and boat construction. Natural bends are used for boat and ship members. The wood, being very similar in its characteristics to that of Black Locust, could well be used as a substitute for that species in its many specialty uses, such as insulator pins. Tatajuba holds

promise as a decking, planking, and framing wood in boat building and as a furniture, cabinet, and flooring wood. Because of its high resilience, the wood might well be suitable for some kinds of sporting equipment.

References: 42, 49, 63, 79, 104.

CEDRO ESPINO *Bombacopsis quinata* (Jacq.) Dugand

Other important vernacular names for this timber are Pochote (Costa Rica), Tolú (Colombia), and Saqui-saqui (Venezuela). Often it carries a vernacular name compounded with Ceiba which the tree resembles, or Cedro which has somewhat similar wood.

As its name suggests, *Bombacopsis* is a member of the Bombacaceae family which also includes the Ceiba (from which kapok is obtained) and Balsa. Due to the close similarity of its leaves, flowers, and fruits with those of other genera this species has at various times and specific names under the genera *Bombax* and *Pachira*.[79] Taxonomic botanists recognize several species of *Bombacopsis* but in general the woods have the same appearance and similar properties.

Cedro Espino is a medium-sized to large tree, not infrequently 3 feet and sometimes 5 or 6 feet in diameter. Heights of 75 to 100 feet are recorded although the bole is commonly relatively short and the crown very large. It is generally buttressed at the base and often the bole is irregular in shape. The trunk and larger branches are densely armed with hard, sharp prickles.

Cedro Espino is common in the more open forests of western Nicaragua, Costa Rica, and Panama. It is also well known on the Atlantic side of eastern Panama, and in Colombia and Venezuela. It is fairly abundant throughout this range except close to centers of population and adjacent to the more heavily traveled routes of transportation where cutting for local use has removed a large percentage of the material. The best areas may have 5 to 6 trees per acre yielding 4000 to 5000 board feet. The trees are typically found on well-drained, often gravelly, soils on the upper slopes of low hills and ridges. Frequently the areas on which the tree occurs can be classed as semi-dry.

The heartwood is uniform pale pinkish or pinkish brown when freshly cut in the unseasoned condition, becoming reddish or reddish brown; prolonged exposure to sunlight causes it to become dull brown. Sapwood fairly thin in mature, thick in younger trees, yellowish to white. Grain straight to mildly interlocked. Texture medium, the side-grain figure characterized by scattered lines of prominent vessels; growth layers not distinct. Heartwood without distinctive odor but sometimes with a slightly astringent taste. Density variable, generally medium; material used in these tests comparable to holly with an average specific gravity of 0.51 (0.46 to 0.56) based on oven-dry weight and green volume. Weight per cubic foot averages 59 pounds in the green condition and 38 pounds when air dry,

Cedro Espino has the reputation of air seasoning very slowly with a minimum of checking and splitting. A limited amount of material from Honduras, mostly sapwood, air-dried rapidly with slight surface checking and warping. It has been reported that the wood has been successfully kiln dried with a reasonably short drying schedule.

The mechanical properties of Cedro Espino in the green condition are in general below average for most species of comparable density. Only shock resistance and tension across the grain may be considered as average on this basis, whereas stiffness, hardness, compression perpendicular to the grain, and cleavage resistance are slightly below average, and bending strength, elastic resilience, crushing strength, and shear are distinctly below average.

Included in the table are comparative data for a closely related species, *Bombacopsis sepium*, from Venezuela. In general the Venezuela species appears to be both lighter and weaker than *Bombacopsis quinata* from Honduras but the limited sample from Venezuela precludes any definite conclusion in this respect.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Cedro Espino (*Bombacopsis quinata*)	Honduras	3	86.0	0.58	0.51	4,650	8,060	1,380	0.95	7.8
(*Bombacopsis sepium*)[1]	Venezuela	1	204.2	0.39	0.36	4,300	6,500	1,070	0.98	6.7
Mahogany[2] (*Swietenia macrophylla*)	Central America		58	0.50	0.45	6,120	9,240	1,290	—	10.2
Black Walnut[3] (*Juglans nigra*)	United States		81	0.56	0.51	5,400	9,500	1,420	1.16	14.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit lb. per sq. in.	Compression Parallel to Grain: Maximum Crushing Strength lb. per sq. in.	Compression Parallel to Grain: Modulus of Elasticity 1000 lb. per sq. in.	Hardness End lb.	Hardness Side lb.	Compression Perpendicular to Grain Stress at proportional limit lb. per sq. in.	Tension Perpendicular to Grain lb. per sq. in.	Shear lb. per sq. in.	Cleavage lb. per in. of width	Toughness in.-lb. per specimen
Cedro Espino (*Bombacopsis quinata*) Honduras	2,790	3,690	1,520	840	790	660	760	1110	340	116.9
(*Bombacopsis sepium*)[1] Venezuela	2,710	2,930	1,220	660	600	1000	490	760	230	—
Mahogany[2] (*Swietenia macrophylla*) Central America	—	4,540	—	750	650	710	—	1310	—	—
Black Walnut[3] (*Juglans nigra*) United States	3,520	4,300	—	960	900	600	570	1220	360	—

[1]Kynoch and Norton (47).
[2]Heck (37).
[3]U. S. Dept. Agr. Tech. Bul. 479.

Cedro Espino has the same green volume specific gravity as Black Walnut, but is somewhat weaker than Walnut, particularly in static-bending strength properties, crushing strength, and hardness. These two woods are closely comparable in compression across the grain, stiffness, shear, and cleavage, and Cedro Espino shows an appreciably higher strength in tension across the grain.

The shrinkage of Cedro Espino is moderately high among species of comparable density.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Cedro Espino				
(Bombacopsis quinata)				
Honduras	4.1	7.6	0.10	12.8
(Bombacopsis sepium)[1]				
Venezuela	3.0	4.4	—	6.4
Mahogany[2]				
(Swietenia macrophylla)				
Central America	3.5	4.8	—	7.7
Black Walnut[3]				
(Juglans nigra)				
United States	5.2	7.1	—	11.3

[1]Kynoch and Norton (47).
[2]Heck (37).
[3]U. S. Dept. Agr. Tech. Bul. 479.

As shown in the preceding table, volumetric shrinkage of 12.8 percent is somewhat greater than that of Black Walnut, and much greater than that found for *Bombacopsis sepium* or for Mahogany. Radial shrinkage of 4.1 percent and tangential shrinkage of 7.6 percent indicate a normal differential in these two directions but considerably less uniformity than for Black Walnut.

Heartwood of Cedro Espino is reported to be resistant to insect attack and decay. In decay resistance tests conducted as a part of the present study, *Bombacopsis quinata* from Honduras was found to be extremely variable, probably because of the inadvertant inclusion of poorly demarcated sapwood. Average ratings based upon several logs, however, indicate that the heartwood is predominantly durable to very durable in resistance to a white rot and very durable with respect to a brown-rot fungus.

The wood of *Bombacopsis* has been reported as easy to work and finishing smoothly. It is considered fire resistant. The wood absorbs moisture readily and heartwood is reputed to retain moisture tenaciously under normal atmospheric conditions.

Cedro Espino is used locally for general construction, boxes, interior finish and cabinet work. The wood, while not particularly strong, is durable and is recommended for tank stock and exterior uses where durability rather than strength is important. Because of its ease of working, the wood should be suitable for turning and millwork. Other suggested uses are for utility veneer and plywood.

References: 5, 20, 21, 25, 26, 27, 34, 47, 58, 64, 65, 66, 69, 70, 71, 79, 92, 96, 98, 112, 113.

YELLOW SANDERS *Buchenavia capitata* (Vahl.) Eich.

The Cuban name for this species is Júcaro Amarillo; Puerto Rican, Granadillo; Haitian, Bois Gris-gris; Trinidad, Olivier; Colombian, Almendro; Venezuelan, Amarillo Boj; Brazilian, Mirindiba or Periquiteira. Yellow Sanders is the most common name in English-speaking countries.

Yellow Sanders attains its best development in the West Indies and on the northern edge of South America. Closely related species are found in the Amazon Valley.

The Yellow Sanders tree attains a height of 80 feet and diameter of three feet. It is buttressed but has a good log form above this.

Heartwood yellowish brown when freshly cut in the unseasoned condition becoming yellow- to golden-brown usually with a gray or olive hue upon exposure; sapwood light yellow-brown. Grain more or less interlocked producing a distinct roe figure on the radial surface and an attractive figure on the tangential surface characterized by the wavy course of the prominent vessels; texture medium

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending				
				Oven-dry vol.	Green vol.	Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	3	65.1	0.66	0.60	6,330	10,050	1,460	1.62	8.8
White Oak[1] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
Hard Maple[1] (*Acer saccharum*)	United States		58	0.68	0.56	5,100	9,400	1,550	1.03	13.3

Species	Compression Parallel to Grain			Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	End	Side					
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Yellow Sanders (*Buchenavia capitata*) Puerto Rico	3,790	5,130	1,570	1350	1230	1070	800	1340	400	122.8
White Oak[1] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—
Hard Maple[1] (*Acer saccharum*) United States	2,850	4,020	—	1070	970	800	—	1460	—	—

[1] U. S. Dept. Agr. Tech. Bul. 479.

to rather coarse, uniform; growth layers not distinct. With faint spicy odor and mildly bitter taste when seasoned. Heavy to very heavy, comparable to White Oak, with an average specific gravity of 0.60 (0.52 to 0.67) based on oven-dry weight and green volume. Weight per cubic foot averages 62 pounds in the green condition and 44 pounds when air dry.

Observations made on a limited sample of material of this species indicate that it can be air seasoned at a fast rate with only slight warping and checking. It compares in air-seasoning characteristics with Yellow Poplar (*Liriodendron tulipifera*).

Most of the strength properties of Yellow Sanders are normal for a wood of its density class. When compared with other woods of similar density, Yellow Sanders is approximately average in static-bending strength and elastic resilience (as measured by work to proportional limit), crushing strength, compression across the grain, shear, and toughness. It is above average in hardness, slightly above average in tension perpendicular to grain and cleavage resistance, and somewhat below average in stiffness and shock resistance as measured by work to maximum load in static bending. Comparable data are shown in the tabulation for White Oak, having the same average specific gravity as *Buchenavia capitata*, and Hard Maple which is somewhat lighter. It is evident that *Buchenavia capitata* exceeds White Oak in all properties shown except work to maximum load in which *Buchenavia capitata* is approximately three-fourths as strong.

The shrinkage of Yellow Sanders is exceptionally low among woods of comparable density. In volumetric shrinkage, *Buchenavia capitata* with a value of 9.6 percent is far more stable than White Oak as shown in the tabulation and may be classed with Black Locust and Teak, both of which are noted for their exceptionally low shrinkage. On the basis of its low shrinkage of 2.8 percent radially and of 5.7 percent tangentially, the wood is nearly comparable to Teak, although the high ratio of tangential to radial shrinkage is

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Yellow Sanders (*Buchenavia capitata*) Puerto Rico	2.8	5.7	0.32	9.6
White Oak[1] (*Quercus alba*) United States	5.3	9.0	—	15.8
Black Locust[1] (*Robinia pseudoacacia*) United States	4.4	6.9	—	9.8
Teak[2] (*Tectona grandis*) Burma	2.3	4.2	—	6.8

[1]U. S. Dept. Agr. Tech. Bul. 479.
[2]Handbook of Empire Timbers (32).

indicative of somewhat less uniformity than Teak in this characteristic. Longitudinal shrinkage of 0.32 percent is not unusual among woods characterized by interlocked grain.

The heartwood of *Buchenavia capitata* from Trinidad has been reported as fairly resistant to decay and to attack by termites. The wood has been included among the Puerto Rican timbers immune or very resistant to attack by the dry-wood termite of the West Indies. On the basis of decay resistance tests in the present study the heartwood is rated very durable in resistance to deterioration by both white-rot and brown-rot organisms. The wood has little resistance to marine borers.

Yellow Sanders is not very easy to work but takes a glossy finish. It appears to be somewhat difficult to glue.

Although local use of Yellow Sanders is limited mainly to furniture, the wood has much to recommend its use as a decking, planking, and framing material in boat construction. Other uses for which this wood appears well suited on the basis of its durability, low shrinkage characteristics, wear resistance and attractive figure, are exterior and interior flooring, turning, durable construction, figured and utility plywood, and wood tanks. Yellow Sanders is well suited not only for solid parts of furniture and cabinet work but as a face veneer in these products.

References: 8, 14, 29, 32, 49, 50, 53, 62, 63, 64, 79, 83, 114.

PIQUIÁ *Caryocar villosum* (Aubl.) Pers.

Other frequently used Guiana names include Piquiá Bravo, Souari, Bats Souari, and Arbe à Beurre. Both Piquiá and Souari have numerous variations of spelling. The combined forms of the names frequently refer to other species of *Caryocar* whose wood may have similar or different properties. Piquiá-Marfim is an entirely unrelated tree (*Aspidosperma eburneum*).

There are a considerable number of species of *Caryocar* in northern South America and the range of distribution extends into Central America. Some of these have woods somewhat resembling Piquiá but differences are great enough to prevent their acceptance as the wood described here. *Caryocar villosum* is widely but rather sparsely distributed in the upland forests throughout the Amazon region and the State of Marinhao and the Guianas. The various Piquiá-ranas (false Piquiás, mostly other species of *Caryocar*) are more abundant.

The tree attains heights of 120 to 150 feet. It is one of the largest-boled trees in the Amazon Valley, commonly with diameters of 5 to 7 feet and a reported maximum of 16 feet.

The heartwood of Piquiá is yellowish or buff to light brown when freshly cut in the unseasoned condition, becoming yellowish to light grayish brown when dry. Sapwood narrow, distinguished in the unseasoned condition by a greenish tinge, but hardly separable from the heartwood after seasoning. Grain interlocked resulting in a broad stripe figure on the radial surface. Texture medium, uniform; growth layers distinct as a result of terminal bands of denser tissue that appear as fine brown lines and distinguish the grain pattern on both radial and tangential surfaces. Freshly cut wood with a mild, vinegar odor when green but both odorless and tasteless when seasoned. Very heavy to exceedingly heavy, somewhat denser than Hickory, with an average specific gravity of 0.72 (0.63 to 0.80) based on oven-dry

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Piquiá (*Caryocar villosum*)	Brazil	3+[1]	61.3	0.84	0.72	8,260	12,450	1,820	2.17	8.4
Shagbark Hickory[2] (*Carya ovata*)	United States		60	—	0.64	5,900	11,000	1,570	1.28	23.7
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
Teak[3] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,000	1,670	1.7	9.3

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	Hardness: End	Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Piquiá (*Caryocar villosum*) Brazil	4,990	6,290	2,210	1450	1720	2080	990	1640	430	150.5
Shagbark Hickory[2] (*Carya ovata*) United States	3,430	4,580	—	—	—	1040	—	1520	—	—
White Oak[2] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—
Teak[3] (*Tectona grandis*) Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—

[1]Based upon tests of two logs and a shipment of plank representing an unknown number of trees.
[2]U. S. Dept. Agr. Tech. Bul. 479. [3]A. V. Thomas (105).

weight and green volume. Weight per cubic foot averages 72 pounds in the green condition and 55 pounds when air-dry.

The wood of Piquiá has a tendency to check and warp during air seasoning and should be dried at a moderate to slow rate to minimize these defects. It is comparable to Red Gum *(Liquidambar styraciflua)* in seasoning characteristics and like that species has interlocked grain which undoubtedly accounts for the tendency to twist and crook.

The strength properties of Piquiá in the green condition are for the most part considerably higher than those of Shagbark Hickory. In comparison with other species of similar density, however, they lie close to the average as shown by static-bending strength and stiffness, crushing strength, shear, and cleavage resistance. Elastic resilience and compression across the grain are well above average; hardness is slightly below average, and shock resistance and tension perpendicular to the grain below average. Values for Shagbark Hickory, White Oak, and Teak, all somewhat lower in density than Piquiá, are shown in the preceding tabulation. Piquiá exceeds all three in all properties for which comparative data are available except shock resistance as indicated by work to maximum load, a property in which this timber is conspicuously deficient. It nevertheless approaches Teak even in this respect. Static-bending strength, stiffness, crushing strength and shear exceed the properties of Hickory by an amount that corresponds closely to the difference in specific gravity of these two woods, but in compression across the grain *Caryocar villosum* shows twice the strength of Hickory although only about 12 percent higher in density.

Shrinkage values for Piquiá are compared with those of White Oak in the following tabulation.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Piquiá (*Caryocar villosum*) Brazil	5.0	8.0	0.20	13.0
White Oak[1] (*Quercus alba*) United States	5.3	9.0	—	15.8

[1]U. S. Dept. Agr. Tech. Bul. 479.

Shrinkage values for *Caryocar villosum* are not high in consideration of the relatively high density of the wood. Volumetric shrinkage of 13.0 percent is measurably less than that of White Oak, a lower density species. Radial shrinkage of 5.0 percent and tangential shrinkage of 8.0 percent are also somewhat less than in White Oak, and furthermore indicate greater uniformity in these two directions. Longitudinal shrinkage of 0.20 percent lies within the normal range of variation for wood.

The heartwood of *Caryocar villosum* from Brazil has been studied in relation to its resistance to attack by the drywood termite of the West Indies and has been classified among the very resistant woods in this respect.[114] The timber has been variously reported as durable to very durable against fungal attack. It has been rated moderately resistant to marine borers.

The wood of *Caryocar* is reported as fairly easy to saw but requiring sharp tools to finish smoothly. The wood weathers with only a slight amount of checking.

Piquiá has been used for general construction, marine construction, ship building (particularly futtocks and decking), heavy flooring, carriage building, oars, barrel staves and crossties. It is esteemed in northern Brazil as a decking wood that does not check in service. The wood should be especially suited for uses where hardness and high wear resistance are needed as in ice-sheathing and factory flooring. Other recommended uses are miscellaneous boat parts, furniture and durable construction.

References: 4, 11, 17, 24, 29, 40, 43, 49, 63, 79, 102, 103, 110, 114.

Fig. 8
Cedro Granadino tree approximately five feet in diameter above the buttresses and 110 feet tall

CEDRO GRANADINO *Cedrela Tonduzii* C.DC.

In the Chiriqui Province of Panama, above 5000 feet elevation, where this tree grows it is known as Cedro Granadino. Unfortunately at lower elevations both here and in nearby Costa Rica, other similar Cedro timbers are also known by this name. The name Cedro, with its many descriptive appellations, is universally applied in Spanish speaking countries to the wood known as Spanish Cedar. The timber described here differs in several significant respects from this well-known wood so that it was believed necessary to give it a distinctive vernacular name. Cedro Rojo would have been preferred in reference to the deep red color of the wood but unfortunately this name is already in use in Brazil and Argentina.

The tree is frequently 90 to 120 feet high with a straight, symmetrical trunk, often 30 inches and sometimes to six feet or more in diameter above the buttresses. The prominent buttress flanges extend up the trunk from 4 to 12 feet, depending upon the size of the tree and its exposure. The grayish bark is fairly thick and fissured into rather long narrow plates, or sometimes broken into smaller rectangular segments on the butt logs of very old trees. The clear trunk is commonly 50 to 75 feet in length.

The heartwood is light red when freshly cut, becoming a uniform, rich reddish brown upon exposure. The sapwood is sharply demarcated from the heartwood, grayish or pinkish, two to five inches thick. Luster fairly high, texture medium, uniform. General appearance chiefly characterized by scattered vessel lines on a plain background with a satiny sheen. Odor and taste are lacking or not distinctive. The wood is straight-grained and easily split. Moderately light, comparable to Port Orford Cedar with a specific gravity of .041 (0.32 to 0.45) based on oven-dry weight and green volume. Weight per cubic foot averages 43 pounds in the green condition and 31 pounds when air dry.

Cedro Granadino air seasons readily and may be dried at a fast rate with no apparent damage. It compares very favor-

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	67.4	0.46	0.41	4,520	7,510	1,310	0.94	7.1
Spanish Cedar[1] (*Cedrela* sp.)	Nicaragua		73	0.38	0.34	3,360	5,220	870	—	7.4
Port Orford Cedar[2] (*Chamaecyparis lawsoniana*)	United States		43	0.44	0.40	4,000	6,200	1,420	0.65	7.4
Mahogany[1] (*Swietenia macrophylla*)	Central America		58	0.50	0.45	6,120	9,240	1,290	—	10.2

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Cedro Granadino (*Cedrela Tonduzii*) Panama	2,770	3,370	1,330	650	550	600	430	990	260	106.2
Spanish Cedar[1] (*Cedrela* sp.) Nicaragua	—	2,760	—	380	350	310	—	720	—	—
Port Orford Cedar[2] (*Chamaecyparis lawsoniana*) United States	2,770	3,130	—	460	400	350	180	830	100	—
Mahogany[1] (*Swietena macrophylla*) Central America	—	4,450	—	750	650	710	—	1310	—	—

[1]Heck (37). [2]U. S. Dept. Agr. Tech. Bul. No. 479.

ably with Eastern White Pine *(Pinus strobus)* in its seasoning characteristics.

The mechanical properties of Cedro Granadino are generally those that might be anticipated on the basis of its moderately light weight. Static-bending properties, including strength, stiffness and resilience, hardness, compression across the grain, shear, and toughness, are average for woods of comparable density. Compression parallel to grain properties, tension across the grain, and cleavage resistance are slightly below average on this basis.

In comparison with previously published data on *Cedrela* sp. from Nicaragua, *Cedrela Tonduzii* from Panama is appreciably more dense and correspondingly higher in all strength values except work to maximum load in static bending, a measure of shock resistance. In the foregoing tabulation strength values of Port Orford Cedar and Central American Mahogany are shown for comparison. *Cedrela Tonduzii* is intermediate to these woods in density as well as in most properties for which comparable data are available. It is comparable to Mahogany in stiffness and shows a degree of shock resistance approximately equal to that of Port Orford Cedar.

Cedro Granadino is characterized by moderate shrinkage. The differences between corresponding shrinkage values for

Species and Source	Shrinkage (percent): Radial	Tangential	Longitudinal	Volumetric
Cedro Granadino (*Cedrela Tonduzii*) Panama	4.2	6.3	0.16	10.3
Spanish Cedar[1] (*Cedrela* sp.) Nicaragua	4.1	4.9	—	8.9
Port Orford Cedar[2] (*Chamaecyparis lawsoniana*) United States	4.6	6.9	—	10.1
Yellow Poplar[2] (*Liriodendron tulipifera*) United States	4.0	7.1	—	12.3

[1]Heck (37).
[2]U. S. Dept. Agr. Tech. Bul. No. 479.

this species and Spanish Cedar from Nicaragua are probably the result of the considerably greater average density of *Cedrela Tonduzii*. Radial shrinkage of 4.2 percent, tangential of 6.3 percent, and volumetric shrinkage of 10.3 percent correspond closely in magnitude to shrinkage values for Port Orford Cedar, and are somewhat more uniform and less than values for Yellow Poplar, a lighter wood.

Woods of the genus *Cedrela* generally have been regarded as highly resistant to decay and insect attack. However, *Cedrela Tonduzii* appears to be an exception at least insofar as decay resistance is concerned. Based on tests of Panama material conducted as a part of the present study, *Cedrela Tonduzii* was rated as non-durable to moderately durable in resistance to both white-rot and brown-rot fungi.

Cedro Granadino like other species of *Cedrela* is employed locally for construction, furniture and cabinet work, millwork and other numerous uses where an easy working, light but strong, straight-grained wood is desired. Cedro Granadino has characteristics which recommend it for millwork, furniture and cabinet construction, exterior use, patterns, wood novelties, instruments, venetian blind slats, and superstructure in small water-craft. The character of the wood and the size of the tree should make this a very satisfactory species for rotary veneering in the production of both decorative and utility grades of plywood.

References: 2, 18, 32, 34, 37, 58, 79, 92, 98.

LAUREL BLANCO *Cordia alliodora* (R. & P.) Cham.[1]

Laurel[2] is the generally recognized name for this wood throughout Central America. Laurel Blanco refers to light-colored heartwood and Laurel Negro refers to dark material apparently having somewhat different properties. Its wide range and general usefulness have caused it to acquire many additional names in these countries. It is known as Pardillo in Venezuela; Uruá in Brazil; Peterebí in Argentina; Prince-

[1] = *C. Gerascanthus* Jacq. not *C. Gerascanthus* L.
[2] Pronounced *la-oo-rél*.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Laurel Blanco (*Cordia alliodora*)	British Honduras	3	106.6	0.53	0.49	6,000	10,100	1,330	1.59	10.5
	Honduras	4	118.5	0.44	0.40	4,780	7,640	1,080	1.34	8.3
	Nicaragua	3	141.4	0.40	0.38	5,270	8,410	1,100	1.45	10.5
	Average	10	122.2	0.46	0.42	5,350	8,720	1,170	1.46	9.8
	Venezuela[1]	1	58.4	0.56	0.52	5,900	10,100	1,590	1.24	10.7
Mahogany[2] (*Swietenia macrophylla*)	Central America		58	0.50	—	6,120	9,240	1,290	—	10.2
Alaska Cedar[3] (*Chamaecyparis nootkatensis*)	United States		38	0.46	0.42	3,800	6,400	1,140	0.77	9.2

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Laurel Blanco (*Cordia alliodora*)										
British Honduras	3,740	4,530	1,440	1090	1030	920	630	1330	320	154.8
Honduras	3,140	3,560	1,240	730	630	640	580	970	300	114.3
Nicaragua	3,220	3,650	1,250	630	560	550	360	980	200	125.9
Average	3,370	3,910	1,310	820	740	700	520	1090	270	131.7
Venezuela[1]	4,680	4,960	1,700	900	610	480	590	930	290	—
Mahogany[2] (*Swietenia macrophylla*) Central America	—	4,540	—	750	650	710	—	1310	—	—
Alaska Cedar[3] (*Chamaecyparis nootkatensis*) United States										

wood in British West Indies; Bois Soumis in Haiti; and Varía in Cuba. Among the numerous Mexican names are Bojón and Hormiguero (for the fierce ants that inhabit the swellings at forks of the small branches).

There are many species of *Cordia*. A few are medium to large trees, the remainder are shrubs or small trees. Laurel Blanco grows from southern Mexico to northern Argentina, and in the West Indies. The tree varies in size in different regions. Frequently it can be classed as medium-sized with diameters of 18 to 24 inches and heights of 40 to 60 feet; in areas of optimum growth it attains diameters of 36 inches or more and heights of 120 feet, with long symmetrical trunks. The narrow buttresses are commonly six feet or less in height.

Laurel Blanco heartwood is light greenish brown to olive brown frequently streaked with black when freshly cut in the unseasoned condition, drying to a pale golden brown to brown with dark streaks. The sapwood is one to three inches wide, not sharply demarcated, yellowish to light brown. Grain generally straight, sometimes interlocked; texture fine to medium, uniform; growth rings delineated by narrow dark streaks as seen on side-grain surfaces. Small dark rays give the wood a mottled appearance on the radial surface. Luster medium to high. No distinctive odor or taste except in the darker colored specimens which have a distinct spicy odor. Moderately light to moderately heavy, comparable to mahogany, with an average specific gravity of 0.42 (0.31 to 0.56) based on oven-dry weight and green volume. Weight per cubic foot averages 58 pounds in the green condition and 31 pounds when air dry.

Laurel Blanco air seasons readily. Only a slight amount of checking and warping results from rapid air drying. It is comparable to Yellow Poplar *(Liriodendron tulipifera)* in its seasoning characteristics.

The mechanical properties of Laurel Blanco are above average for woods of comparable density in all static-bending properties except stiffness; the wood is also above aver-

age in hardness and toughness; slightly above average in compression parallel to the grain; and average in stiffness, compression across the grain, tension across the grain, cleavage, and shear.

Strength values for Laurel Blanco from several sources are shown in the accompanying table together with average values based upon material from British Honduras, Honduras and Nicaragua. Although a considerable range in values is shown by timber from these various sources, the differences shown are not sufficiently clear cut to justify any geographical distinction but are more probably indicative of local site and individual tree variations. Results of previous tests of *Cordia alliodora* from Venezuela are higher in nearly all respects, including density, but are limited to tests upon a single log.

In the tabulation, values for Central American Mahogany and Alaska Cedar are shown for comparison with Laurel Blanco. With the exception of hardness, the average values for Laurel Blanco are intermediate to those of Mahogany, a slightly heavier wood, and Alaska Cedar, characterized by the same density as *Cordia alliodora*. In hardness Laurel Blanco exceeds Mahogany by an appreciable margin.

Laurel Blanco is relatively low in shrinkage. Its volumetric shinkage of 8.7 percent is intermediate to that of Mahogany

	SHRINKAGE (percent)			
Species and Source	Radial	Tangential	Longitudinal	Volumetric
Laurel Blanco				
(Cordia alliodora)				
British Honduras	3.6	6.9	0.12	9.5
Honduras	3.3	6.8	0.14	9.1
Nicaragua	2.4	6.4	0.17	7.4
Average	3.1	6.7	0.14	8.7
Venezuela[1]	—	5.6	—	8.5
Mahogany[2]				
(Swietenia macrophylla)				
Central America	3.5	4.8	—	7.7
Alaska Cedar[3]				
(Chamaecyparis nootkatensis)				
United States	2.8	6.0	—	9.2

[1]Kynoch and Norton (47).
[2]Heck (37).
[3]U. S. Dept. Agr. Tech. Bul. No. 479.

and Alaska Cedar. Radial and tangential shrinkage values of 3.1 percent and 6.7 percent respectively are in about the same ratio as in Alaska Cedar, indicative of non-uniform shrinkage in these two directions in contrast to the exceptionally uniform shrinkage of Mahogany.

The heartwood of Laurel Blanco is reported to be variable in durability, the degree of resistance to decay being associated with the color of the wood. The darker colored wood is considered more durable. In Costa Rica the wood is highly esteemed for its resistance to decay and termite attack.[58] On the basis of results obtained in the present study involving moderately light-colored heartwood of *Cordia alliodora* from Honduras and British Honduras, the wood is rated very durable in resistance to both white-rot and brown-rot fungi. Similar high resistance of *Cordia alliodora* to white-rot fungi in both soil and pure culture tests has been found by Scheffer and Duncan.[84] The wood is easily worked, finishes smoothly, glues readily, and holds in place remarkably well when manufactured. Its weathering characteristics are excellent. Laurel Blanco has little resistance to marine borers on the basis of tests in Hawaiian waters.

Because of its ease of working, low shrinkage, and durability, Laurel Blanco has enjoyed considerable local use in cabinet and furniture construction, general construction, millwork, and for bridge and ship decking. It corresponds closely to Mahogany in many of its characteristics and might well be a substitute for that wood in many of its uses such as boat planking and miscellaneous boat parts. In addition to uses in furniture and cabinet work, millwork (including both exterior and interior trim), and general construction, Laurel Blanco should be suitable for patterns, wood turning, instruments, and plain veneer. It might well be used as a substitute for various species of cedar in many uses where durability is required.

References: 1, 8, 12, 17, 18, 20, 21, 29, 34, 39, 44, 47, 48, 49, 51, 53, 58, 64, 68, 70, 72, 73, 79, 84, 85, 90, 91, 92, 93, 94, 96, 98, 99, 111, 113.

ANGÉLIQUE *Dicorynia paraensis* Benth.

The French Guiana name Angélique is generally recognized for this timber. Its historical use as a Teak substitute has caused it to be referred to as Teck de la Guyane. In Surinam it is more commonly known as Basra Locus. Angélica do Pará and Tapaiuna have been recorded as Brazilian names but Horn (*Tropical Woods* 93:30) states that this species has no accepted vernacular name in Brazil. Tapaiuna is applied to a closely related species, *Dicorynia ingens* Ducke, growing in the State of Para.

The tree is plentiful in Surinam, French Guiana, and the Brazilian Amazon. It is said to be one of the most common of the larger trees along the Rio Negro. Apparently its range does not extend into British Guiana.

Angélique grows on moist, well-drained lowland sites. It is a large tree, attaining a maximum height of 150 feet and a diameter of five feet or more, measured above the low buttresses. Timbers one to two feet square and up to 50 feet long have been produced.

The heartwood of Angélique Gris (used in these tests) is russet when freshly cut in the unseasoned condition, becoming superficially dull brown with an unusual subsurface luster. It commonly has a purplish tinge and frequently has dark brown streaks. The grayish or brownish white sapwood is sharply demarcated. (Angélique Rouge has a distinct reddish cast and is somewhat harder and heavier. Dr. G. Stahel, Director, Agriculture Experiment Station, Paramaribo, indicates doubt that it is the same species and reports that their tests for mineral content showed no silica as compared with 1.2 percent for Angélique Gris.) Grain usually straight. Texture medium, uniform, although vessels are prominent as long brown lines on side-grain surfaces producing an attractive figure somewhat resembling that of Walnut; growth layers indistinct. Heartwood without a distinctive odor or taste when seasoned. Heavy to very heavy, comparable to White Oak, with an average specific gravity of 0.60 (0.54 to 0.63) based on oven-dry weight and green volume. Weight per cubic foot averages 67 pounds in the green condition and 45 pounds when air-dry.

The wood has a tendency to check and split in drying and should be air seasoned at a moderate to slow rate to minimize these defects. Thick stock tends to become severely case-hardened.

In most of its mechanical properties in the green condition, Angélique is similar to Teak which is characterized by the same average density. Its properties are approximately average for species of similar density in bending strength, elastic resilience, hardness, compression across the grain, shear, and toughness, as shown in the accompanying tabulation. They are above average in stiffness and work to maximum load, slightly above average in crushing strength, and slightly below average in tension across the grain and cleavage resistance.

In the table are shown values for White Oak and Teak, both having the same specific gravity. 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. Angélique 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 close similarity of the two woods from a mechanical standpoint.

Shrinkage values for Angélique are comparable to such well known domestic woods as Red Oak and Hard Maple. The volumetric shrinkage of 14.0 percent is intermediate to that of Maple and Oak; radial shrinkage of 4.6 percent and tangential shrinkage of 8.2 percent are also comparable in magnitude and ratio to these two species, both of which are slightly lower in density than Angélique. Longitudinal shrinkage is shown as 0.16 percent, well within normal limits of variation for straight-grained wood. In all directions

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
				Oven-dry vol.	Green vol.					
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Angélique (*Dicorynia paraensis*)	Surinam	2	78.7	0.69	0.60	7,650	11,410	1,840	1.78	12.0
White Oak[1] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
Teak[2] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,400	1,670	1.7	9.3

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
				End	Side					
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Angélique (*Dicorynia paraensis*) Surinam	4,810	5,590	2,180	1100	1100	1000	700	1340	340	151.2
White Oak[1] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—
Teak[2] (*Tectona grandis*) Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—

[1] U. S. Dept. Agr. Tech. Bul. 479.
[2] A. V. Thomas (105).

Species and Source	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Angélique *(Dicorynia paraensis)* Surinam	4.6	8.2	0.16	14.0
Red Oak[1] *(Quercus borealis)* United States	4.0	8.2	—	13.5
Hard Maple[1] *(Acer saccharum)* United States	4.9	9.5	—	14.9
Teak[2] *(Tectona grandis)* Burma	2.3	4.2	—	6.8

[1]U. S. Dept. Agr. Tech. Bul. 479.
[2]Handbook of Empire Timbers (32).

the shrinkage of *Dicorynia paraensis* is about twice that of Teak, which it so closely resembles in mechanical properties.

The heartwood of Angélique is reported as highly durable under conditions favorable to decay and to insect attack. In decay resistance tests conducted as a part of the present study, material from Surinam was found to be moderately durable to durable in resistance to a white rot and durable to very durable in resistance to a brown-rot organism.

The wood has an excellent reputation for high degree of resistance to marine-borer attack. After 15 years of exposure in marine-borer infested waters at Balboa, Canal Zone, little pholad attack and no significant damage by teredos had occurred. This high degree of resistance has generally been attributed to the relatively high silica content of the wood. Results of ash-content determinations, made as a part of the current study, on Surinam specimens show that the heartwood has an average ash content of 0.32 percent including a silica content of 0.28 percent. Although the over-all ash content is not extraordinary, the silica content is exceptionally high and warrants further study from the standpoint of its possible dulling effect on woodworking saws and knives.

The working properties of Angélique are reported to be variable, dependent upon density and silica content. The wood with high silica content has the reputation of dulling

saws and knives. The wood finishes smoothly, and lighter material holds its place well under variable atmospheric conditions.

Angélique has a favorable reputation as a marine-borer resistant wood in French Guiana, the Panama Canal, and France. Marine construction parts, piling, poles, crossties, and carriage work are the more common local uses, although it has been used to a limited extent for furniture. Because of its similarity in appearance to Black Walnut, as well as matching this wood in many other properties, Angélique should be very suitable for furniture and cabinet work. Its high resistance to marine-borer attack and decay, as well as its general strength properties, makes this wood very suitable for marine piling and construction, and for durable construction. Quarter-sawed material might well be suitable for boat decking and planking as the radial shrinkage of Angélique is quite small. Other uses recommended are flooring (wears to smooth surface), millwork, general building construction, boat framing and agricultural implements.

References: 3, 4, 11, 22, 42, 43, 44, 49, 52, 63, 79, 89, 102.

BLACK KAKERALLI *Eschweilera Sagotiana* Miers

There are a number of closely related species with similar woods and properties in this genus. Those in British Guiana are generally known as Kakeralli but only *Eschweilera subglandulosa* (Steud.) Miers is also commonly known as Black Kakeralli. The Manbarklak *(Eschweilera longipes* [Poit.] Miers) of Surinam, whose reputation for marine borer resistance is well known, is closely related to Black Kakeralli. Also well known is Mata-Mata *(Eschweilera odora* [Poepp.] Miers) of the Amazon basin. It is probable that further study of several of the more important of these species will indicate sufficient similarity to permit combining some of them under one common name.

Black Kakeralli trees frequently attain a height of 100 feet and diameters of 24 inches or more. Buttresses are small or absent. Timbers squared to 12 inches and 40 feet long, and round piling up to 60 feet long are obtainable. It is found through most of the climax rain forests of British Guiana but is most abundant in the western districts.

Heartwood light brown with a pinkish tinge when freshly cut in the unseasoned condition, later becoming light grayish brown or light to medium reddish brown. Sapwood one to two inches wide, not sharply differentiated in the log, but retaining its light color or becoming yellowish after exposure and seasoning and then clearly distinct from the heartwood. Luster low, grain generally straight; texture fine and uniform except for scattered lines of vessels with whitish contents that are clearly visible on side-grain surfaces; growth layers not distinct. Heartwood without characteristic odor or taste when seasoned. Exceedingly heavy, comparable to Greenheart, with an average specific gravity of 0.82 (0.75 to 0.86) based on oven-dry weight and green volume. Weight per cubic foot averages 77 pounds in the green condition and 63 pounds when air-dry.

Observations of a limited amount of material from British Guiana indicate that the wood air seasons at a moderate to slow rate but with a minimum of warping and checking. However, it has a local reputation for checking considerably in seasoning and in exposed situations.

The mechanical properties of Black Kakeralli in the green condition exceed those of any common domestic timber by a wide margin. In comparison with other woods of similar high density, *Eschweilera Sagotiana* is approximately average in static-bending strength, elastic resilience, work to maximum load, crushing strength and shear; the wood is above average in stiffness, hardness, and toughness; and below average in compression across the grain, tension across the grain, and cleavage resistance.

In most properties the wood approaches Greenheart as shown in the tabulation. Greenheart exceeds Black Kakeralli in bending strength and crushing strength by varying amounts as high as 30 percent but the two woods are similar in stiffness, shock resistance, hardness, and shear. The fol-

Species	Source	No. of Logs	Moisture Content	Specific Gravity: Oven-dry vol.	Specific Gravity: Green vol.	Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	50.7	0.98	0.82	10,680	17,780	2,910	2.28	13.4
Greenheart[1] (*Ocotea Rodiaei*)	British Guiana	2	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Black Kakeralli (*Eschweilera Sagotiana*) British Guiana	6,170	7,780	2,880	2000	2480	1580	560	1790	390	264.5
Greenheart[1] (*Ocotea Rodiaei*) British Guiana	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
White Oak[2] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—

[1] Kynoch and Norton (47).
[2] U. S. Dept. Agr. Tech. Bul. 479.

lowing tabulation, based on White Oak expressed as 100 in each instance, shows the relative properties of these two woods. This comparison clearly indicates that with the exception of work to maximum load, tension across the grain, and cleavage, the properties of *Eschweilera Sagotiana* are proportionately higher than Oak in relation to density.

Specific Gravity Green Volume	Static Bending: Modulus of Rupture	Modulus of Elasticity	Work to Prop. Limit	Work to Max. Load
137	214	233	211	116

Maximum Crushing Strength	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain
218	178	234	190	73

Shear	Cleavage
143	93

The shrinkage of Black Kakeralli is moderately high.

Species and Source	Shrinkage (percent): Radial	Tangential	Longitudinal	Volumetric
Black Kakeralli (*Eschweilera Sagotiana*) British Guiana	4.9	10.5	0.34	14.4
Greenheart[1] (*Ocotea Rodiaei*) British Guiana	8.2	9.0	—	16.8
White Oak[2] (*Quercus alba*) United States	5.3	9.0	—	15.8

[1]Kynoch and Norton (47).
[2]U. S. Dept. Agr. Tech. Bul. 479.

Volumetric shrinkage of 14.4 percent is less than that of either Greenheart or White Oak. Radial shrinkage of 4.9 percent and tangential shrinkage of 10.5 percent are indicative of a somewhat greater differential between shrinkage in these two directions than is shown by White Oak. Longitudinal shrinkage of 0.34 percent is within limits of normal variation for wood.

The heartwood of Kakeralli is reported as highly durable. In decay resistance tests conducted as a part of the present

study, British Guiana specimens were found to be very durable in resistance to both brown-rot and white-rot fungi. Closely related species of the genus *Eschweilera (E. longipes, E. subglandulosa, E. corrugata)* have gained wide recognition for their high degree of resistance to marine-borer attack. Piles of Manbarklak were found to be perfectly sound after 17 years of service in the Saramacea Canal, Surinam, although Greenheart was completely riddled in less than a year in the same waters. Manbarklak also has shown the best record of a considerable number of resistant species after 15 years exposure to marine-borer attack in an experimental installation at Balboa, Canal Zone. *Eschweilera Sagotiana* appears to share this characteristic on the basis of early results obtained on samples of material from the test logs of this study. After the first six months of exposure to attack at Kure Beach, North Carolina, specimens of Kakeralli remained perfectly sound although Hemlock, White Oak, Douglas Fir, and Southern Pine were completely destroyed.[16] It has also shown considerable resistance to marine borers in Hawaiian waters.

The wood is reported as difficult to work but machining to a smooth surface with a slate-like feel. It is difficult to glue.

Black Kakeralli is used locally for posts, crossties, and construction where durability is a requirement. The favorable results of durability studies indicate that such uses are well warranted for this species. Because of the resistance of Kakeralli to marine-borer attack, it is particularly recommended for marine piling and construction. Among other uses for which this timber appears suitable, particularly because of its good strength properties and high wear resistance or abrasion resistance, are ice sheathing for boats, factory flooring, shoe keels for landing boats, and pulp-mill equipment such as beaters and bed plates.

References: 16, 24, 29, 38, 42, 43, 45, 63, 76, 79, 89, 103.

COURBARIL *Hymenaea courbaril* L. and *H. Davisii* Sandw.

This timber has long been called West Indian or South American Locust by the British. It is better known in the Spanish-speaking countries of Mexico, Central and South America by the names Algarrobo or Guapinol. In Brazil Algarrobo is less commonly used than Jutaí-acu or Jatobá. In the Guianas it is commonly called Courbaril.

The best known species *Hymenaea courbaril* grows from Mexico into Bolivia, and in the West Indies. It is a common tree in many parts of its range. There are some 20 other more or less distinct species, thirteen of which are found in the Amazon Valley.

The Courbaril tree attains heights of 60 to 120 feet and diameters of 20 inches to 4 feet or more. The trunk is generally straight and free of branches for 40 to 70 feet. The grey or reddish brown bark is smooth, ½ to 1 inch thick, and contains an abundance of inflammable gum. Buttresses are small or lacking.

Courbaril heartwood is salmon-red to orange-brown in freshly exposed unseasoned wood becoming russet to reddish brown, often with dark streaks, after exposure. The sapwood is generally thick, especially in rapidly grown second-growth trees, white to gray, usually sharply demarcated from the heartwood. Grain commonly interlocked (straight in the specimens of *Hymenaea Davisii* tested); texture mostly medium, uniform; growth layers not very distinct. The sapwood has an attractive appearance, resembling hard maple on the radial surface; whereas the figure on the tangential surface is distinguished chiefly by its lustrous sheen marked with scattered lines of vessels. The wood has no distinctive odor or taste when seasoned. Very heavy, comparable to Black Locust, with an average specific gravity of 0.70 (0.62 to 0.80)* based on oven-dry weight

*The average specific gravity of *Hymenaea Davisii* is 0.67 (0.60-0.75).

Fig. 9
Logs of Courbaril (*Hymenaea courbaril*) sound and free from checks or splits after four years of storage; Panama

and green volume. Weight per cubic foot averages 70 pounds in the green condition and 52 pounds when air dry.

Although Ernst[30] states that Courbaril wood warps when exposed to the air, observations made on *Hymenaea courbaril* from Surinam, Honduras, and Puerto Rico indicate that this species can be air seasoned without difficulty at a moderate to fast rate with very little warping or checking. Material of the same species from Brazil is reported to season with a minimum of checking and warping. Courbaril compares favorably with Black Walnut *(Juglans nigra)* in its drying characteristics.

Observations made on a limited sample of material from British Guiana *(Hymenaea Davisii)** indicate that air seasoning must proceed at a slow rate if checking is to be kept at a minimum. This species is comparable to White Oak *(Quercus alba)* in air-drying characteristics.

The mechanical properties of *Hymenaea courbaril* in the green condition are in general intermediate to those of such well known strong domestic woods as Black Locust *(Robinia pseudoacacia)* and Shagbark Hickory *(Carya ovata.)* The differences shown by the data for Honduras, Puerto Rico, and Surinam are probably due to variations between old growth and second growth, and in local site, rather than a reflection of general geographical influences. The average values shown are believed to be representative of the species.

The mechanical properties of *Hymenaea Davisii* in the green condition are representative of most woods of similar density. On this basis the wood may be rated as average in all respects except resilience. Work to proportional limit and to maximum load in static bending are both below the average of most species of like density.

In comparison with most woods of similar density *Hymenaea courbaril* is slightly below average in bending

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*Henceforth in this report the name British Guiana Courbaril is applied to *Hymenaea Davisii.* It is not meant to imply that this is the only species available from this country.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Courbaril (*Hymenaea courbaril*)	Honduras	2	49.6	0.84	0.74	7,250	12,910	1,740	1.76	12.8
	Surinam	1	77.0	0.73	0.65	8,190	12,930	1,930	1.91	10.7
	Puerto Rico	3	53.0	0.84	0.72	5,420	10,700	1,250	1.19	18.7
	Average	6	59.9	0.80	0.70	6,890	12,180	1,640	1.62	14.1
Black Locust[1] (*Robinia pseudoacacia*)	United States		40	0.71	0.66	8,800	13,800	1,850	2.36	15.4
Shagbark Hickory[1] (*Carya ovata*)	United States		60	—	0.64	5,900	11,000	1,570	1.28	23.7
British Guiana Courbaril (*Hymenaea Davisii*)	British Guiana	3	64.8	0.79	0.67	8,230	12,440	2,080	1.62	8.5
White Oak[1] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
Teak[2] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,400	1,670	1.7	9.3

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Courbaril (*Hymenaea Courbaril*)										
Honduras	3,840	5,620	1,910	1940	2140	1860	1180	1700	520	187.4
Surinam	4,780	5,870	2,080	1570	1630	1890	1380	1800	590	189.2
Puerto Rico	2,840	4,530	1,320	1840	2140	1690	1320	1910	600	267.2
Average	3,820	5,340	1,770	1780	1970	1810	1290	1800	570	214.6
Black Locust[1] (*Robinia pseudoacacia*) United States	6,120	6,800	—	1640	1570	1430	770	1760	400	—
Shagbark Hickory[1] (*Carya ovata*) United States	3,430	4,580	—	—	—	1040	—	1520	—	—
British Guiana Courbaril (*Hymenaea Davisii*) British Guiana	4,260	5,540	2,450	1480	1610	1120	890	1680	410	187.8
White Oak[1] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—
Teak[2] (*Tectona grandis*) Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—

[1]U. S. Dept. Agr. Tech. Bul. 479.
[2]A. V. Thomas (105).

strength, stiffness, and crushing strength, and somewhat above average in shock resistance, hardness, compression perpendicular to grain, cleavage, and tension perpendicular to the grain. As shown in the tabulation, *Hymenaea courbaril* is slightly denser than Black Locust but intermediate to Black Locust and Hickory in static-bending strength and work to proportional limit, stiffness, and crushing strength, nearly comparable to Black Locust in shock resistance (work to maximum load) and shear, and slightly to considerably stronger in hardness and the perpendicular to grain properties.

Hymenaea Davisii is compared with White Oak and Teak in the preceding tabulation. It is evident that although somewhat heavier than White Oak, the wood of British Guiana Courbaril shows more than a proportionate difference in nearly all properties. The margin of difference is particularly notable in stiffness. Only in work to maximum load, indicative of shock resistance, is the Oak superior, although the two woods are essentially the same in cleavage resistance. Teak more nearly approximates the strength properties of *Hymenaea Davisii*, but the greater density of the latter is reflected in its generally higher strength values. The wood of *Hymenaea Davisii* is only slightly below Teak in elastic resilience, shock resistance, and maximum crushing strength.

Shrinkage properties of *Hymenaea courbaril* are shown in the following tabulation in which values for Black Locust and Shagbark Hickory are included for comparison. The differences in shrinkage shown between *Hymenaea courbaril* from different sources are not great and the average values are believed to represent the species from the three sources given. Volumetric shrinkage of 12.6 perecnt is intermediate to that of Black Locust and Shagbark Hickory, both woods of somewhat lower density than Courbaril. Black Locust is characterized, among woods of its weight class, by its exceptionally low shrinkage and *Hymenaea courbaril* also occupies a relatively favorable position in this respect.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Courbaril				
(Hymenaea courbaril)				
Honduras	3.8	9.4	0.47	12.8
Surinam	4.0	7.8	0.14	12.1
Puerto Rico	5.4	8.5	0.26	12.8
Average	4.4	8.6	0.29	12.6
Black Locust[1]				
(Robinia pseudoacacia)				
United States	4.4	6.9	—	9.8
Shagbark Hickory[1]				
(Carya ovata)				
United States	7.0	10.5	—	16.7

[1] U. S. Dept. Agr. Tech. Bul. 479.

Although radial shrinkage of 4.4 percent and tangential shrinkage of 8.6 percent are relatively low, the ratio of tangential to radial shrinkage values is rather high, indicative of non-uniform shrinkage. Variations in longitudinal shrinkage are associated with varying degrees of interlocked grain but the average of 0.29 percent is within normal limits of variation for wood.

Shrinkage values for British Guiana Courbaril are shown in the acompanying table.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
British Guiana Courbaril				
(Hymenaea Davisii)	4.1	7.6	0.51	14.8
White Oak[1]				
(Quercus alba)				
United States	5.3	9.0	—	15.8

[1] U. S. Dept. Agr. Tech. Bul. 479.

Volumetric shrinkage of 14.8 percent is slightly less than that of White Oak. Radial and tangential shrinkage values of 4.1 and 7.6 percent, respectively, are somewhat less than corresponding values for White Oak. The ratio of tangential to radial shrinkage is moderate, indicative of relatively uniform dimensional change in these directions. Longitudinal shrinkage of 0.51 percent is slightly high for straight-grained wood.

The heartwood of Courbaril appears to be rather variable in durability. Many widely conflicting statements as to decay and insect resistance appear in the literature on this species. According to Horn[40] the wood is very durable under moist conditions and is not attacked by termites. Samples from several logs of *Hymenaea courbaril* from Honduras and Puerto Rico tested in the present study were rated as durable to very durable in resistance to a white-rot fungus and moderately durable to very durable in resistance to a brown rot. Courbaril has been rated low in resistance to marine-borer attack.

The wood of Courbaril is reported as moderately difficult to work but taking a high polish. It is comparable to White Oak in steam-bending qualities.

The heartwood of British Guiana Courbaril generally is not regarded as highly durable when used in contact with the ground. Decay resistance tests, conducted as a part of the present study, indicate variable resistance. The wood was predominantly non-durable in resistance to a white-rot organism and only moderately durable in resistance to a brown-rot fungus. On the basis of a short period of exposure at Kure Beach, North Carolina, the wood appears to lack resistance to marine-borer attack. Heartwood specimens were damaged by *Bankia* in these tests.[16]

Courbaril was once exported to a considerable extent for ship planking, tree-nails, gear cogs, and felloes of wheels. It is still used locally for sugar-mill and other mill machinery, looms, cart wheels, ship- and boat-building, balls, furniture, interior trim and cabinet work. Recently Courbaril has attracted attention as a piano wood in Europe. In the Guianas Courbaril is used for large dug-out canoes because its elasticity and strength permit navigation of rapids without breakage.

Courbaril not only meets the requirements for these uses but has additional properties which recommend it for a wide variety of purposes. Courbaril is comparable to White Oak in steam-bending properties and should be most suitable

for steam-bent boat parts. The species holds promise as a source of material for attractive veneer and plywood. The light sapwood layer, which is found in considerable thickness in second-growth timber, should be particularly desirable as a veneer for natural and blond-finish furniture. Both sapwood and heartwood are suitable for solid furniture parts and for use in cabinet work. Other uses for which Courbaril seems particularly fitted include decking, interior trim, durable construction, turning (the wood has a reputation for turning well and taking a high polish), and flooring. The wood has high shock resistance and could well be considered for use in sporting goods where this property is required. Likewise, it should be tried as a substitute for ash as tool handle material.

British Guiana Courbaril, which is more limited in its potential uses than Courbaril, is suited for heavy-duty flooring, boat and ship framing, and uses where high wear resistance is an important requisite as in keel shoes and ice sheathing.

References: 2, 3, 6, 7, 8, 11, 16, 17, 30, 34, 36, 38, 40, 42, 49, 53, 54, 58, 63, 64, 67, 79, 82, 89, 90, 92, 98, 100, 101, 102, 103, 111.

HUBUBALLI — *Loxopterygium Sagotii* Hook. f.

Hububalli (also Hoobooballi) is the British Guiana name for this timber. A French Guiana name is Kooel Pialli. In Surinam it is known as Hoeboeballie or Slangenhout, meaning Snakewood, presumably because of the prominent dark markings of the wood. The term "Snakewood" should be avoided to eliminate confusion with certain other timbers sometimes bearing this name, notably the Letterwood of the Guianas.

Close relatives of the Hububalli include Quebracho, the well known source of tannin in Argentina; the Cashew "nut" tree; Gonçalo Alves, a durable furniture wood; and the familiar Sumach. The wood is distinctive, however, and can be readily recognized.

Hububalli grows 70 to 100 feet tall and 24 to 30 inches in diameter. Logs 12 to 16 inches in diameter and 30 to 40 feet long are common and material is obtained that will square to 20 inches.

The heartwood is light brown to light reddish brown, usually with few to numerous prominent, dark brown, narrow to rather wide streaks. The sapwood is two to three inches wide, not distinctly defined, light brown to white; becoming brownish gray, often with a pale reddish tinge, upon exposure and seasoning. Grain straight or interlocked. Texture medium, uniform; growth layers indistinct. Oil specks frequently present on the lighter colored surfaces. Heartwood without distinctive odor or taste when seasoned. Heavy, comparable to Yellow Birch, with an average specific gravity of 0.56 (0.47 to 0.65) based on oven-dry weight and green volume. Weight per cubic foot averages 69 pounds in the green condition and 41 pounds when air-dry.

The wood appears to vary greatly in its seasoning characteristics. Material from Surinam air seasoned readily at a fast rate with no checking and only slight warping, whereas that from British Guiana, drying at a moderate rate, developed severe end and surface checks, as well as showing a definite tendency to warp. The causes of this difference are being investigated.

The mechanical properties of Hububalli in the green condition are representative, in general, of most woods of comparable density. On this basis all properties except work to maximum load and compression perpendicular to the grain may be considered as average. Of these exceptions the former, indicative of shock resistance, is slightly below average and the latter is above average.

Values are given in the table for *Loxopterygium Sagotii* from British Guiana and Surinam. Because of the close similarity shown by the data from these two sources, average values are considered representative for the species.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Hububalli (*Loxopterygium Sagotii*)	British Guiana	3	96.5	0.61	0.54	5,960	9,000	1,600	1.35	6.9
	Surinam	1	99.4	0.64	0.58	5,530	9,760	1,750	1.03	8.3
	Average	4	98.4	0.62	0.56	5,740	9,380	1,680	1.20	7.6
Teak[1] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,000	1,670	1.7	9.3
Yellow Birch[2] (*Betula lutea*)	United States		67	0.66	0.55	4,200	8,300	1,500	0.70	16.1

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Hububalli (*Loxopterygium Sagotii*)										
British Guiana	2,910	4,110	1,760	840	930	1110	530	1180	400	114.4
Surinam	4,670	5,280	2,090	1080	1140	1020	730	1220	340	107.3
Average	3,790	4,700	1,920	960	1040	1060	660	1200	370	110.8
Teak[1] (*Tectona grandis*)										
Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—
Yellow Birch[2] (*Betula lutea*)										
United States	2,620	3,380	—	810	780	530	430	1110	270	—

[1] A. V. Thomas (105).
[2] U. S. Dept. Agr. Tech. Bul. 479.

In the tabulation comparable values are shown for Yellow Birch and Teak. Although of similar density, Hububalli exceeds Yellow Birch in every strength property except work to maximum load in static bending. In many respects its properties are similar to those of Teak. Hububalli is slightly lighter than Teak, and somewhat lower in static-bending strength, elastic resilience, shock resistance, and crushing strength. It is similar to Teak in stiffness, hardness, compression across the grain, and shear.

The shrinkage of Hububalli is moderate.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Hububalli				
(Loxopterygium Sagotii)				
British Guiana	3.8	7.1	0.42	11.2
Surinam	3.1	7.4	0.27	11.0
Average	3.4	7.2	0.34	11.1
Teak[1]				
(Tectona grandis)				
Burma	2.3	4.2	—	6.8
Black Walnut[2]				
(Juglans nigra)				
United States	5.2	7.1	—	11.3

[1]Handbook of Empire Timbers (32).
[2]U. S. Dept. Agr. Tech. Bul. 479.

The average volumetric shrinkage of 11.1 percent is almost identical to that of Black Walnut, a lighter weight species. The radial shrinkage of 3.4 percent and tangential shrinkage of 7.2 percent indicate a considerable difference between dimensional changes in these two directions. Longitudinal shrinkage of 0.34 percent is within limits characteristic of interlocked-grain species.

The heartwood of Hububalli has been reported as fairly durable.[89] Decay resistance tests conducted as a part of the present study, however, indicate a wide variation in material from British Guiana. Individual heartwood specimens ranged from non-durable to very durable but averaged moderately durable to durable in resistance to a white rot and durable to very durable in resisting attack by a brown-rot organism.

The wood has been rated low in resistance to marine-borer attack in tests conducted in Hawaiian waters. In tests of the material used in this study, Hububalli showed little resistance to attack by *Bankia* and was riddled within six months of installation at Kure Beach, North Carolina.[16]

The wood works easily, finishes smoothly, and takes a good polish. It is extremely low in rate of moisture absorption, comparable to Teak.

Hububalli is used locally for general carpentry and interior construction to a limited extent. Its greatest use, because of ease of working, stability, ease of gluing and attractiveness, has been for furniture. The general properties of the species indicate that it is best suited for furniture and cabinet work. Additional uses for which it could be employed are general construction timbers and flooring.

References: 16, 29, 38, 43, 45, 63, 76, 79, 89, 103.

VACO *Magnolia sororum* Seibert

The wood tested in this study came from the Chiriqui Province of Panama where it is known as Vaco. It is fairly plentiful in a limited region in these highlands and probably extends into the mountains of nearby Costa Rica. Other species of *Magnolia* and the closely related *Talauma* occur scatteringly through Central America, northern South America, and the West Indies. The properties of some of them differ from those of Vaco, described here.

Vaco is a medium-sized to large tree, often 30 inches and occasionally 5 feet or more in diameter. Heights of 70 to more than 100 feet are attained, with clear, straight bole lengths of 40 to 65 feet. Buttresses are small and usually are not significant more than 3 to 5 feet above the ground. The bark is smooth, light yellowish brown, about three-fourths inch thick.

In appearance, Vaco very much resembles darker shades of native (U. S.) Yellow Poplar or Magnolia. Heartwood olive-green when freshly cut in the unseasoned condition becoming light yellowish brown to greenish brown, often with a purplish tinge, upon exposure; purple, dark brown, or nearly black streaks are common, particularly near the center and lower portions of old or defective trees. Sapwood wide, white to greenish when freshly cut, darkening somewhat upon exposure and drying. Grain straight; texture fine, uniform; the wood resembling Yellow Poplar in general appearance. Growth layers differentiated by light bands of terminal parenchyma. Odor and taste not distinctive. Moderately heavy, comparable to Paper Birch, with an average specific gravity of 0.50 (0.40 to 0.58) based on oven-dry weight and green volume. Weight per cubic foot averages 58 pounds in the green condition and 37 pounds when air dry.

Based on observation of a limited amount of material from Panama, Vaco air seasons rapidly with no checking and slight warping. It is comparable to Yellow Poplar *(Liriodendron tulipifera)* in drying characteristics.

The strength properties of Vaco are generally average or somewhat below the average of woods of similar density. Static-bending strength, compression across the grain, shear, cleavage, and toughness are approximately average; compression parallel to the grain and hardness are less than average. Stiffness, on the other hand, is exceptionally high among species of comparable density.

In the foregonig tabulation some of the properties of Baguaçu *(Talauma ovata)*, a closely related species of Brazil, are shown for compariosn. The differences are rather slight and appear to reflect the somewhat lower density of the Brazilian material. As shown in the tabulated data *Magnolia sororum,* although considerably lighter than Yellow Birch, exceeds the latter in practically all properties for which comparable data are available. Only in work to maximum load, measuring shock resistance, is Vaco seriously deficient as compared with Yellow Birch.

The shrinkage properties of *Magnolia sororum* are superior to those of many species of similar density. In all respects

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Vaco *(Magnolia sororum)*	Panama	3	84.8	0.56	0.50	4,950	8,560	1,690	0.84	6.5
Baguaçu[1] *(Talauma ovata)*	Brazil		Green	—	0.47[2]	3,620	7,820	1,450	—	—
Yellow Birch[3] *(Betula lutea)*	United States		67	0.66	0.55	4,200	8,300	1,500	0.70	16.1
Evergreen Magnolia[3] *(Magnolia grandiflora)*	United States		105	0.53	0.46	3,600	6,800	1,100	0.67	15.4

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Vaco *(Magnolia sororum)* Panama	2,610	3,590	2,060	880	860	740	860	1120	410	118.3
Baguaçu[1] *(Talauma ovata)* Brazil	2,560	3,410	1,630	—	—	—	—	—	—	—
Yellow Birch[3] *(Betula lutea)* United States	2,620	3,380	—	810	780	530	430	1110	270	—
Evergreen Magnolia[3] *(Magnolia grandiflora)* United States	2,160	2,700	—	780	740	570	610	1040	340	—

[1]Brotero and Vieira (15).
[2]Estimated from apparent specific gravity at 15 percent moisture content.
[3]U. S. Dept. Agr. Tech. Bul. 479.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Vaco (*Magnolia sororum*) Panama	3.6	7.0	0.23	11.2
Baguaçu[1] (*Talauma ovata*) Brazil	3.8	9.4	—	14.5
Paper Birch[2] (*Betula papyrifera*) United States	6.3	8.6	—	16.2
Yellow Poplar[2] (*Liriodendron tulipifera*) United States	4.0	7.1	—	12.3
Evergreen Magnolia[2] (*Magnolia grandiflora*) United States	5.4	6.6	—	12.3

[1]Brotero and Vieira (15).
[2]U. S. Dept. Agr. Tech. Bul. 479.

shrinkage of Vaco is less than that of Paper Birch, a well known domestic wood of comparable density, and even slightly lower than that of Yellow Poplar which is much lighter in weight. Radial shrinkage of 3.6 percent, tangential shrinkage of 7.0 percent, and volumetric shrinkage of 11.2 percent are quite similar to the corresponding shrinkage values for Yellow Poplar. Longitudinal shrinkage of 0.23 percent is within normal limits of variation for straight-grained wood. Based on the data shown, the related Brazilian *Talauma ovata* appears to be somewhat less stable in dimension.

In decay resistance tests conducted as a part of the present study, heartwood of Vaco was found to be durable to highly durable with respect to deterioration by both white-rot and brown-rot fungi.

The wood appears easy to work, comparable in this respect to Yellow Poplar.

The reported local uses of this wood are extremely limited. However, Vaco has a number of desirable qualities and should be suitable for the manufacture of utility veneer and plywood, boat planking, durable construction, and exterior use as well as for turning and millwork.

References: 54, 56, 58, 79, 90, 98, 100, 117.

BULLETWOOD *Manilkara bidentata* (A.DC). Chev.[1]

The name Balata is frequently given to this tree as it is the most important source of this gum. Bulletwood, Bully Tree, Beefwood, and Horseflesh are the usual English names. In Surinam it is called Bolletrie, Balata, and Paardevleeschout; in Brazil, Maparajuba or Massaranduba (the latter is better applied to *Manilkara Huberi* (Ducke) Standl.). It is known as Purgio in Venezuela; Pamashto or Quinilla in Peru; Nispero in Panama and (probably) Costa Rica.

Bulletwood is common in northern South America, Panama, possibly Costa Rica, and parts of the West Indies. Other species of *Manilkara* and closely related genera of the Sapotaceae also occur throughout this range and extend it through Central America. Some of these are sometimes confused with *M. bidentata*.

The Bulletwood tree is typically large, well-formed, and tall. It commonly attains diameters of 3 to 4, sometimes over 5, feet and heights of 100 to 150 feet. Buttresses are usually small or lacking.

Heartwood light red to rose-red when freshly cut in the unseasoned condition, becoming light to dark reddish brown upon exposure. Sapwood usually narrow (1½ to 2 inches), whitish or pale brown, distinct but not sharply demarcated from the heartwood. Grain is usually straight, sometimes coarsely interlocked; texture fine, uniform; without pronounced figure; growth layers indistinct. Odor sometimes present when green, odor and taste not evident in the seasoned condition. Exceedingly heavy to extremely heavy, comparable to Greenheart. The material studied in the present investigation showed an average specific gravity of 0.85 (0.77 to 0.91) based on oven-dry weight and green

[1]= *Mimusops bidentata* A. DC. = *Mimusops darienensis* Pitt.
= *Manilkara darienensis* Standl. = *Mimusops balata* (Aubl). Pierre
= *Manilkara balata* (Aubl.) Dub. = *Mimusops sieberi* A. DC.
= *Mimusops riedeleana* Pierre ex Baill. = *Mimusops nitida* Urb.
= *Manilkara nitida* Dub.; et al.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Bulletwood	Surinam	1	44.4	1.06	0.87	12,910	18,420	2,860	2.96	14.1
(Manilkara	British Guiana	3	45.5	1.04	0.88	12,740	18,430	2,890	3.12	12.6
bidentata)	Puerto Rico	3	52.9	0.98	0.80	7,700	15,080	2,340	1.45	14.0
	Average	7	47.6	1.03	0.85	11,120	17,310	2,700	2.51	13.6
Greenheart[1] *(Ocotea Rodiaei)*	British Guiana		42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.3
Greenheart[2] *(Ocotea Rodiaei)*	British Guiana		41	0.92	—	—	19,300	2,970	—	—

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	Hardness: End	Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Bulletwood *(Manilkara bidentata)*										
Surinam	9,390	10,060	3,550	2240	2230	2940	970	1880	500	266.8
British Guiana	7,820	9,570	2,940	2280	2430	2500	700	1980	370	274.3
Puerto Rico	3,870	6,430	2,680	1950	2040	2010	1310	1840	580	253.2
Average	7,030	8,690	3,060	2160	2230	2480	990	1900	480	264.8
Greenheart[1] *(Ocotea Rodiaei)* British Guiana	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
Greenheart[2] *(Ocotea Rodiaei)* British Guiana	—	10,500	—	2160	2110	—	—	1320	500	—

[1] Kynoch and Norton (47). [2] Handbook of Empire Timbers (32).

volume. Weight per cubic foot averages 78 pounds in the green condition and 66 pounds when air dry.

Bulletwood tends to check badly, warp, and caseharden during seasoning and must be dried slowly to keep these defects at a minimum. It is comparable in drying characteristics to White Oak *(Quercus alba)*.

Bulletwood is generally comparable to Greenheart *(Ocotea Rodiaei)* in its mechanical properties in the green condition. Although the data tabulated for material from Surinam, British Guiana, and Puerto Rico show diversity in some properties, these differences are probably due to individual tree variations and the average strength values are believed to be representative of the species. On the basis of the average results shown, the wood is rated in the very strong class in all properties. It is slightly weaker than Greenheart in most static-bending and compression parallel to grain properties, but compares favorably with that timber in compression perpendicular to grain and shear. In shock resistance, hardness, tension perpendicular to grain, and cleavage little difference is evident between Bulletwood and Greenheart.

The density and strength of Bulletwood are greatly in excess of those of any commercial domestic wood. The following tabulation indicates the relative properties of the wood in a comparison in which the value for White Oak *(Quercus alba)* has been taken as 100.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
145	209	216	117	244

Hardness	Shear	Bending strength	Cleavage resistance
210	152	299	114

Shrinkage data for *Manilkara bidentata* from different sources are shown in the acompanying tabulation.

Source	Shrinkage (percent): Radial	Tangential	Longitudinal	Volumetric
British Guiana	6.2	8.9	0.23	15.5
Puerto Rico	6.5	10.2	0.14	19.1
Surinam	6.0	9.1	0.31	16.0
Average	6.3	9.4	0.23	16.9

The volumetric shrinkage averages 16.9 percent, somewhat higher than that ordinarily associated with other species of comparable density, but actually only slightly greater than that of White Oak *(Quercus alba)* with a volumetric shrinkage of 15.8 percent. Radial and tangential shrinkage values average 6.3 and 9.4 percent respectively, quite similar to comparable values of 5.3 and 9.0 percent for White Oak. Longitudinal shrinkage of 0.23 percent is within the limits of normal variation for wood.

The heartwood of *Manilkara bidentata* has long been recognized for its high degree of resistance to decay and insect attack. Brooks, et al.[14] have reported the results of tests indicating that the wood is very resistant to fungi and to termites. In the present study, samples of heartwood from Puerto Rico, British Guiana, and Surinam have been subjected to decay resistance tests and the species is rated as durable to very durable in resistance to a white-rot fungus and very durable in resistance to a brown rot. The wood is rated as low in resistance to marine-borer attack on the basis of tests in Hawaiian waters; and early results of exposure at Kure Beach, North Carolina of specimens from British Guiana substantiate this conclusion as they showed heavy attack by *Bankia* within six months.[16]

Woods of the genus *Manilkara* are reported as easy to moderately difficult to work and as finishing to a very smooth surface. Bulletwood is extremely impermeable to moisture and is difficult to glue. It appears to be comparable to White Oak in steam-bending qualities.

Bulletwood has a number of desirable characteristics which have resulted in a wide variety of local uses including flooring, foundations, bridge members, tools, violin bows, mill rollers, posts, telegraph poles, railway ties, marine construction, and all types of carpentry and joinery work.

The strength, high wear resistance, and durability of this wood particularly recommend it for heavy and durable construction, ice sheathing, boat frames, and keel shoes. There are, in addition, other uses for which certain properties of

the wood make it very suitable. Its similarity to White Oak in steam-bending properties recommends its use for steam-bent boat frames and other bent work. Its fine texture, density, and ability to take a high polish suggest such uses as shuttles and other textile items, turnings and special furniture parts such as desk legs. Other suggested uses are instruments, heel stock, and pulp-mill equipment including beater liners, bed plates, and agitator bars.

References: 2, 8, 14, 16, 19, 24, 29, 34, 38, 44, 45, 46, 49, 58, 63, 64, 67, 74, 79, 83, 87, 91, 92, 95, 98, 103, 111.

DETERMA *Ocotea rubra* Mez.

In addition to Determa, the British Guiana name, this timber is known as Wane in Surinam, Grignon Rouge in French Guiana, and Louro Vermelho in Brazil.

Determa is closely related to Greenheart *(Ocotea Rodiaei)* although the woods are not similar. It is also closely related to numerous other poorly classified species of several genera of the Lauraceae family. The wood is distinctive, however, and the apparent limitation of its range to lowlands of the Guianas and the lower Amazon region makes it possible to obtain the timber true to name.

The trees have straight, cylindrical trunks that are typically sound and free of branches for 40 to 70 feet. They are often 36 to 40, sometimes 50, inches in diameter and attain heights of 100 feet or more.

Heartwood deep salmon red when freshly cut in the unseasoned condition, later becoming light reddish brown with a golden sheen. Pink or yellow streaks are sometimes present but, generally, the color is uniform. Sapwood narrow, dull gray to pale yellow-brown. Texture coarse, uniform; with numerous tyloses appearing as shiny deposits in the vessels; growth layers indistinct. Grain either straight or interlocked in medium-sized bands that form a roey stripe on the quarter surface. Figure of straight-grained material characterized chiefly by the closely spaced coarse vessel lines. Odor somewhat pungent when green but with-

Species	Source	No. of Logs	Moisture Content	Specific Gravity: Oven-dry vol.	Specific Gravity: Green vol.	Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Determa (*Ocotea rubra*)	Surinam	2	75.2	0.62	0.56	6,360	8,810	1,650	1.42	5.2
Louro Vermelho[1] (*Ocotea rubra*)	Brazil		—	0.69	0.58	4,060	10,350	1,460	—	—
Yellow Birch[2] (*Betula lutea*)	United States		67	0.66	0.55	4,200	8,300	1,500	0.70	16.1

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Determa (*Ocotea rubra*) Surinam	3,620	4,380	2,070	540	600	700	640	910	320	74.9
Louro Vermelho[1] (*Ocotea rubra*) Brazil	3,450	5,150	2,340	—	—	—	—	—	—	—
Yellow Birch[2] (*Betula lutea*) United States	2,620	3,380	—	810	780	530	430	1110	270	—

[1]Brotero and Vieira (15).
[2]U. S. Dept. Agr. Tech. Bul. 479.

out a distinctive odor or taste when seasoned. Heavy, comparable in this respect to Yellow Birch, with an average specific gravity of 0.56 (0.52 to 0.59) based on oven-dry weight and green volume. Weight per cubic foot averages 61 pounds in the green condition and 41 pounds when air dry.

When dried at a moderate rate the wood shows only a slight tendency to warp and check. Thick stock shows a tendency to remain moist in the center for considerable time, which in turn may cause casehardening stresses to develop.

The strength properties of *Ocotea rubra* in the green condition range from average to below average for species of comparable density.

The values shown in the tabulation are close to the average for other species of similar weight in most static-bending properties, crushing strength, tension across the grain and cleavage. On the same basis they are below average in shock resistance (work to maximum load and toughness), hardness, compression perpendicular to the grain, and shear.

Published data on some of these properties based on Brazilian material are shown for comparison. Strength values of Yellow Birch are also shown for comparative purposes since these woods are similar in density. *Ocotea rubra* is slightly stronger in bending, slightly stiffer, and appreciably higher in crushing strength and in tension and compression across the grain than Yellow Birch. Shock resistance, hardness and shear values are, on the other hand, substantially below those of Birch.

Shrinkage is moderate as shown in the accompanying tabulation.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Determa *(Ocotea rubra)* Surinam	4.0	7.7	0.30	11.6
Louro Vermelho[1] *(Ocotea rubra)* Brazil	4.0	10.0	—	15.9
Yellow Birch[2] *(Betula lutea)* United States	7.2	9.2	—	16.7
Black Walnut[2] *(Juglans nigra)* United States	5.2	7.1	—	11.3

[1]Brotero and Vieira (15).
[2]U. S. Dept. Agr. Tech. Bul. 479.

Volumetric shrinkage of the Surinam wood is 11.6 percent, approximately equal to that of Black Walnut and considerably less than that of Yellow Birch. Radial shrinkage of 4.0 percent and tangential shrinkage of 7.7 percent indicate a greater differential shrinkage in these two directions than for Walnut. Longitudinal shrinkage of 0.30 percent is not unusual among woods characterized by interlocked grain.

Heartwood of *Ocotea rubra* is reported to be highly resistant to insects and moderately resistant to decay. The timber from Surinam has been described as durable. In decay resistance tests conducted as a part of the present study, heartwood from a single Surinam log was rated as durable to very durable in resistance to a white rot and very durable against a brown-rot organism. It has been reported as termite resistant. Determa has shown little or no deterioration as a result of marine-borer attack after 13 months in Hawaiian waters.

The working properties of Determa are reported to be excellent. The rate of moisture absorption by the heartwood is exceptionally low, amounting to only three-fourths that of Burma Teak in tests conducted as a part of this study.

Determa is used locally for furniture, interior and exterior construction, greenhouse sash framing, sugar boxes, boat planking, and punt masts. Large trunks are used for dug-out canoes, esteemed because of their freedom from splitting during use. In considering potential uses of this wood, its low moisture absorption property should be considered and might well fit this timber for such items as wood tanks, tight cooperage, floats and special boat parts. Other uses for which Determa seems particularly fitted are boat trim and handrails, durable construction, and marine piling and construction.

References: 15, 29, 38, 42, 45, 57, 63, 79, 89, 103, 106.

FRIJOLILLO *Pseudosamanea guachapele* (H.B.K.) Harms[1]

Other names for this species are Cadeno (Guatemala), Tabaca, Guamarillo (Colombia), Samanigua (Venezuela), and Guachapele (Ecuador). Frijolillo is the Honduras name.

This is the only species in the genus although superficially similar wood is produced by certain other Leguminosae species of *Albizzia*, *Enterolobium*, *Lysiloma*, and *Samanea*.

So far as is known Frijolillo grows only from Guatemala to Venezuela and Ecuador. Only in Ecuador is it a well known and frequently used wood. Here it grows in the dry tropical forests near the coast and is often used for shade in coffee plantations. In Honduras (the source of the material reported here), Frijolillo is common in the Chamelecon valley and its watershed. It grows on the alluvial river deposits and in the gullies and rocky hills of the watershed, extending into the pine belt of the upper hills. It also occurs in the vicinity of Choluteca on the west coat. In Honduras the tree is generally found in dry areas or in well-drained situations on soil types ranging from sandy loam to gravel and rocks.

Frijolillo seeds naturally in openings, in pastures, and abandoned fields. Being naturally fire resistant it thrives

[1]= *Albizzia longepedata* Britt. & Rose.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending				
				Oven-dry vol.	Green vol.	Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	60.4	0.62	0.56	4,920	8,190	1,200	1.11	9.2
Hard Maple[1] (*Acer saccharum*)	United States		58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
White Oak[1] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain			Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	End	Side	Stress at proportional limit				
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Frijolillo (*Pseudosamanea guachapele*) Honduras	2,790	3,930	1,410	1060	1030	960	710	1270	310	13.3
Hard Maple[1] (*Acer saccharum*) United States	2,850	4,020	—	1070	970	800	—	1460	—	—
White Oak[1] (*Quercus alba*) United States	3,090	3,560	—	1120	1060	830	770	1250	420	—

[1]U. S. Dept. Agr. Tech. Bul. 479.

despite repeated burning of the lesser vegetation. It grows rapidly and develops a large, well-formed bole without significant buttresses. A large spreading top and distinctive shaggy bark make it easily recognizable.

The heartwood of Frijolillo is light orange brown when freshly cut in the unseasoned condition becoming yellow-brown or rich brown with a golden luster. The sapwood is thin, whitish, and rather sharply demarcated from the heartwood. Grain generally interlocked to a pronounced degree producing a conspicuous striped figure on the radial surface, sometimes straight. Texture medium to rather coarse, uniform; growth layers indistinct. Tasteless and odorless when seasoned. Heavy, comparable in this respect to Hard Maple, with an average specific gravity of 0.56 (0.50 to 0.62) based on oven-dry weight and green volume. Weight per cubic foot averages 56 pounds in the green condition and 41 pounds when air dry.

Frijolillo wood air seasons readily and can be dried at a moderate to fast rate. Warping is the only serious defect and is probably the result of the interlocked grain prevalent in this species.

The mechanical properties of Frijolillo in the green condition are for the most part rather low in comparison with other woods of comparable density. On this basis its static-bending properties including modulus of rupture and stiffness, together with its crushing strength, may be considered below average; its work values in static bending, compressive strength across the grain, shear, tension across the grain, and cleavage properties about average; and its toughness and hardness somewhat about average.

As shown in the foregoing tabulation, Frijolillo with a specific gravity identical to that of Hard Maple is exceeded by the latter in virtually all strength properties except side hardness and compression perpendicular to the grain. The wood is closely comparable in most strength properties to White Oak as shown by the tabulated data.

The wood is characterized by exceptionally low shrinkage.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Frijolillo *(Pseudosamanea guachapele)*				
Honduras	2.9	4.5	0.37	7.6
White Oak[1]				
United States	5.3	9.0	—	15.8
Black Locust[1]				
United States	4.4	6.9	—	9.8
Teak[2]				
Burma	2.3	4.2	—	6.8

[1]U. S. Dept. Agr. Tech. Bul. 479.
[2]Handbook of Empire Timbers (32).

Shrinkage values for Frijolillo are compared with values for White Oak because of the close similarity between these woods in their mechanical properties. It is evident that the wood shrinks only about one-half as much as Oak. Comparison is also made with Black Locust and Teak, both noted for their low shrinkage characteristics. Volumetric shrinkage values of 7.6 percent, radial 2.9 percent, and tangential 4.5 percent are each less than the corresponding shrinkage for Black Locust and closely approach the values for Teak. Longitudinal shrinkage of 0.37 percent is characteristic of interlocked grain wood.

The heartwood is reported as fairly resistant to decay. On the basis of decay tests of material from Honduras in the present study, the wood is rated as durable to very durable in resistance to both white-rot and brown-rot fungi although some variability was noted in this respect.

The wood is considered easy to work but the sawn surface is rather woolly. Surfaces finish smoothly and attractively after sanding.

In Ecuador this wood is used principally for planking, ribs, decking, and treenails in shipbuilding as well as for pole stubs and railway crossties. Frijolillo having as its more outstanding characteristics low shrinkage, high durability, and a pleasing figure, should be suitable for boat decking and framing, durable and general exterior construction,

flooring (both exterior and interior), decorative veneers, and insulator pins.

References: 28, 41, 58, 79, 84.

MAHOGANY *Swietenia macrophylla* King

The general descriptions of Central and South American Mahoganies are too well known to need recounting here. This study is concerned with determining the properties of young second-growth material, particularly of planted origin, as compared with forest-grown Mahogany. Because of its intrinsic value a great many plantings of Mahogany have been made. Most of these are small and of little consequence other than to local users. In recent years more extensive plantings have been made and more are contemplated. Undoubtedly logs of planted origin are marketed from time to time and the volume of such material produced will increase steadily. Much of this timber will be grown on comparatively good, abandoned crop land with little forest competition, thus promoting very rapid growth. The saw-logs from which the material was obtained for these tests came from trees planted in Honduras 19 years prior to cutting.

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, yellowish 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. Moderately light to moderately heavy, slightly lighter than the average forest-grown timber of the same species, with an average specific gravity of 0.42 (0.40 to 0.46) based on oven-dry weight and green volume. Weight per cubic foot averages 40 pounds in the green condition and 31 pounds when air dry.

Mahogany can be air seasoned or kiln dried readily without undue warping or checking. The only defect noticeable

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Mahogany (*Swietenia macrophylla*) (Plantation-grown)	Honduras	3	50.7	0.46	0.42	5,080	8,350	1,140	1.14	7.3
Mahogany (*Swietenia macrophylla*)	Central America[1]		58	0.50	0.45	6,120	9,240	1,290	—	10.2
	Mexico, Nicaragua[2]		101.2	0.50	0.45	5,100	8,800	1,460	1.02	8.4

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Mahogany (*Swietenia macrophylla*) (Plantation-grown) Honduras	2,730	3,500	1,040	1160	1090	1090	750	1500	280	84.3
Mahogany (*Swietenia macrophylla*) Central America[1]	—	4,540	—	750	650	710	—	1310	—	—
Mexico, Nicaragua[2]	3,250	4,530	1,570	810	820	700	770	1080	340	—

[1]Heck (37).
[2]Kynoch and Norton (47).

in plantation-grown stock from Honduras after air seasoning was slight warping.

The strength properties of young plantation-grown Mahogany in the green condition are shown in the accompanying table together with comparable data for forest-grown Mahogany from several sources. The plantation-grown timber is slightly lower in density than forest-grown Mahogany, and bending strength and work to maximum load in static bending are proportionately low. Crushing strength and stiffness are markedly lower than in representative forest-grown *Swietenia macrophylla;* elastic resilience is the only property in bending in which the plantation-grown wood is not deficient. Plantation-grown material is comparable to mature forest-grown Mahogany in tension across the grain, and exceeds the latter in hardness, compression across the grain, and shear.

Shrinkage of plantation-grown Mahogany is remarkably low, comparable to that of forest-grown timber. Volumetric

Species and Source	Shrinkage (percent): Radial	Tangential	Longitudinal	Volumetric
(*Swietenia macrophylla*) (Plantation-grown) Honduras	2.4	4.2	0.42	6.6
(*Swietenia macrophylla*) Central America[1]	2.7	3.3	—	6.0
Mexico, Nicaragua[2]	3.6	5.1	—	9.0

[1]Heck (37).
[2]Kynoch and Norton (47).

shrinkage of 6.6 percent is characteristic of Mahogany and, as shown in the tabulation, is comparable to the value reported by the Forest Products Laboratory for forest-grown timber. Radial shrinkage of 2.4 percent, and tangential shrinkage of 4.2 percent indicate a slightly greater differential shrinkage in these two directions than has been found for forest-grown Mahogany. Longitudinal shrinkage of 0.42 percent is probably associated with the characteristic interlocked grain of the wood.

Heartwood of Mahogany has a reputation for high decay resistance. Plantation-grown Mahogany tested for decay resistance in the course of the present study, was found to vary in its resistance to attack by a white-rot organism, ranging from moderately durable to very durable. It was consistently very durable in tests involving a brown-rot fungus. Mahogany has little resistance to marine-borer attack. The plantation-grown wood weathers well with a minimum of checking.

Mahogany has long enjoyed a reputation as a fine furniture and cabinet wood as well as being used in the boat and ship building industry, and for interior trim and paneling. Plantation-grown stock appears particularly suitable for furniture and cabinet work because of its stripe figure as well as for millwork, patterns, and general exterior use.

References: 29, 32, 37, 44, 47, 58, 61, 70, 79, 90, 106.

PRIMAVERA *Tabebuia Donnell-Smithii* Rose[1]

The Mexican name Primavera is generally recognized by the trade. The name Palo Blanco[2] is commonly used in both Guatemala and Mexico. In Honduras the wood is known as San Juan.[3]

Two other species of *Tabebuia* are described in this report and a number of other genera of the Bignoniaceae have valuable woods. The Catalpa is the only related temperate North American tree of consequence.

The Primavera tree is commonly two to three, occasionally four, feet in diameter. It commonly attains heights of 45 to 75, sometimes to 90, feet with a clear, smooth bole of 24 to 40 feet. High grade logs can be procured but the available supply could be greatly augmented through the acceptance of defective material. The principal defect consists of patches or centers of brown discoloration.

Primavera wood is cream colored, yellowish white to pale yellowish brown. Not infrequently the darker colored

[1]= *Cybistax Donnell-Smithii* (Rose) Seibert.

[2]Palo Blanco is frequently used in Spanish American countries for other light colored woods.

[3]The San Juan of Guatemala is an entirely different wood.

Species	Source	No. of Logs	Moisture Content	Specific Gravity: Oven-dry vol.	Specific Gravity: Green vol.	Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	3	56.2	0.44	0.40	4,170	7,180	990	0.99	7.2
	Honduras[1]		66	0.44	0.40	6,220	9,940	1,200	—	13.0
Mahogany[1] (*Swietenia macrophylla*)	Central America		58	0.50	0.45	6,120	9,240	1,290	—	10.2
Holly[2] (*Ilex opaca*)	United States		82	0.61	0.50	3,400	6,500	900	0.72	10.8

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness: End	Hardness: Side	Compression Perpendicular to Grain: Stress at proportional limit	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Primavera (*Tabebuia Donnell-Smithii*)										
Honduras	2,850	3,510	1,050	310	700	800	720	1030	320	74.8
Honduras[1]	—	4,280	—	720	590	690	—	—	—	—
Mahogany[1] (*Swietenia macrophylla*) Central America	—	4,540	—	750	650	710	—	1310	—	—
Holly[2] (*Ilex opaca*) United States	2,050	2,640	—	860	790	610	610	1130	360	—

[1]Heck (37).
[2]U. S. Dept. Agr. Tech. Bul. 479.

characteristics that recommend it for patterns, millwork, boat planking, and special exterior uses.

References: 2, 13, 36, 37, 45, 70, 77, 79, 86, 90, 93, 94.

GUAYACÁN *Tabebuia guayacan* (Seem.) Hemsl.[1]

This species is found in Central America, southern Mexico, and Colombia. Several species with similar woods occur here and numerous others are found in South America, into Argentina. Because of the similarity of the woods and trees they frequently have the same common names. In Panama, Costa Rica, and Colombia this wood is known as Guayacán, a name also used for Lignum-vitae and several other dense woods. It is known as Cortez in Guatemala, Honduras, Nicaragua, and Costa Rica. In Mexico it is commonly called Amapa Prieta or Verdecillo. The British Honduras name is Yellow Mayflower.

Guayacán is a tall, straight forest tree reaching heights of 90 feet and diameters of 24 to 36, sometimes 48 inches. The cylindrical trunk may be free of branches for 40 to 50 feet. Buttresses are prominent but usually low, merging into conspicuous surface roots.

Heartwood bright yellow-green when freshly cut in the unseasoned condition, later becoming olive-brown or dark brown, often with lighter or darker, fine striping, sometimes tinged with red, frequently oily in appearance. The vessel elements are filled with a yellow powder (lapachol)[2] which is very noticeable on freshly sawn boards. The sapwood is two to three inches thick, creamy white or yellowish, rather sharply demarcated. Grain typically interlocked in thin layers producing a fine, striped figure on the quarter-sawed surface. Luster low to medium. Texture fine to medium, moderately uniform; growth layers usually distinct. Without distinctive odor or taste when seasoned. Exceedingly heavy,

[1] =*Tecoma guayacan* Seem.

[2] In Colombia this wood is often called Guayacán Polvillo, with reference to this powder *(polvillo)*.

FIG. 10

... inches in diameter. Honduras.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Guayacán (*Tabebuia guayacan*)	Honduras	3	35.4	1.00	0.85	11,060	18,480	2,580	2.71	18.7
Greenheart[1] (*Ocotea Rodiaei*)	British Guiana		42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.3
Greenheart[2] (*Ocotea Rodiaei*)	British Guiana		41	0.92	—	—	19,300	2,970	—	—

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Guayacán (*Tabebuia guayacan*) Honduras	7,730	9,740	2,910	2820	3140	2390	990	2230	510	286.3
Greenheart[1] (*Ocotea Rodiaei*) British Guiana	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
Greenheart[2] (*Ocotea Rodiaei*) British Guinana	—	10,500	—	2160	2110	—	—	1320	500	—

[1]Kynoch and Norton (47).
[2]Handbook of Empire Timbers (32).

comparable to Greenheart. The material studied in this investigation showed an average specific gravity of 0.85 (0.80 to 0.91) based on oven-dry weight and green volume. Weight per cubic foot averages 72 pounds in the green condition and 65 pounds when air dry.

Based on limited observations of material obtained from Honduras, Guayacán is moderately difficult to air season. Drying is accompanied by moderate end and surface checking as well as limited warping. Its drying characteristics are comparable to those of Paper Birch *(Betula papyrifera)*.

Guayacán compares closely with Greenheart *(Ocotea Rodiaei)* in most of its mechanical properties in the green condition as shown in the accompanying tabulation. The wood is very high in static-bending strength, stiffness, crushing strength, cleavage, and tension perpendicular to the grain; it is exceptionally high in shock resistance, as indicated by work to maximum load and toughness, also in hardness, compression perpendicular to the grain, and shear.

Although its specific gravity and strength properties are much greater than those of any well known domestic timber, the following comparative values, based upon a scale in which values for White Oak *(Quercus alba)* are taken as 100, indicate the relative properties of *Tabebuia guayacan*.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
141	223	206	161	273

Hardness	Shear	Bearing strength	Cleavage resistance
296	178	288	121

Volumetric shrinkage of 14.8 percent is comparable to that of most other woods of similar density, but is nevertheless slightly less than that of White Oak *(Quercus alba)*. Shrinkage of 6.8 percent radially and 8.5 percent tangentially reveals a considerably lower ratio of tangential to radial values, indicative of uniform shrinkage and relative freedom from cupping, than does White Oak which is characterized by radial and tangential shrinkage values of 5.3 and 9.0 percent respectively. Longitudinal shrinkage of 0.18 percent is within normal limits of variation for wood.

Guayacán heartwood is extremely durable and resistant to insect attack. It has been reported sound after 300 years exposure in Panama. On the basis of a limited amount of testing conducted in the course of the present study, it is rated as very durable in resistance to both white-rot and brown-rot fungi.

Guayacán is reported to be rather difficult to work and inclined to splinter, but finishes to a very smooth polished surface. The yellow dust resulting from milling operations of woods of this group is reputed to cause a mild form of dermatitis in some individuals. The wood is highly resistant to water absorption, has excellent weathering characteristics, but is difficult to glue.

Because of its durability and strength, Guayacán finds local use as house parts, railway crossties, heavy construction timbers, mine timbers, sills, door and window frames, piling, and other marine construction. Because of its strength and resilience, it is used for wagon wheels, carriage work, handles, axles, archery bows, and fishing rods. It is frequently used for mortars and pestles, rollers for sugar cane mills, and for small boat work–particularly bent ribs.

The demand for Guayacán probably will be for many of the uses given above. In particular, its properties recommend its being used for heavy duty flooring, heavy and durable construction, boat frames, ice sheathing, keel stock, and wood tanks. It should prove to be a desirable material in furniture manufacture where a dense, mar-resistant wood capable of taking a smooth finish is required as in desk legs. Because of the close grain and ability to take a high polish, Guayacán might well be used for turning and as shuttles and picker sticks in the textile industry. Pulp mill equipment including beater liners, bed plates, and agitator bars is another use for which this wood appears suitable. As has already been mentioned, it has been used for certain sporting goods equipment and this use might well be extended to other types of such equipment where high bending strength and high shock resistance are required.

References: 11, 18, 34, 51, 77, 79, 80, 81, 86, 92, 96, 101, 111.

ROBLE BLANCO *Tabebuia pentaphylla* (L.) Hemsl.[1]

This timber is widely known in Spanish America as Roble ("oak") or Roble Blanco but it also bears numerous other appellations. Amapa or Rosa Morado are other Mexican names; Mayflower is the common name in British Honduras; Maqueliz in Guatemala and Honduras; Roble Morado in Colombia; and Apamate in Venezuela.

Close relatives of Roble Blanco include the native Catalpa, the tropical Calabash tree, Primavera whose wood is prized for furniture manufacture, Guayacán with very strong and dense wood, and many of the jungle lianas. There are many species of *Tabebuia* and some of them quite closely resemble *T. pentaphylla*. The species is common throughout its range which includes Mexico, Central America, Ecuador, Colombia, Venezuela, and the West Indies. Despite the large number of species and its great range of distribution, Roble Blanco is well known and seldom confused with other timbers.

The Roble Blanco tree is generally of medium size, commonly 18 to 24, occasionally 36, inches in diameter and 60 to 95 feet in height. It is typically short boled with 20 to 35, occasionally 50, feet of clear length above the seven- to 10-foot buttresses. The trunk is frequently irregular or squarish in cross-section.

The heartwood of Roble Blanco is pale brown, either somewhat grayish or somewhat golden. A fine brown penciling gives the wood a distinctive figure of fine lines on the quarter-surface and a more prominent "feather" pattern on the tangential or "flat cut" surface. Sapwood narrow, not clearly differentiated from the heartwood, yellowish to

[1] = *Tecoma pentaphylla* (L.) Juss.

Species	Source	No. of Logs	Moisture Content	Specific Gravity Oven-dry vol.	Specific Gravity Green vol.	Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Roble Blanco (*Tabebuia pentaphylla*)	British Honduras	3	67.4	0.59	0.54	6,060	9,720	1,270	1.62	10.6
	Honduras	3	68.3	0.56	0.51	6,230	11,190	1,470	1.47	11.9
	Average	6	67.8	0.58	0.52	6,140	10,460	1,370	1.54	11.2
	Venezuela[1]	1	107.8	0.50	0.45	6,000	9,600	1,620	1.24	7.2
White Ash[2] (*Fraxinus americana*)	United States		42	0.64	0.55	5,100	9,600	1,460	1.04	16.6
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness End	Hardness Side	Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Roble Blanco (*Tabebuia pentaphylla*)										
British Honduras	3,490	4,650	1,470	1070	950	980	900	1340	390	171.1
Honduras	4,240	4,780	1,580	1120	970	750	710	1240	430	133.5
Average	3,860	4,720	1,520	1100	960	860	800	1290	410	152.3
Venezuela[1]	4,410	5,030	1,650	910	670	610	670	1100	320	—
White Ash[2] (*Fraxinus americana*)										
United States	3,190	3,990	—	1010	960	810	590	1380	330	—
White Oak[2] (*Quercus alba*)										
United States	3,090	3,560	—	1120	1060	830	770	1250	420	—

[1] Kynoch and Norton (47). [2] U. S. Dept. Agr. Tech. Bul. 479.

white when freshly cut becoming pale brown upon exposure and drying. Grain straight to interlocked producing a fine, striped figure on the quarter-sawed surface when interlocked. A conspicuous irregular pattern of brown parenchyma characterizes the tangential surface. Texture medium to rather coarse; growth layers visible but not sharply defined; ripple marks present. Heartwood without distinctive odor or taste when seasoned. Heavy, comparable to White Ash, with an average specific gravity of 0.52 (0.44 to 0.63) based on oven-dry weight and green volume. Weight per cubic foot averages 55 pounds in the green condition and 38 pounds when air dry.

Roble Blanco may be air seasoned at a fast rate with little or no checking and only slight warping. In its seasoning properties, it compares favorably with Yellow Poplar *(Liriodendron tulipifera)*.

The mechanical properties of Roble Blanco are higher than average for most species of comparable density in all static-bending properties except stiffness. They are also above average in cleavage, tension across the grain, and toughness; and average in compression parallel to and perpendicular to grain, hardness, and shear. In the accompanying table data are included for a single log of *Tabebuia pentaphylla* from Venezuela which show somewhat lower density and strength values except for crushing strength and stiffness. In the latter properties the Venezuela material was apparently superior.

In comparison with two well known species in the United States, White Ash and White Oak, Roble Blanco is distinctly higher than both in bending strength, elastic resilience, crushing strength, and tension across the grain. It is intermediate to White Ash and Oak in stiffness, hardness, shear, and cleavage and approximately equal to Oak in compression across the grain and shock resistance. This generally favorable comparison is shown in spite of the slightly greater density of Ash and a considerably higher density for White Oak.

Roble Blanco is moderate in shrinkage. As shown in the tabulation, its shrinkage is intermediate to that of Mahogany

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Roble Blanco				
(Tabebuia pentaphylla)				
British Honduras	3.6	6.1	0.18	8.7
Honduras	3.7	5.9	0.15	9.5
Average	3.6	6.0	0.16	9.1
Venezuela[1]	2.6	5.9	—	9.3
Mahogany[2]				
(Swietenia macrophylla)				
Central America	3.5	4.8	—	7.7
Black Walnut[3]				
(Juglans nigra)				
United States	5.2	7.1	—	11.3

[1]Kynoch and Norton (47).
[2]Heck (37).
[3]U. S. Dept. Agr. Tech. Bul. 479.

and Black Walnut. Volumetric shrinkage is 9.1 percent. Radial shrinkage of 3.6 percent and tangential of 6.0 percent indicate moderate uniformity in these two directions although the ratio of tangential to radial is greater than in Mahogany.

The heartwood of Roble Blanco is reported generally to be low in resistance to insect attack and to decay although a contradictory opinion indicating a moderately high degree of resistance to fungal and insect attack has been expressed.[48] In the present study material from Honduras and British Honduras was subjected to decay tests and rated as durable to very durable in resistance to brown-rot fungal attack but variable, ranging from non-durable to durable, when exposed to a white-rot fungus.

Roble Blanco has excellent working properties in sawing, planing, boring, and turning and remains in place when manufactured. According to Fritz[33] the wood machines cleanly with sharp edges, planes to a glossy smoothness, and nails well although it is advisable to pre-bore nail holes in thick stock. It finishes attractively in natural color and takes mahogany and oak stains with good results. The wood weathers without serious checking or warping, perhaps because of the extreme ease with which moisture is absorbed and released.

Roble Blanco is widely used for furniture and interior trim in the regions where it grows. It also finds favor for sash, doors, floors, boat building, paddles, oars, axe handles, ox-yokes, wagons, packing boxes, and general construction. Roble Blanco closely resembles White Ash in many of its characteristics and might well be considered as a substitute for that species in sporting goods and agricultural implement uses as well as for motor vehicle body parts. It shows promise as a figured and utility veneer wood. It has characteristics which recommend its use for boat decking and for boat parts where natural durability is not a necessary attribute. Undoubtedly much of the future demand for this wood will be for uses for which it is now best known, namely, furniture, millwork, flooring, and general construction.

References: 20, 21, 31, 33, 34, 39, 46, 47, 48, 51, 58, 64, 70, 72, 77, 79, 80, 87, 90, 92, 94, 97, 98, 99, 106, 107, 108, 112, 113.

TEAK *Tectona grandis* L.f.

The Teak wood tested in this investigation was obtained from young planted trees grown in Honduras. Extremely favorable growing conditions caused these trees to reach a size large enough for saw logs in 20 years. Plantations in other tropical regions give similar results. In view of the potential value of wood produced in this manner the tests recorded here were conducted to give a preliminary basis for comparison of the plantation-grown with forest-grown Teak from Burma.

Heartwood olive-green when freshly cut in the unseasoned condition, later becoming golden brown upon exposure and drying. Sapwood one to two inches wide, sharply demarcated, yellowish to white. Grain usually straight. Texture fine, uniform; growth layers distinguished on side-grain surfaces by narrow brown lines darker than the background color. Heartwood oily, faintly fragrant but without distinc-

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Teak (*Tectona grandis*) (Plantation-grown)	Honduras	3	72.3	0.59	0.56	6,160	9,940	1,350	1.59	10.9
Teak[1] (*Tectona grandis*)	Burma		52	0.64	0.60	7,090	11,440	1,670	1.7	9.3

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Teak (*Tectona grandis*) (Plantation-grown) Honduras	3,960	4,780	1,350	1140	1290	1290	940	1730	390	116.2
Teak[1] (*Tectona grandis*) Burma	4,080	5,870	1,940	920	1040	1060	—	1100	—	—

[1]A. V. Thomas (105).

tive taste when seasoned. Heavy, but somewhat lower in density than the average for Burma Teak, with an average specific gravity of 0.56 (0.52 to 0.62) based on oven-dry weight and green volume. Weight per cubic foot averages 60 pounds in the green condition and 40 pounds when air dry.

The Forest Products Research Laboratory at Princes Risborough, England,[32] states that Teak air seasons or kiln dries somewhat slowly but with a minimum of defect and that advanced girdling of the trees has little or no effect on the drying characteristics. Plantation-grown stock from Honduras air seasoned readily at a fast rate with no appreciable defect.

The strength properties of young plantation-grown Teak in the green condition are compared with those of forest-grown Burma Teak in the accompanying tabulation.

Values for young plantation-grown stock are somewhat lower than values for forest-grown Burma Teak in specific gravity, static-bending strength, stiffness, and crushing strength. However, the differences in crushing strength and stiffness exceed those that might be anticipated on the basis of density differences alone. The plantation-grown Teak appears to be comparable to mature forest-grown Teak in elastic resilience and shock resistance, and exceeds the latter in hardness, compression across the grain, and shear. Comparable data are not available for other mechanical properties.

Teak is widely known for its exceedingly low shrinkage and young plantation-grown Teak is no exception. Volumetric shrinkage for the plantation-grown material averages

Species and Source	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Tectona grandis (Plantation-grown) Honduras	2.1	4.6	0.37	5.1
Tectona grandis[1] Burma	2.3	4.2	—	—

[1]Handbook of Empire Timbers (32).

5.1 percent. In the tabulation, the close similarity of radial and tangential shrinkage to corresponding values for Burma Teak is clearly shown. Radial shrinkage is 2.1 percent and tangential 4.6 percent. Longitudinal shrinkage of 0.37 percent is within the range commonly encountered among woods with irregular grain.

Heartwood of Teak is highly regarded for its high degree of resistance to decay as well as to termite and marine-borer attack. Previous studies of the durability against fungus and insect attack of young (10 yr. old) plantation-grown Teak have shown that this wood is fairly resistant to fungal attack but susceptible to deterioration by termites.[14] In decay resistance tests conducted as one phase of the current study, 20-year old plantation grown Teak from Honduras was found to be somewhat variable but generally very durable in resisting deterioration by both white-rot and brown-rot organisims.

The wood of plantation-grown Teak is readily worked, finishing to a very smooth surface.

Teak, because of its many desirable qualities, has long been used in boat and ship construction where it is highly prized as a decking wood. Other common uses are for furniture, cabinets, interior and exterior fittings and flooring. Plantation-grown Teak, while not measuring up in all respects to forest-grown material, is recommended for general use in boat-building, durable construction, flooring, high quality millwork including sash and doors, and general exterior use. Its low shrinkage and durability favor its use for tank stock.

References: 14, 32, 44, 50, 62, 105, 106.

NARGUSTA *Terminalia amazonia* (Gmel.) Exell[1]

There are many vernacular names for this species and its various forms. Among them are Cochun (Mexico), Bolador, Guayabo, and Naranjo (Guatemala, Honduras, Costa Rica),

[1]= Terminalia obovata (R.&P.) Steud.

Amarillo (Panama), Guayabo Leon (Colombia), Chicharro (Venezuela), Fukadi (Briitsh Guiana), Pau-Mulato Branco (Brazil), and White Olivier (Trinidad).

There are a number of other American species in the genus that have superficially similar woods but they are not sufficiently known to permit the assumption that they will have similar properties. There is the possibility that wood of Nargusta produced in certain areas of its great range will differ from results shown by these tests.

Nargusta grows in the evergreen forests from southern Mexico through Central America and northern South America and in Trinidad. It is a common member of forest types on moist slopes and flat lands and in a few areas is the dominant species.

The trees are typically tall and straight with clear symmetrical boles above the buttress flutes. It attains heights of 80 to 140 feet and diameters of four to five feet but in many regions trees over 25 inches in diameter are hollow.

The heartwood of Nargusta is typically brownish yellow, light yellowish brown, or yellowish olive; widely spaced prominent reddish brown stripes are sometimes present. Sapwood two to five inches wide, yellowish but not well differentiated from the heartwood. The wood has a medium to rather high luster. Texture medium, uniform; growth layers not clearly defined; grain straight, wavy, or roey. No distinctive odor or taste when seasoned. Very heavy, comparable to Hickory in this respect, with an average specific gravity of 0.66 (0.53 to 0.77) based on oven-dry weight and green volume. Weight per cubic foot averages 71 pounds in the green condition and 50 pounds when air dry.

Observations of seasoning characteristics of this wood indicate considerable variability. Based on a limited amount of material, *Terminalia amazonia* from British Honduras air dries readily at a fast rate with no checking and only a slight amount of warping, whereas material from British Guiana dries more slowly and both end and surface checking are very pronounced, particularly in thick stock. This wood is

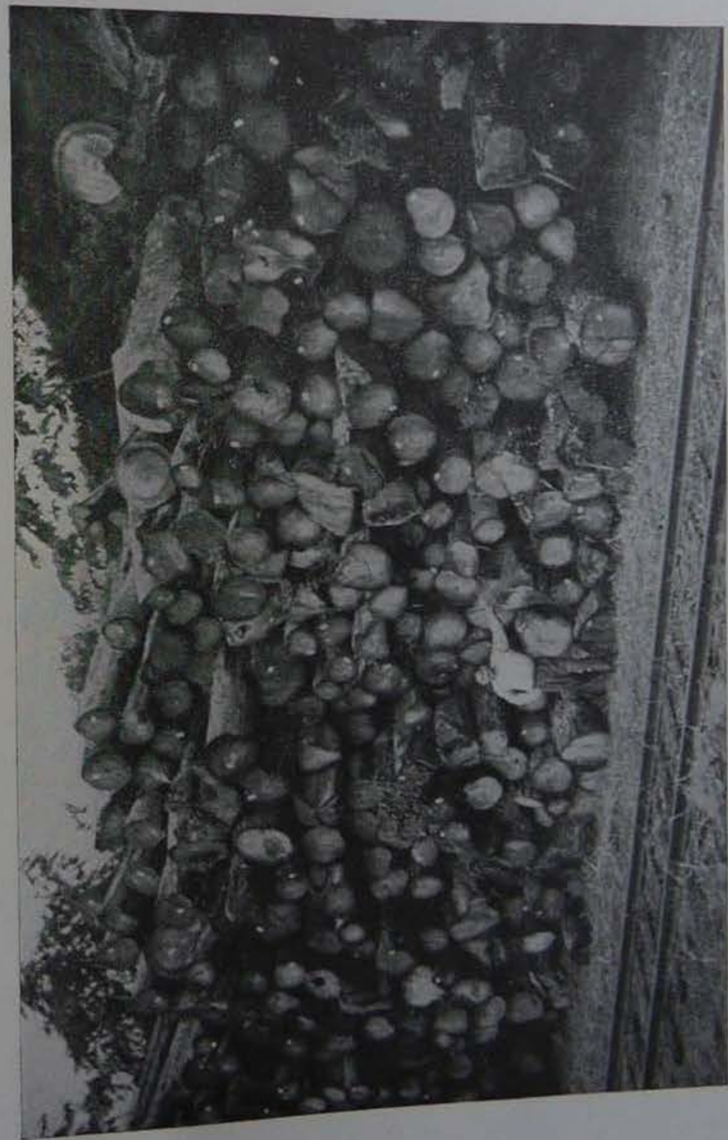

Fig. 11

Logs of Nargusta (*Terminalia amazonia*) awaiting sawing, Panama Canal

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending: Fiber Stress at Proportional Limit	Static Bending: Modulus of Rupture	Static Bending: Modulus of Elasticity	Static Bending: Work to Proportional Limit	Static Bending: Work to Maximum Load
			percent	Oven-dry vol.	Green vol.	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Nargusta (*Terminalia amazonia*)	British Guiana	3	64.2	0.82	0.70	9,160	14,980	2,620	1.81	13.8
	British Honduras	3	80.4	0.71	0.63	7,130	10,470	1,700	1.77	8.9
	Average	6	72.3	0.76	0.66	8,140	12,720	2,160	1.79	11.4
	British Honduras[1]		83	—	0.58	—	11,700	1,830	—	—
	Trinidad[1]		51	—	0.70	—	14,200	2,200	—	—
White Oak[2] (*Quercus alba*)	United States		68	0.71	0.60	4,700	8,300	1,250	1.08	11.6

Species	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Compression Parallel to Grain: Maximum Crushing Strength	Compression Parallel to Grain: Modulus of Elasticity	Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	End lb.	Side lb.	Stress at proportional limit lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Nargusta (*Terminalia amazonia*)										
British Guiana	5,340	6,820	2,970	1640	1670	1310	1110	1700	440	212.1
British Honduras	4,050	5,110	1,950	1270	1220	1200	660	1290	390	184.6
Average	4,700	5,960	2,460	1460	1440	1260	880	1500	420	198.4
British Honduras[1]	—	5,530	—	1250	1130	—	—	1460	470	—
Trinidad[1]	—	7,330	—	1610	1580	—	—	1750	490	—
White Oak[2] (*Quercus alba*)										
United States	3,090	3,560	—	1120	1060	830	770	1250	420	—

[1]Handbook of Empire Timbers (32).
[2]U. S. Dept. Agr. Tech. Bul. 479.

prone to check and split badly, requiring carefully controlled seasoning practices to avoid these defects.

The strength properties of Nargusta in the green condition are representative of a majority of woods with comparable high density.

The tabulated data show higher density and proportionately higher strength properties throughout for the British Guiana timber as compared with that from British Honduras. It is not clearly established that such differences may be explained on the basis of geographical origin or whether they represent local variations in site or other growth conditions. In this respect, however, it is interesting to observe that in a previous comparison of this species from British Honduras and Trinidad similar differences were shown, the material from British Honduras having the lower density and strength.[32]

When the test results of British Guiana and British Honduras material are combined, Nargusta is close to the average for most woods of similar density. In comparison with White Oak, Nargusta is about 10 percent higher in density, about 50 percent higher in bending strength, hardness, and compression across the grain; about 70 percent higher in crushing strength, elastic resilience, and stiffness; and approximately comparable in tension across the grain, cleavage, shear, and shock resistance.

The shrinkage of Nargusta is moderate for its density. Volumetric shrinkage averaging 12.8 percent is considerably less than that of Hard Maple, White Oak, or Shagbark Hickory, all of which are lighter in weight than Nargusta. Radial shrinkage of 5.0 percent is comparable to that of Hard Maple; tangential shrinkage of 8.0 percent is less than in Maple. The ratio of shrinkage in these two directions indicates moderately uniform shrinkage characteristics. Longitudinal shrinkage of 0.18 percent is within limits of normal variation for straight-grained wood.

Heartwood of Nargusta has been variously reported to be fairly high to high in its resistance to decay although

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Nargusta				
(*Terminalia amazonia*)				
British Guiana	5.5	8.4	0.20	14.4
British Honduras	4.5	7.6	0.17	11.2
Average	5.0	8.0	0.18	12.8
British Honduras[1]	4.8[2]	9.4[2]	—	—
Trinidad[1]	6.0[2]	10.6[2]	—	—
White Oak[3]				
United States	5.3	9.0	—	15.8
Shagbark Hickory[3]				
United States	7.0	10.5	—	16.7
Hard Maple[3]				
United States	4.9	9.5	—	14.9

[1]Handbook of Empire Timbers (32).
[2]Calculated green to oven-dry shrinkage based upon shrinkage green to 12 percent moisture content.
[3]U. S. Dept. Agr. Tech. Bul. 479.

susceptible to attack by pinhole borers. In tests on a number of Trinidad timbers resistance to fungi and to termite attack was rated as fairly high.[14] Soil tests and pure culture tests using two white-rot fungi both resulted in a rating of resistant as applicable to this species.[84] In the present study considerable variation ranging from moderately durable to very durable was found in material from British Guiana alone when subjected to attack by both brown-rot and white-rot fungi. Resistance to marine-borer attack appears to be low on the basis of the first six-month exposure period of Nargusta from British Guiana at Kure Beach, North Carolina. In these tests heavy attack by *Bankia* was noted.[16]

Working properties of Nargusta are reported as fair to good. The wood saws cleanly and straight-grained material planes well, although some tearing occurs on quarter-sawn surfaces of material having interlocked grain. It bores well and is reported to have excellent turning characteristics.

Nargusta is used locally for general construction, bridge timbers and decking, railway crossties, piers, split house timbers, flooring, and furniture. On small boats it has been used successfully for sheer strakes, rubbing molding on gunwales, superstructures, hatch covers, and decking. For some boat parts it is bent, either cold or following steaming. Veneer has been produced from this timber on an experimental basis and some very attractive veneers have been produced from selected logs.

Nargusta should be very suitable for boat construction both as a framing and as a planking material. It also has characteristics which recommend it for decking use. In general this timber can be substituted for Oak in many of its uses in furniture and cabinet manufacture, general construction and flooring. It appears to be especially suitable for turned wood products. Because of its durability, it can be recommended for durable construction and general exterior use. Other possible uses are as a utility plywood and in instruments.

References: 9, 14, 16, 32, 34, 39, 44, 48, 53, 58, 79, 84, 92, 102, 109, 113.

MASA *Tetragastris balsamifera* (Sw.) Kuntze

Masa is the Puerto Rican name for this timber. It is known as Palo Cochino in Cuba, Bois Cochon in Haiti, and Amacey in Dominican Republic. A few other species grow in Central America and northern South America but *T. balsamifera* is limited to the West Indies. Masa is a medium-sized tree, frequently 50 to 60 feet tall and 18 to 24 inches in diameter.

Heartwood light reddish brown when freshly cut in the unseasoned condition becoming orange brown upon exposure. Sapwood relatively wide especially in fast grown timber, sharply demarcated, white when freshly cut becoming yellowish brown upon exposure and drying. Grain irregular to distinctly roey; texture fine, uniform, growth layers not distinct; general appearance somewhat like that of Yellow Birch. Taste not distinctive, but odor of seasoned wood mildly fragrant. Very heavy, comparable in this respect to Hickory, with an average specific gravity of 0.67 (0.61 to 0.78) based on oven-dry weight and green volume. Weight per cubic foot averages 67 pounds in the green condition and 52 pounds when air dry.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending				
				Oven-dry vol.	Green vol.	Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	60.5	0.80	0.67	7,600	12,300	1,650	1.96	10.0
Shagbark Hickory[1] (*Carya ovata*)	United States		60	—	0.64	5,900	11,000	1,570	1.28	23.7
Hard Maple[1] (*Acer saccharum*)	United States		58	0.68	0.56	5,100	9,400	1,550	1.03	13.3

Species	Compression Parallel to Grain			Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	End	Side	Stress at proportional limit				
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Masa (*Tetragastris balsamifera*) Puerto Rico	4,230	5,460	1,730	1740	1760	950	1230	1700	590	222.8
Shagbark Hickory[1] (*Carya ovata*) United States	3,430	4,580	—	—	—	1040	—	1520	—	—
Hard Maple[1] (*Acer saccharum*) United States	2,850	4,020	—	1070	970	800	—	1460	—	—

[1]U. S. Dept. Agr. Tech. Bul. 479.

Air seasoning observations made on a limited sample of this species from Puerto Rico indicate that the wood must be dried slowly to avoid serious end and surface checking.

The strength properties of Masa might be anticipated, in general, on the basis of the density of the wood. In comparison with other woods of similar high density, *Tetragastis balsamifera* is about average in its static bending strength, crushing strength, and shear properties; somewhat below average in stiffness and compression perpendicular to the grain; slightly above average in hardness and toughness; and exceptionally high in tension perpendicular to grain and cleavage resistance. As shown in the tabulation, Masa exceeds Shagbark Hickory and Hard Maple in all properties for which comparable data are available except shock resistance (work to maximum load) and compression across the grain. In the latter test it falls only slightly below Hickory.

Shrinkage values for Masa are shown in the following tabulation together with Shagbark Hickory and Hard Maple. Volumetric shrinkage of 13.9 percent for *Tetragastris balsamifera* is average for most woods of comparable high density, although it is clear that the volumetric shrinkage is less than that of Hard Maple or Hickory. This in spite of the fact that Masa exceeds these woods, particularly Hard Maple, in density. Radial shrinkage averages 4.4 percent, tangential 8.5 percent, and the high ratio of tangential

	SHRINKAGE (percent)			
Species and Source	Radial	Tangential	Longitudinal	Volumetric
Mesa (*Tetragastris balsamifera*)				
Puerto Rico	4.4	8.5	0.18	13.9
Shagbark Hickory[1] (*Carya ovata*)				
United States	7.0	10.5	—	16.7
Hard Maple[1] (*Acer saccharum*)				
United States	4.9	9.5	—	14.9

[1]U. S. Dept. Agr. Tech. Bul. 479.

to radial shrinkage is comparable to that of Hard Maple. Longitudinal shrinkage of 0.18 percent is normal.

The heartwood has been reported to be resistant to insect attack but in tests intended to measure its resistance to attack by dry wood termites, Wolcott[114] rated the wood in the least desirable group. The wood has been said to lack durability in contact with the ground, but decay resistance data on *Tetragastris balsamifera* available from the present study indicate that the heartwood is very durable in its resistance to a white-rot organism and extremely variable in its resistance to a brown-rot fungus although averaging durable to very durable. Masa is rated low in resistance to marine-borer attack on the basis of tests conducted in Hawaiian waters.

The wood is moderately difficult to machine.

Masa is used locally for the better grade of interior construction and carpentry as well as for furniture and oars. At one time it had considerable use as staves for sugar barrels. The wood does not have a particularly distinctive figure but should be very suitable in furniture and cabinet work as a substitute for Birch and Maple for solid parts. Other uses for this wood include house and factory flooring and general and durable construction.

References: 8, 17, 29, 63, 79, 83, 114.

FLOR AZUL — *Vitex Kuylenii* Standl.

Flor Azul (meaning blue flower) is the usual name for this tree in Honduras; it is also used in British Honduras, along with the equally general name Fiddlewood (better applied to *Vitex Gaumeri*). The Guatemalan name is Barbás.

This species is found in Mexico, Guatemala, British Honduras, and Honduras. The tree is generally small to medium-sized. In Guatemala its wood is considered inferior to that of Rajate Bién.

The woods of the two species are much alike and have very similar mechanical properties in the green condition. For these reasons the data for them are combined here.

RAJATE BIÉN *Vitex Cooperi* Standl.

Rajate Bién is the name in Guatemala where it is sometimes confused with Barbás or Barabás, *Vitex Kuylenii* Standl. The Mexican and Honduran names are not certainly known but may be Negrito Coyote and Flor Azul respectively.

The known range of this species includes only Mexico, Guatemala, and Honduras. It is probable that it also occurs in British Honduras. Rajate Bién is a medium-sized or occasionally large tree.

So little is known about the timbers of the various species in this genus that there is little basis for comparing their relative properties or for suggesting that several of them may be similar. Their close relationship with several valuable Eastern Hemisphere timbers, including Teak, makes them an interesting group for study.

Heartwood tan, yellowish brown to dark brown when freshly cut in the unseasoned condition becoming gray brown to deep brown upon exposure. Sapwood narrow to rather thick, usually not sharply demarcated, cream to grayish tan turning to a pale brown after drying. Grain usually straight but sometimes wavy. Texture fine to medium, uniform; growth layers indistinct; no characteristic figure; no distinctive odor or taste when seasoned. Heavy, comparable to yellow birch, with an average specific gravity of 0.53 (0.47 to 0.56) on the basis of oven-dry weight and green volume. Weight per cubic foot averages 66 pounds in the green condition and 40 pounds when air dry.

When air seasoned at a moderate rate *Vitex Cooperi* exhibits little or no seasoning defects. This wood is reported by Record and Hess[79] as drying very slowly but without serious checking. The results of observations made on a limited amount of material of *Vitex Kuylenii* from Honduras showed great variability in seasoning characteristics. Some material which dried at a fast rate showed little checking while other material checked badly even though drying more slowly.

Species	Source	No. of Logs	Moisture Content	Specific Gravity		Static Bending				
				Oven-dry vol.	Green vol.	Fiber Stress at Proportional Limit	Modulus of Rupture	Modulus of Elasticity	Work to Proportional Limit	Work to Maximum Load
			percent			lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	in.-lb. per cu. in.	in.-lb. per cu. in.
Rajate Bién (*Vitex Cooperi*)	Guatemala	2	107.4	0.61	0.54	5,580	9,440	1,460	1.26	9.8
Flor Azul (*Vitex Kuylenii*)	Honduras	2	90.1	0.58	0.51	6,150	9,400	1,520	1.32	5.6
	Average	4	98.8	0.60	0.53	5,860	9,420	1,490	1.29	7.7
Hard Maple[1] (*Acer saccharum*)	United States		58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
Persimmon[1] (*Diospyros virginiana*)	United States		58	0.78	0.64	5,600	10,000	1,370	1.35	13.0

Species	Compression Parallel to Grain			Hardness		Compression Perpendicular to Grain	Tension Perpendicular to Grain	Shear	Cleavage	Toughness
	Fiber Stress at Proportional Limit	Maximum Crushing Strength	Modulus of Elasticity	End	Side	Stress at proportional limit				
	lb. per sq. in.	lb. per sq. in.	1000 lb. per sq. in.	lb.	lb.	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.	lb. per in. of width	in.-lb. per specimen
Rajate Bién (*Vitex Cooperi*) Guatemala	3,690	4,850	1,760	1110	1140	920	650	1350	280	122.4
Flor Azul (*Vitex Kuylenii*) Honduras	3,720	4,700	1,810	990	960	1440	650	1220	360	93.6
Average	3,700	4,780	1,780	1050	1050	1180	650	1280	320	108.0
Hard Maple[1] (*Acer saccharum*) United States	2,850	4,020	—	1070	970	800	—	1460	—	—
Persimmon[1] (*Diospyros virginiana*) United States	3,160	4,170	—	1240	1280	1110	770	1470	410	—

[1] U. S. Dept. Agr. Tech. Bul. 479.

In their mechanical properties *Vitex Cooperi* and *Vitex Kuylenii* are sufficiently similar to be considered the same for practical purposes.

The average values shown for these species in the accompanying tabulation are in line with those exhibited by most woods of the same density in nearly all properties. In compression perpendicular to the grain these *Vitex* species are distinctly above average. They are compared directly with Hard Maple and Persimmon, both of greater density than *Vitex*, in the tabulation. It is evident that *Vitex* is closely comparable to Hard Maple in all static-bending properties, except work to maximum load, and hardness; it is considerably superior to Hard Maple in crushing strength and compression across the grain, but inferior to Maple in shock resisting ability. The chief distinction in the properties of these *Vitex* species and Persimmon is the considerably lower shock resistance and slightly lower hardness of *Vitex*.

The shrinkage of these *Vitex* species is appreciably less than for most woods of comparable density.

	Shrinkage (percent)			
Species and Source	Radial	Tangential	Longitudinal	Volumetric
Vitex Cooperi				
Guatemala	3.5	7.1	0.15	10.9
Vitex Kuylenii				
Honduras	2.8	5.8	0.18	10.0
Average	3.2	6.4	0.16	10.4
Yellow Birch[1] *(Betula lutea)*				
United States	7.2	9.2	—	16.7
Black Locust[1] *(Robinia pseudoacacia)*				
United States	4.4	6.9	—	9.8

[1]U. S. Dept. Agr. Tech. Bul. 479.

The average volumetric shrinkage of 10.4 percent is only two-thirds that of Yellow Birch, a wood of corresponding density, and is only slightly greater than that of Black Locust which is noted for its dimensional stability. Radial shrinkage of 3.2 percent and tangential shrinkage of 6.5 percent are both below corresponding values for Black

Locust, but the ratio of tangential to radial values indicates a degree of non-uniformity in these two directions that is rather high. Longitudinal shrinkage of 0.16 percent is within the range of normal variation for straight-grained wood.

Little information is available concerning durability of the wood of these species. Record and Hess,[79] in a general statement covering 21 species of *Vitex* occurring in Tropical America, report that durability is variable. *Vitex Cooperi* is reported by these authors to be used locally for durable construction. *Vitex Kuylenii* is stated to be fairly high in resistance to fungal and insect attack but of limited serviceability when used in contact with soil or when exposed to marine borers.[48] Considerable quantities of *V. Cooperi* are in use in Guatemala as posts and heavy timber in contact with the ground; specimens in place for 16 years are still sound. In the present study, specimens of *Vitex Kuylenii* from Honduras were found very durable in resistance to both brown-rot and white-rot fungi. The relatively high silica content (0.14 percent) of heartwood of *Vitex Kuylenii* suggests the desirability of further investigating the marine-borer resistance of this species.

Both species are very easy to work and take a smooth finish. Rajate Bién derives its name from the ease with which the timber can be split. Flor Azul has been reported to saw, plane, bore, and turn readily, and to hold nails well.

In Guatemala both of the woods are reported as being used for general and durable construction, Rajate Bién being considered the better of the two and the more widely used. Besides being suitable for these uses, Rajate Bién appears very suitable for boat decking and planking, flooring, dowels, small-tool handles such as chisels, and instruments. One of the outstanding characteristics of this wood is its low shrinkage in relation to its density. In this and many other respects it resembles Black Locust and might well be used as a substitute for that wood in its many specialty uses. Because of the observed variable seasoning characteristics of the test material of Flor Azul, this wood is recommended only for durable and general construction. It may well be that further study of the seasoning characteristics will indicate that this species too can be recommended for more exacting uses.

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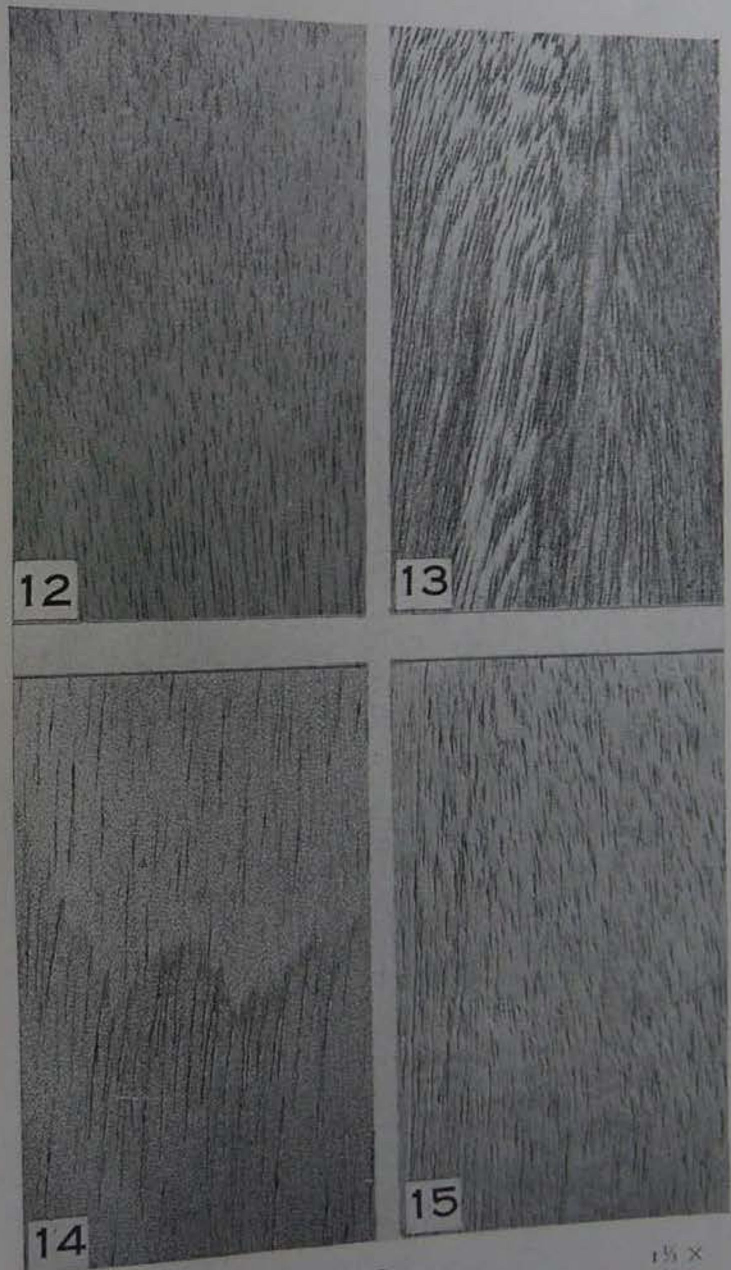

Fig. 12. *Astronium graveolens* Jacq. 1⅓ ×
Fig. 13. *Buchenavia capitata* (Vahl.) Eich. 1⅓ ×
Fig. 14. *Cedrela Tonduzii* C. DC. 1⅓ ×
Fig. 15. *Tabebuia Donnell-Smithii* Rose 1⅓ ×

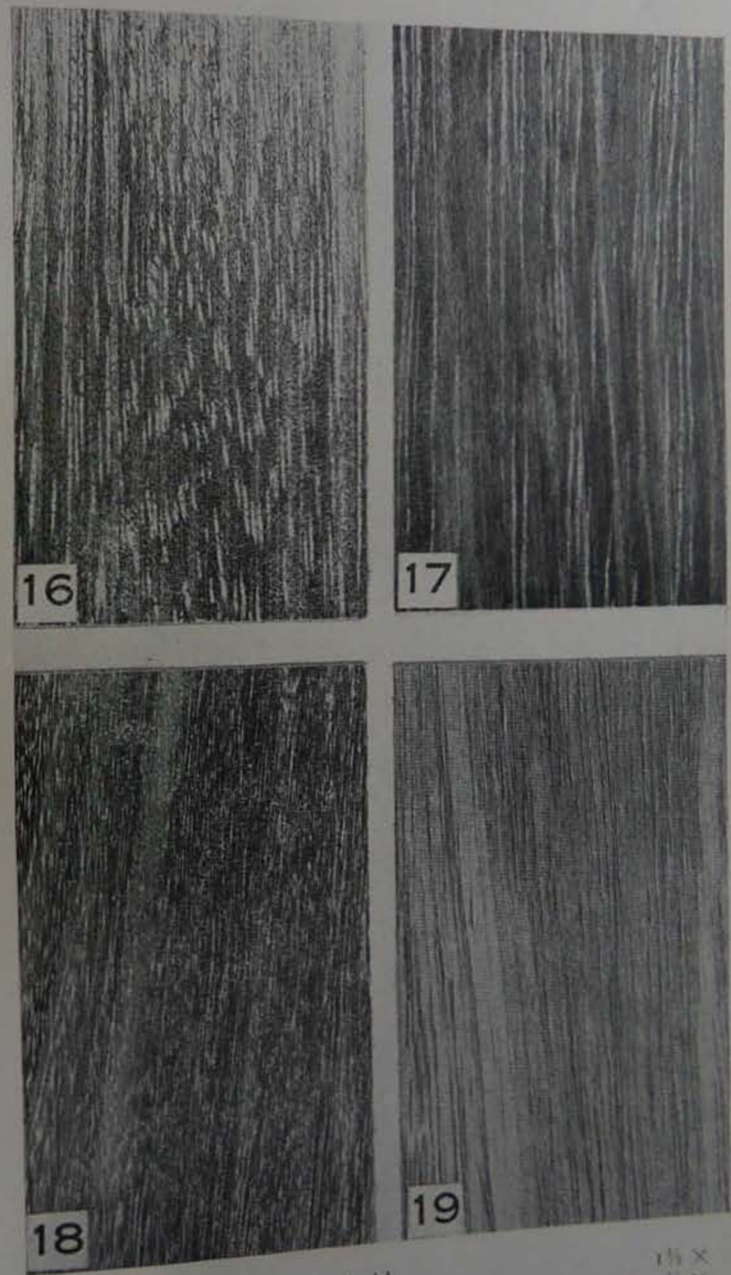

Fig. 16. *Bagassa guianensis* Aubl. 1⅓ ×
Fig. 17. *Hymenaea Davisii* Sandw. 1⅓ ×
Fig. 18 *Tabebuia guayacan* (Seem.) Hemsl. 1⅓ ×
Tabebuia pentaphylla (L.) Hemsl. 1⅓ ×

Test Material

Tree No.	Species	Source	Tree Height, feet	Diameter at stump, inches	Top Diameter of test log inches	Character	Remarks
44	*Aspidosperma cruentum*	British Honduras			14		Hardwood transition forest, creek banks.
52	" "	" "		18	15		
53	" "	" "		19	16		" "
318	*Astronium graveolens*	Honduras		22	19	Old growth.	Mountains
332	" "	Venezuela	53	23	18	Old growth.	Plains, without hills.
333	" "	"	84	22	15	Old growth.	" " "
334	" "	"	91	22	17	Old growth.	" " "
170	*Buchenavia capitata*	Puerto Rico	60	26	18.5	Second growth.	Lower montane evergreen forest, lower slopes.
171	" "	" "	70	24	17.0	Second growth.	" "
172	" "	" "	76	29	20	Second growth.	" "
141	*Bagassa guianensis*	Brazil	116	28	19	Old growth.	Virgin upland forest.
282*	" "	"					
97	*Bombacopsis quinata*	Honduras	55	10	6	Old growth. (?)	Mountains
98	" "	"	45	15	5.5	Old growth. (?)	"
99	" "	"	43	11	5	Old growth. (?)	"
312	" "	"	64	20	14	Old growth.	"
313	" "	"	83	31	20	Old growth.	"
314	" "	"	100	38	24	Old growth.	"
264	*Cedrela Tonduzii*	Panama	95	46	31	Old growth.	Upper mountain slopes, 7000′ elev.
265	" "	"	90	35	30	Old growth.	" "
266	" "	"	85	43	27	Old growth.	" "

*Received in the form of plank from the U. S. Navy Department, Terminal Island, California.

TEST MATERIAL—*Continued*

Tree No.	Species	Source	Tree Height, feet	Diameter at stump, inches	Top Diameter of test log inches	Character	Remarks
41	*Cordia alliodora*	British Honduras			13		
50	" "	" "		20	18		River flood plain.
51	" "	" "		29	21		" " "
85	" "	Honduras	103	20	11	Old growth. (?)	Second growth forest.
86	" "	"	94	16	11.5	Old growth. (?)	" " "
87	" "	"	103	20	13	Old growth. (?)	" rocky soil.
288	" "	Nicaragua	97	22	18.5	Second growth.	Rain forest, hilly.
289	" "	"	111	24	20	Old growth.	" " "
290	" "	"	91	20	18.5	Second growth.	" " "
320	" "	Honduras			17	Old growth.	Mountains.
137	*Caryocar villosum*	Brazil	97	42	39	Old growth.	Virgin upland forest.
281*	" "	"					
371	" "	"			20		Upland forest, sandy soil.
245	*Dicorynia paraensis*	Surinam	120		12	Old growth.	Low; sandy soil.
246	" "	"	74	32	20	Old growth.	" " "
213	*Eschweilera Sagotiana*	British Guiana	109	18	16	Old growth.	Mixed forest, brown sand.
215	" "	" "	99	17	14	Old growth.	" " " "
66	*Hymenaea courbaril*	Surinam			18		
103	" "	Honduras	77	16	13	Old growth. (?)	Virgin forest, level.
104	" "	"	52	12	10.5	Old growth. (?)	" " "
164	" "	Puerto Rico	49	19	14.5	Second growth.	Lower montane evergreen forest, steep slopes.
165	" "	" "	49	17.5	14	Second growth.	" "
166	" "	" "	48	25	17	Second growth.	" "

*Received in the form of plank from the U. S. Navy Department, Terminal Island, California.

TEST MATERIAL—*Continued*

Tree No.	Species	Source	Tree Height, feet	Diameter at stump, inches	Top Diameter of test log inches	Character	Remarks
216	*Hymenaea Davisii*	British Guiana	129	20	19.7	Old growth.	Mixed forest, brown sand.
217	" "	" "	112	20	18.5	Old growth.	Wallaba forest, white sand.
218	" "	" "	102	16	12.7	Old growth.	Mixed forest, brown sand.
210	*Loxopterygium Sagotii*	British Guiana	98	20	15	Second growth.	Second growth forest, brown sand.
211	" "	" "	113	20	17	Second growth.	" "
212	" "	" "	110	18	13	Second growth.	" "
260	" "	Surinam	107	22	16	Old growth.	Sandy soil.
261	*Magnolia sororum*	Panama	101	50	31	Old growth.	Uppper mountain slopes, 7000' elev.
262	" "	"	104	48	29	Old growth.	" "
263	" "	"	90	54	29	Old growth.	" "
161	*Manilkara bidentata*	Puerto Rico	70	24	16	Old growth.	Lower montane evergreen forest, steep slopes.
162	" "	" "	72	23	16	Old growth.	" "
163	" "	" "	65	18	12	Old growth.	" "
204	" "	British Guiana	103	19	13	Old growth.	Mixed forest, brown sand.
205	" "	" "	128	24	20	Old growth.	" " " "
206	" "	" "	113	18	15	Old growth.	" " " "
242	" "	Surinam	104		14	Old growth.	Low; sandy soil.
307	*Swietenia macrophylla*	Honduras	70	17	16	Plantation.	Level, low pasture land.
309	" "	"	73	22	20	Plantation.	" " " "
311	" "	"	75	17	12	Plantation.	" " " "

TEST MATERIAL—*Continued*

Tree No.	Species	Source	Tree Height, feet	Diameter at stump, inches	Top Diameter of test log inches	Character	Remarks
301	*Tectona grandis*	Honduras	76	19	14	Plantation.	" " " "
303	" "	"	81	14	11	Plantation.	" " " "
305	" "	"	82	19	14	Plantation.	" " " "
241	*Ocotea rubra*	Surinam	114		14	Old growth.	Low; sandy soil; sometimes under water.
249	" "	"	104	32	20	Old growth.	" "
79	*Pseudosamanea guachapele*	Honduras			14	Second growth.	
80	" "	"	40	15	10	Second growth.	
81	" "	"	53	16	10.5	Second growth.	
88	*Tabebuia Donnell-Smithii*	"	48	18	8.7	Approx. 12 yr. old.	Second growth forest.
90	" " "	"	63	13	11	Approx. 14 yr. old.	Second growth forest, low hills.
321	" " "	"	95	36	22	Old growth.	Level terrain.
82	*Tabebuia guayacán*	"	111	18	14	Old growth.	Virgin forest, steep hills.
83	" "	"	93	21	13.5	Old growth.	Mountains.
84	" "	"	134	24	16	Old growth. (?)	"
45	*Tabebuia pentaphylla*	British Honduras			13		
48	" "	" "		36	21		Swamp.
49	" "	" "			22		"
76	" "	Honduras	63	25	16	Old growth. (?)	Pasture land.
77	" "	"	48	16.5	12.5	Old growth.?	Second growth forest, flat.
322	" "	"	83	28	19	Old growth.	Plains.

TEST MATERIAL—*Continued*

Tree No.	Species	Source	Tree Height, feet	Diameter at stump, inches	Top Diameter of test log inches	Character	Remarks
42	*Terminalia amazonia*	British Honduras			13		
54	" "	" "		30	19		
55	" "	" "			21		
207	" "	British Guiana	107	18	16	Old growth.	Wallaba forest, white sand.
208	" "	" "	102	17	16	Old growth.	Mixed forest, brown sand.
209	" "	" "	104	20	19	Old growth.	Wallaba forest, white sand.
167	*Tetragastris balsamifera*	Puerto Rico	52	23	17	Old growth.	Lower montane evergreen, slope.
168	" "	" "	76	24	17	Old growth.	" "
169	" "	" "	77	24	19	Second growth.	" "
286	*Vitex Cooperi*	Guatemala	64	18	13.5	Old growth.	Rain forest, flat.
287	" "	"	57	15.5	12.5	Old growth.	" " "
91	*Vitex Kuylenii*	Honduras	65	20	14	Second growth.	Plains.
93	" "	"	99	19	15	Second growth.	Plains.

H. H. Chattaway

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A technical magazine devoted to the furtherance of knowledge of tropical woods and forests and to the promotion of forestry in the Tropics.

Editor: ROBERT W. HESS, *Associate Professor of Forest Products, Yale University School of Forestry.*

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CUMULATIVE INDEX TO *TROPICAL WOODS*

NUMBERS 1 TO 94 INCLUSIVE

All indexes are compromises between convenient conciseness and complete but bulky referencing. To achieve a measure of completeness without excessive bulk the basic index to this series has been prepared with a maximum amount of consolidation under major subject heads and the minimum amount of cross-indexing or individual referencing. The major heads consist of World divisions and countries (named), Anatomy (of wood), Flora, Forest Exploitation, Forest, Forestry, Identification, Names, Properties of wood, Utilization of woods, Wood Descriptions, and numerous lesser categories.

All countries or geographical divisions are listed under one of the following: Africa; America, North; America, South; Asia; Australia; Europe; Oceania; West Indies. Thus the woods of Ethiopia are indexed AFRICA, *Ethiopia*, Woods of.

Under the heading *Anatomy* are listed the structural features and also references to anatomical *Description* of specific woods.

The term *Flora* as used in this index refers loosely to any botanical account that may be useful for taxonomic purposes. In some instances these may be additions to the known plants (mainly trees) and in others, descriptive accounts of the vegetation of a given geographical region.

The heading *Forestry* covers many different phases of this complex profession. *Forest Exploitation* includes logging and forest use.

The abbreviation *art.* refers to complete articles printed in *Tropical Woods* while *rev.* denotes that the reference was reviewed or abstracted in the issue noted.

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