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PROPERTIES AND USES OF TROPICAL WOODS, III

By FREDERICK F. WANGAARD and ARTHUR F. MUSCHLER

YALE SCHOOL OF FORESTRY

This report is the third of a series prepared under a research program that has been conducted at the Yale School of Forestry since 1947. In cooperation with the Office of Naval Research and the Bureau of Ships, United States Navy Department, this program was initiated to determine the basic properties of a selected group of woods from the American tropics as a first step in evaluating their adaptability to various specific uses.

Previous reports outlined the scope of the studies and described the test procedures that are being employed on this project.[1] These reports dealt with some fifty species and, for these, included results of tests to determine specific gravity, mechanical properties of unseasoned wood, shrinkage, decay resistance, and air-seasoning characteristics. Information relative to the source of the timber, its availability,

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[1]Properties and Uses of Tropical Woods, I. *Tropical Woods* 95: 1-145 (June 1, 1949).
Properties and Uses of Tropical Woods, II. *Tropical Woods* 97: 1-132 (November 1, 1950).

and general characteristics was also presented, together with an evaluation of each wood with respect to its present or potential utilization.

The principal purpose of this paper is to present the results of tests to determine the mechanical properties of the same woods in the air-dry condition. However, in a number of instances additional material has been made available since publication of the earlier reports, and as a consequence it has seemed desirable to incorporate in this report revised tables of the strength properties of the green wood, shrinkage, decay resistance, and air-seasoning characteristics. Results of other phases of the over-all project including studies of gluing, moisture absorption, weathering, and steam bending, most of which have been published separately, have also been included here as a part of the descriptions of individual species (1, 2, 3, 16). Only to this extent should this report be considered to summarize available information concerning the characteristics of these woods. In the main, and this is particularly true of the principal portion dealing with the properties and characteristics of individual species, this report is intended to supplement rather than to summarize the information presented in *Tropical Woods* Nos. 95 and 97.

The species covered by this report are listed in Table 1. In this table species are arranged alphabetically by generic name. The same arrangement is followed in the section entitled *Species Descriptions* which begins on page 37.

TABLE I. INDEX TO SPECIES COVERED IN THIS REPORT

Common Name	Scientific Name
Carabali	*Albizzia caribaea* (Urban) Britton and Rose
Espavé	*Anacardium excelsum* (Bert. and Balb.) Skeels
Brazilian Louro	*Aniba Duckei* Kosterm., *A.* cf. *riparia* (Nees) Mez, *Ocotea* sp.
Muirá-juba	*Apuleia molaris* Spruce
Mylady	*Aspidosperma cruentum* Woodson
Gonçalo Alves	*Astronium graveolens* Jacq.
Tatajuba	*Bagassa guianensis* Aubl.
Brazil Nut	*Bertholletia excelsa* Humb. & Bonpl.
Cedro Espino	*Bombacopsis quinata* (Jacq.) Dugand

Common Name	Scientific Name
Yellow Sanders	*Buchenavia capitata* (Vahl) Eich.
Andiroba	*Carapa guianensis* Aubl., *C. procera* DC.
Piquiá	*Caryocar villosum* (Aubl.) Pers.
Cedro Branco	*Cedrela Huberi* Ducke
Cedro Granadino	*Cedrela Tonduzii* C. DC.
Mora Amarillo	*Chlorophora tinctoria* (L.) Gaud.
Laurel Blanco	*Cordia alliodora* (R. & P.) Cham.
Candelera	*Cordia Collococca* L.
Almendro	*Coumarouna oleifera* (Benth.) Taub., *C. odorata* Aubl.
Tauary	*Couratari pulchra* Sandw.
Angélique	*Dicorynia paraensis* Benth.
Black Kakeralli	*Eschweilera Sagotiana* Miers
Possumwood	*Hura crepitans* L.
Courbaril	*Hymenaea courbaril* L., *H. Davisii* Sandw.
Hububalli	*Loxopterygium Sagotii* Hook. f.
Vaco	*Magnolia sororum* Seibert
Bulletwood	*Manilkara bidentata* (A. DC). Chev.
Angelino Aceituno	*Nectandra concinna* Nees
Determa	*Ocotea rubra* Mez
Ocote Pine	*Pinus oocarpa* Schiede
Chupón	*Pouteria carabobensis* Pittier
Cativo	*Prioria Copaifera* Gris.
Frijolillo	*Pseudosamanea guachapele* (H.B.K.) Harms
Sangre	*Pterocarpus vernalis* Pittier
Gronfoeloe	*Qualea albiflora* Warm.
Wiswiskwalie	*Qualea* sp.
Simaruba	*Simaruba amara* Aubl.
Mahogany	*Swietenia macrophylla* King
Primavera	*Tabebuia Donnell-Smithii* Rose
Guayacán	*Tabebuia guayacan* (Seem.) Hemsl., *T. heterotricha* (DC). Hemsl.
Roble Blanco	*Tabebuia pentaphylla* (L.) Hemsl.
Teak	*Tectona grandis* L. f.
Nargusta	*Terminalia amazonia* (Gmel.) Exell
Guayabo de Monte	*Terminalia guyanensis* Eichl.
Masa	*Tetragastris balsamifera* (Sw.) Kuntze
Rajate Bién	*Vitex Cooperi* Standl.
Fiddlewood	*Vitex Gaumeri* Greenm.
Flor Azul	*Vitex Kuylenii* Standl.
Quaruba	*Vochysia guianensis* Aubl., *V. hondurensis* Sprague

Mechanical Properties

Table 2 summarizes the mechanical properties of about fifty tropical American woods in both the green and air-dry

Species	Source	Condition	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	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[7]
			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
Almendro (*Coumarouna oleifera*)	Panama	Green	46.7	1.02	0.89	12,160	17,950	2,690	3.14	11.2	6,460	8,600	2,800	2200	2380	1970	1080	2060	480	255.1
(*Coumarouna odorata*)	Brazil	Air Dry[1]	11.6			18,040	25,840	3,120	6.12	21.6	10,440	13,660	3,260	2760	3400	2400	600*	2320	400*	
Greenheart[2] (*Ocotea Rodiaei*)	British Guiana	Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
		Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
Bulletwood (*Manilkara bidentata*)	British Guiana, Puerto Rico, Surinam	Green	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
		Air Dry[1]	13.2			15,030	27,280	3,450	3.76	28.5	8,050	11,640	3,360	2650	3190	2320*	1100	2500	330*	
Gonçalo Alves (*Astronium graveolens*)	Venezuela, Honduras	Green	46.2	0.94	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
		Air Dry[1]	13.4			11,320	16,620	2,230	3.34	10.4	7,800	10,320	2,620	2020	2160	2110	840*	1960	450	
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	Green	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
		Air Dry[1]	14.2			12,860	23,420	3,250	2.84	24.4	5,930*	11,210	3,750	2760	2780	1530*	860	2250	300*	
Guayacán (*Tabebuia guayacan*)	Honduras	Green	38.0	0.96	0.82	10,970	19,280	2,350	3.01	23.0	7,160	8,710	2,720	2540	2840	1910	1080	2180	500	314.6
(*Tabebuia heterotricha*)	Panama	Air Dry[1]	13.0			14,240	24,890	2,640	3.80	24.4	7,290	11,700	2,740	3200	3240	2280	680*	2490	390*	
Muirá-juba (*Apuleia molaris*)	Brazil	Green	55.0	0.86	0.76	9,800	15,360	2,180	2.50	13.4	6,100	7,330	2,480	1780	2060	1690	1180	1860	560	277.3
		Air Dry[1]	12.1			14,470	20,960	2,510	4.62	20.4	7,240	10,530	2,480	1880	2280	2040	1130*	1970	510*	
Piquiá (*Caryocar villosum*)	Brazil	Green	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	1640	430	150.5
		Air Dry[1]	13.8			10,990	17,060	2,160	3.07	15.8	5,140	8,410	2,260	1610	1720	1620*	780*	1990	380*	
Mylady (*Aspidosperma cruentum*)	British Honduras	Green	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
		Air Dry[1]	11.4			14,150	20,790	2,760	4.12	16.9	8,380	11,110	3,270	1950	1820	1320	460*	1700	260*	
Courbaril (*Hymenaea courbaril*)	Panama, Puerto Rico, Honduras, Surinam	Green	60.8	0.81	0.71	7,910	12,940	1,840	1.87	14.6	4,260	5,800	1,960	1780	1970	1640	1220	1770	540	230.5
		Air Dry[1]	12.6			11,900	19,400	2,160	3.72	17.6	6,500	9,510	2,240	2520	2350	1880	960*	2470	470*	
(*Hymenaea Davisii*)	British Guiana	Green	64.8	0.79	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
		Air Dry[1]	12.1			10,720	19,290	2,950	2.30	19.3	6,430	9,400	3,170	2070	1760	1230	860*	2130	390*	
Mora Amarilla (*Chlorophora tinctoria*)	Guatemala, Honduras, Venezuela	Green	64.7	0.77	0.71	9,320	14,840	1,590	3.45	14.4	4,860	6,860	1,690	2070	2190	1800	1030	1850	450	229.3
		Air Dry[1]	11.4			14,420	19,560	2,160	5.44	17.4	8,470	11,080	2,000	2600	2380*	1940	650*	1990	360*	
Chupón (*Pouteria carabobensis*)	Venezuela	Green	63.8	0.81	0.68	5,490	11,420	1,740	1.02	12.9	2,900	4,360	1,820	1470	1440	1200	1250	1480	580	230.4
		Air Dry[1]	11.1			8,400	17,770	2,320	1.74	22.1	4,800	7,660	2,230	1850	1800	1500	1000*	1880	430*	

Species	Source	Condition	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	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[7]
			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
Tatajuba (*Bagassa guianensis*)	Brazil	Green	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
		Air Dry[1]	12.0			13,900	20,050	2,580	4.18	14.4	9,670	11,560	2,850	2140	1730	1690	740	1940	290*	
Masa (*Tetragastris balsamifera*)	Puerto Rico	Green	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
		Air Dry[1]	11.2			10,650	16,090	1,890	3.40	13.3	5,490	8,380	2,300	2570	2150	1730	760*	1770	400*	
Carabali (*Albizzia caribaea*)	Venezuela	Green	78.3	0.73	0.66	5,820	11,210	1,560	1.26	8.4	3,420	4,830	1,670	1320	1370	1540	840	1500	400	197.0
		Air Dry[1]	12.3			9,070	14,480	1,800	2.57	13.5	4,360	7,220	1,980	1150*	1330*	1070*	780*	1710	380*	
Dogwood[3] (*Cornus florida*)	United States	Green	62	0.80	0.64	4,800	8,800	1,180	1.11	21.0	—	3,640	—	1410	1410	1030	—	1520	—	—
		Air Dry	12			9,200	14,900	1,530	3.10	19.5	—	7,700	—	2430	2150	1920	—	2260	—	
Shagbark Hickory[3] (*Carya ovata*)	United States	Green	60	0.78	0.64	5,900	11,000	1,570	1.28	23.7	3,430	4,580	—	—	—	1040	—	1520	—	—
		Air Dry	12			10,700	20,200	2,160	3.01	25.8	—	9,210	—	—	—	2170	—	2430	—	
Nargusta (*Terminalia amazonia*)	British Guiana, Panama, British Honduras	Green	67.3	0.73	0.64	7,710	12,130	2,010	1.70	12.2	4,440	5,530	2,230	1360	1320	1060	850	1440	400	187.1
		Air Dry[1]	12.9			11,310	17,750	2,300	3.16	16.4	6,950	9,540	2,520	1990	1610	1230	670*	1950	270*	
Brazilian Louro (*Aniba* cf. *riparia*) (*Ocotea* sp.) (*Aniba Duckei*)	Brazil	Green	54.6	0.71	0.62	9,960	13,250	2,170	2.60	9.7	5,680	6,560	2,550	1160	1160	1060	750	1420	430	175.8
		Air Dry[1]	13.5			11,760	19,030	2,570	3.12	18.0	7,910	10,010	2,600	1440	1470	1110	560*	1840	290*	
White Oak[3] (*Quercus alba*)	United States	Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
		Air Dry	12			8,200	15,200	1,780	2.27	14.8	4,760	7,440	—	1520	1360	1320	800	2000	450	
Angélique (*Dicorynia paraensis*)	Surinam	Green	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
		Air Dry[1]	11.8			11,610	17,390	2,190	3.32	15.2	6,810	8,770	2,490	1700	1290	1280	560*	1660	360	
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	Green	65.1	0.66	0.59	6,330	10,050	1,460	1.62	8.8	3,790	5,130	1,570	1350	1230	1070	800	1340	430	122.8
		Air Dry[1]	14.2			7,670	12,970	1,650	2.04	8.2	5,200	7,440	1,700	1830	1220*	1280	460*	1880	290*	
Brazil Nut (*Bertholletia excelsa*)	Brazil	Green	69.9	0.66	0.59	5,280	9,740	1,610	1.01	8.4	3,250	4,530	1,280	1000	940	850	680	1140	310	143.3
		Air Dry[1]	13.9			8,480	14,680	1,760	2.05	15.3	4,750	6,890	1,750	1330	1150	890	620*	1380	310*	
Teak[5] (*Tectona grandis*)	Burma	Green	52	0.62	0.58	7,250	11,380	1,580	1.89	10.0	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
		Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	
Sangre (*Pterocarpus vernalis*)	Venezuela	Green	62.0	0.65	0.57	5,600	9,580	1,580	1.13	8.9	3,040	4,140	1,820	1020	980	920	900	1220	460	220.5
		Air Dry[1]	11.4			9,060	16,020	2,000	2.41	19.9	5,140	7,390	1,890	1570	1330	1120	400*	1710	260*	

Species	Source	Condition	Moisture Content (per cent)	Specific Gravity: oven-dry vol.	Specific Gravity: green vol.	Static Bending: Fiber Stress at Proportional Limit (lb. per sq. in.)	Static Bending: Modulus of Rupture (lb. per sq. in.)	Static Bending: Modulus of Elasticity (1000 lb. per sq. in.)	Static Bending: Work to Proportional Limit (in.-lb. per cu. in.)	Static Bending: Work to Maximum Load (in.-lb. per cu. in.)
Guayabo de Monte (*Terminalia guyanensis*)	Venezuela	Green	73.6	0.62	0.57	5,780	9,400	1,330	1.44	7.8
		Air Dry[1]	10.5			8,110	12,690	1,570	2.36	9.7
Hard Maple[8] (*Acer saccharum*)	United States	Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
		Air Dry	12			9,500	15,800	1,830	2.76	16.5
Fiddlewood (*Vitex Gaumeri*)	British Honduras	Green	42.5	0.64	0.56	6,170	10,190	1,600	1.33	9.9
		Air Dry[1]	12.7			11,720	16,550	1,960	3.65	11.1
Angelino Aceituno (*Nectandra concinna*)	Venezuela	Green	88.0	0.63	0.56	5,830	10,440	1,540	1.26	10.4
		Air Dry[1]	12.9			9,580	14,230	1,650	3.12	12.4
Hububalli (*Loxopterygium Sagotii*)	British Guiana, Surinam	Green	98.0	0.62	0.56	5,740	9,380	1,680	1.19	7.6
		Air Dry[1]	12.4			9,900	13,660	1,750	3.18	10.6
Frijolillo (*Pseudo-samanea) guachapele)*	Honduras	Green	60.4	0.62	0.56	4,920	8,190	1,200	1.11	9.2
		Air Dry[1]	13.3			8,150	10,750	1,150*	1.92	6.0*
Teak (plantation-grown) (*Tectona grandis*)	Honduras	Green	72.3	0.59	0.56	6,160	9,940	1,350	1.59	10.9
		Air Dry[1]	12.6			8,430	13,310	1,390	2.92	10.3*
Yellow Birch[8] (*Betula lutea*)	United States	Green	67	0.66	0.55	4,200	8,300	1,500	0.70	16.1
		Air Dry[1]	12			10,100	16,600	2,010	2.89	20.8
White Ash[8] (*Fraxinus americana*)	United States	Green	42	0.64	0.55	5,100	9,600	1,460	1.04	16.6
		Air Dry	12			8,900	15,400	1,770	2.60	17.6
Ocote Pine (*Pinus oocarpa*)	Honduras	Green	40.5	0.61	0.55	5,060	7,970	1,740	0.84	6.9
		Air Dry[1]	13.5			10,010	14,870	2,250	2.47	10.9
Andiroba (*Carapa guianensis*) (*Carapa procera*)	Brazil / Surinam	Green	65.0	0.60	0.54	6,640	10,300	1,690	1.48	9.8
		Air Dry[1]	13.0			10,240	15,540	2,000	2.84	14.0
Rajate Bién (*Vitex Cooperi*) Flor Azul (*Vitex Kuylenii*)	Guatemala / Honduras	Green	98.8	0.60	0.53	5,860	9,420	1,490	1.18	7.2
		Air Dry[1]	13.8			8,720	12,890	1,570	2.56	9.0

TABLE 2—*Continued*

Species	Condition	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[7] (in.-lb. per specimen)
Guayabo de Monte	Green	3,000	4,240	1,380	1110	960	700	790	1230	340	102.3
	Air Dry[1]	4,250	6,730	1,570	1520	1070	1070	510*	1530	210*	
Hard Maple[8]	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	
Fiddlewood	Green	3,240	4,750	1,870	1180	1040	790	1140	1310	450	143.3
	Air Dry[1]	5,740	8,690	2,140	1700	1390	1100	470*	1700	320*	
Angelino Aceituno	Green	3,660	5,020	1,680	1020	930	710	1020	1460	430	122.6
	Air Dry[1]	4,720	7,260	1,880	1170	1060	1140	1070	1460	440	
Hububalli	Green	3,790	4,700	1,920	960	1040	880	660	1200	370	110.8
	Air Dry[1]	5,540	7,420	2,080	1020	1040	900	640	1430	340	
Frijolillo	Green	2,790	3,930	1,410	1060	1030	960	710	1270	310	130.3
	Air Dry[1]	4,880	6,570	1,790	1070	1040	970	660*	1430	290*	
Teak (plantation-grown)	Green	3,960	4,780	1,350	1140	1290	1290	940	1730	390	116.2
	Air Dry[1]	5,300	6,770	1,510	1140	1110*	1340	770*	1600	470*	
Yellow Birch[8]	Green	2,620	3,380	—	810	780	530	430	1110	270	—
	Air Dry[1]	6,130	8,170	—	1480	1260	1190	920	1880	520	
White Ash[8]	Green	3,190	3,990	—	1010	960	810	590	1380	330	—
	Air Dry	5,790	7,410	—	1720	1320	1410	940	1950	480	
Ocote Pine	Green	2,580	3,690	1,920	530	580	530	380	1040	220	119.9
	Air Dry[1]	5,590	7,680	2,210	1050	910	970	630	1720	340	
Andiroba	Green	4,040	4,780	1,720	940	880	730	560	1220	340	112.0
	Air Dry[1]	6,080	8,120	2,240	1500	1130	830	440*	1510	240*	
Rajate Bién / Flor Azul	Green	3,700	4,780	1,780	1050	1050	1180	650	1280	320	108.0
	Air Dry[1]	5,450	7,010	1,680*	1330	960*	990*	400*	1540	280*	

Species	Source	Condition	Moisture Content (per cent)	Specific Gravity (oven-dry vol.)	Specific Gravity (green vol.)	Static Bending: Fiber Stress at Proportional Limit (lb. per sq. in.)	Static Bending: Modulus of Rupture (lb. per sq. in.)	Static Bending: Modulus of Elasticity (1000 lb. per sq. in.)	Static Bending: Work to Proportional Limit (in.-lb. per cu. in.)	Static Bending: Work to Maximum Load (in.-lb. per cu. in.)
Determa (*Ocotea rubra*)	British Guiana, Surinam	Green	83.2	0.58	0.52	5,420	7,820	1,460	1.18	4.8
		Air Dry[1]	12.8			7,640	10,470	1,820	2.00	6.4
Roble Blanco (*Tabebuia pentaphylla*)	Honduras, Panama, British Honduras	Green	68.2	0.57	0.52	6,600	10,770	1,450	1.66	11.7
		Air Dry[1]	13.5			9,480	13,780	1,600	3.18	12.5
Black Walnut[3] (*Juglans nigra*)	United States	Green	81	0.56	0.51	5,400	9,500	1,420	1.16	14.6
		Air Dry	12			10,500	14,600	1,680	3.70	10.7
Tauary (*Couratari pulchra*)	Brazil, British Guiana	Green	68.8	0.56	0.50	5,390	9,240	1,730	0.94	8.3
		Air Dry[1]	13.4			9,680	13,520	1,800	2.88	12.2
Gronfoeloe (*Qualea albiflora*), Wiswiskwalie (*Qualea* sp.)	Surinam	Green	151.8	0.56	0.50	5,960	9,050	1,670	1.24	6.8
		Air Dry[1]	14.8			10,350	14,450	1,970	3.12	9.4
Vaco (*Magnolia sororum*)	Panama	Green	84.8	0.56	0.50	4,950	8,560	1,690	0.84	6.5
		Air Dry[1]	10.8			9,600	14,250	1,970	2.54	10.8
Candelera (*Cordia Collococca*)	Venezuela	Green	87.4	0.54	0.47	4,600	6,970	1,350	0.78	4.7
		Air Dry[1]	13.3			6,990	11,320	1,750	1.61	9.6
American Elm[3] (*Ulmus americana*)	United States	Green	89	0.55	0.46	3,900	7,200	1,110	0.81	11.8
		Air Dry	12			7,600	11,800	1,340	2.53	13.0
Mahogany[6] (*Swietenia macrophylla*)	Central America	Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
		Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5
Cedro Espino (*Bombacopsis quinata*)	Honduras, Panama	Green	116.7	0.50	0.45	4,780	7,560	1,260	1.11	8.8
		Air Dry[1]	12.5			6,980	10,490	1,400	1.95	9.2
Laurel Blanco (*Cordia alliodora*)	Honduras, Nicaragua, British Honduras, Panama	Green	104.4	0.48	0.44	5,710	9,050	1,280	1.50	9.6
		Air Dry[1]	12.3			8,170	12,180	1,510	2.73	9.8
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	Green	50.7	0.46	0.42	5,080	8,350	1,140	1.14	7.3
		Air Dry[1]	13.4			7,620	10,310	1,150	2.52	7.5

TABLE 2—Continued

Species	Condition	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[7] (in.-lb. per specimen)
Determa (*Ocotea rubra*)	Green	3,040	3,760	1,740	450	520	550	620	860	280	75.0
	Air Dry[1]	4,420	5,800	1,810	590	660	640	440*	980	220*	
Roble Blanco (*Tabebuia pentaphylla*)	Green	4,040	4,910	1,510	1030	910	790	790	1250	380	147.0
	Air Dry[1]	5,890	7,340	1,740	1310	960*	940	560*	1450	270*	
Black Walnut[3] (*Juglans nigra*)	Green	3,520	4,300	—	960	900	600	570	1220	360	—
	Air Dry	5,780	7,580	—	1050	1010	1250	690	1370	320	
Tauary (*Couratari pulchra*)	Green	3,390	4,260	2,000	840	740	560	660	1070	320	123.9
	Air Dry[1]	5,720	7,460	1,960*	1260	880	860	550*	1380	270	
Gronfoeloe (*Qualea albiflora*), Wiswiskwalie (*Qualea* sp.)	Green	3,820	4,790	1,940	820	740	680	660	1080	300	96.5
	Air Dry[1]	6,800	8,340	2,240	1440	910	740	340*	1520	270*	
Vaco (*Magnolia sororum*)	Green	2,610	3,590	2,060	880	860	740	860	1120	410	118.3
	Air Dry[1]	5,660	7,850	2,140	1580	1090	890	630*	1490	280*	
Candelera (*Cordia Collococca*)	Green	2,370	3,510	1,410	630	540	380	600	730	260	85.9
	Air Dry[1]	5,110	6,100	1,830	1100	810	900	420*	1320	280	
American Elm[3] (*Ulmus americana*)	Green	1,920	2,910	—	680	620	440	590	1000	—	—
	Air Dry	4,030	5,520	—	1110	830	850	660	1510	—	
Mahogany[6] (*Swietenia macrophylla*)	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	
Cedro Espino (*Bombacopsis quinata*)	Green	2,740	3,440	1,340	660	650	560	600	960	280	102.7
	Air Dry[1]	4,380	5,660	1,520	830	720	740	320*	1040	230*	
Laurel Blanco (*Cordia alliodora*)	Green	3,450	4,040	1,440	830	800	680	540	1140	270	138.1
	Air Dry[1]	5,040	6,330	1,580	1050	810	820	480*	1220	230*	
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Green	2,730	3,500	1,040	1160	1090	1090	750	1500	280	84.3
	Air Dry[1]	4,210	5,680	1,200	1000*	980*	1250	620*	1510	280	

Species	Source	Condition	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
			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.
Cedro Granadino (*Cedrela Tonduzii*)	Panama	Green	67.4	0.46	0.41	4,520	7,510	1,310	0.94	7.1
		Air Dry[1]	11.8			7,940	11,530	1,440	2.45	9.4
Espavé (*Anacardium excelsum*)	Panama, Venezuela	Green	109.0	0.44	0.41	3,250	5,320	1,060	0.62	4.1
		Air Dry[1]	11.0			5,640	7,960	1,280	1.44	5.6
Chestnut[3] (*Castanea dentata*)	United States	Green	122	0.45	0.40	3,100	5,600	930	0.59	7.0
		Air Dry	12			6,100	8,600	1,230	1.78	6.5
Cativo (*Prioria Copaifera*)	Panama	Green	81.2	0.44	0.40	3,240	5,920	940	0.57	5.4
		Air Dry[1]	10.9			6,070	8,560	1,110	1.85	7.2
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	Green	57.7	0.44	0.40	4,170	7,180	990	0.99	7.2
		Air Dry[1]	14.0			7,310	9,530	1,040	2.54	6.4*
Yellow Poplar[3] (*Liriodendron tulipifera*)	United States	Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
		Air Dry	12			6,100	9,200	1,500	1.43	6.8
Possumwood (*Hura crepitans*)	Venezuela, Panama, Surinam	Green	67.2	0.41	0.38	3,930	6,310	1,040	0.89	5.9
		Air Dry[1]	11.9			5,380	8,710	1,170	1.34	6.7
Cedro Branco (*Cedrela Huberi*)	Brazil	Green	83.8	0.41	0.38	4,020	6,730	1,170	0.80	7.4
		Air Dry[1]	16.4			7,300	11,300	1,420	2.08	12.5
Simaruba (*Simaruba amara*)	Surinam	Green	69.2	0.40	0.38	3,900	6,310	1,140	0.76	4.5
		Air Dry[1]	12.2			6,280	8,930	1,240	1.78	5.8
Quaruba (*Vochysia guianensis*) (*Vochysia hondurensis*)	Brazil, Surinam Nicaragua	Green	191.9	0.42	0.37	3,970	6,120	1,220	0.75	5.2
		Air Dry[1]	12.5			6,130	9,090	1,390	1.53	6.1
Butternut[3] (*Juglans cinerea*)	United States	Green	104	0.40	0.36	2,900	5,400	970	0.52	8.2
		Air Dry	12			5,700	8,100	1,180	1.59	8.2

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 4) applies.
[2]Kynoch and Norton (11).
[3]Forest Products Laboratory, Madison, Wisconsin.
[4]Value obtained for plank material received from the New York Naval Shipyard.

Species	Condition	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[7]
		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
Cedro Granadino	Green	2,770	3,370	1,330	650	550	600	430	990	260	106.2
	Air Dry	5,130	6,210	1,540	940	600	660	380*	1100	230*	
Espavé	Green	1,710	2,460	1,200	410	400	360	370	740	190	57.3
	Air Dry	3,580	4,530	1,370	600	470	510	320*	900	160*	
Chestnut	Green	2,080	2,470	—	530	420	380	440	800	240	—
	Air Dry	3,780	5,320	—	720	540	760	460	1080	250	
Cativo	Green	1,610	2,460	1,030	460	440	450	460	860	210	88.4
	Air Dry	2,930	4,290	1,070	830	630	520	420*	1060	220	
Primavera	Green	2,850	3,510	1,050	810	700	800	720	1030	320	74.8
	Air Dry	4,530	5,600	1,270	990	660*	880	440*	1390	240*	
Yellow Poplar	Green	1,930	2,420	—	390	340	330	450	740	220	—
	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	
Possumwood	Green	1,960	2,790	1,170	520	440	420	430	830	220	70.3
	Air Dry	3,300	4,800	1,290	790	550	630	350*	1080	220	
Cedro Branco	Green	2,220	3,100	1,340	460	450	390	450	790	260	82.2
	Air Dry	5,260	6,010	1,460	790	570	710	390*	1200	250*	
Simaruba	Green	2,340	2,970	1,240	510	390	380	560	790	230	65.8
	Air Dry	3,690	4,840	1,360	690	440	600	390*	1160	250	
Quaruba	Green	2,080	2,760	1,490	670	610	400	430	740	210	96.9
	Air Dry	4,700	5,840	1,550	630*	530*	530	350*	980	190*	
Butternut	Green	2,020	2,420	—	410	390	270	430	760	220	—
	Air Dry	4,200	5,110	—	570	490	570	440	1170	220	

[5]A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.
[6]Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.
[7]Toughness values are the average of tests of green and air-dry specimens ⅝ x ⅝ x 10 inches loaded on the tangential face over an 8-inch span.

conditions. Species are arranged in the table in order of decreasing specific gravity (green volume basis). Tests of air-dry wood were conducted at the moisture content shown in column 4 of the table, but in most instances the properties have been adjusted to correspond to a 12 percent moisture content using the equation method (12). Exceptions are noted with an asterisk as stated in a table footnote. A number of well-known domestic and foreign woods are included in Table 2 for comparison with these tropical American woods.

The values shown in Table 2 represent average strength values for each species. When material from more than one source was tested, the properties of the wood from each source are shown separately in the tables included in the section on *Species Descriptions*. The air-dry properties of individual species are also discussed in that section of the report.

A general relationship between most of the strength properties of these woods and specific gravity is indicated from trends of decreasing strength with decreasing specific gravity shown in Table 2. Figures 1 and 2, based upon data gathered in this study supplemented by strength values derived from earlier tests at the University of Michigan (11), clearly illustrate these trends for bending strength as measured by modulus of rupture. The plotted points represent average values for individual species of tropical American woods, whereas the curves are based upon data of the Forest Products Laboratory, Madison, Wisconsin for 168 domestic woods (12).

It is evident from Figure 1 that averages of the plotted points representing the bending strength of the tropical woods in the green condition lie above the curve for domestic woods throughout the entire range of specific gravity. Toward the upper limits of specific gravity the tropical wood trend line exceeds the domestic wood curve by about 25 percent.

Figure 2 shows the comparable relationship for air-dry wood. Improvement in the bending strength of tropical

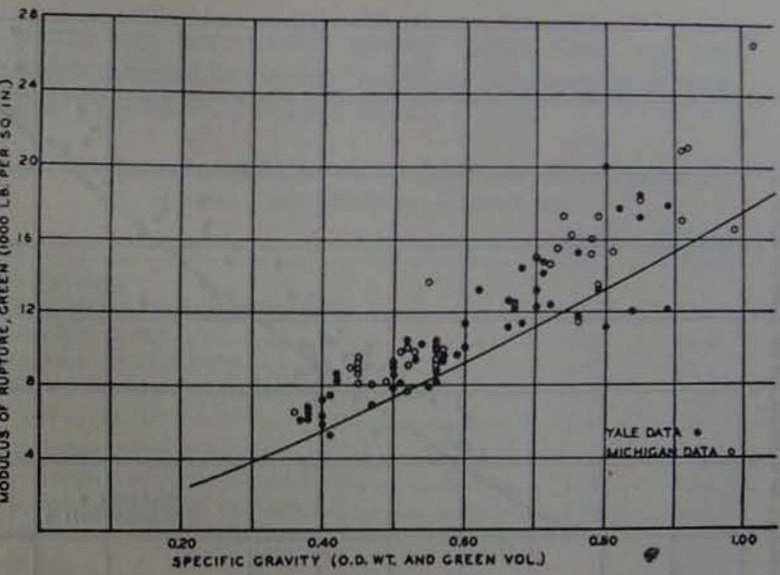

FIGURE 1

Relationship between modulus of rupture and specific gravity for unseasoned tropical woods compared with domestic woods. (Curve representing U. S. woods prepared from data of the Forest Products Laboratory.)

woods is indicated by comparison with Figure 1. In the air-dry condition, however, the superiority of the tropical woods over the domestic woods is no longer obvious and it appears that the curve derived for air-dry domestic woods is also reasonably applicable to the tropical woods.

Similar relationships may be shown for modulus of elasticity, crushing strength, and a number of other properties (17).

As a general rule tropical woods do not improve in strength upon seasoning to the same degree that is characteristic of domestic woods. Table 3 presents average ratios of air-dry to green strength properties for the tropical woods of this study in comparison with similar ratios for domestic hardwoods. With one exception, average ratios of air-dry to green properties as shown in the table are lower for these

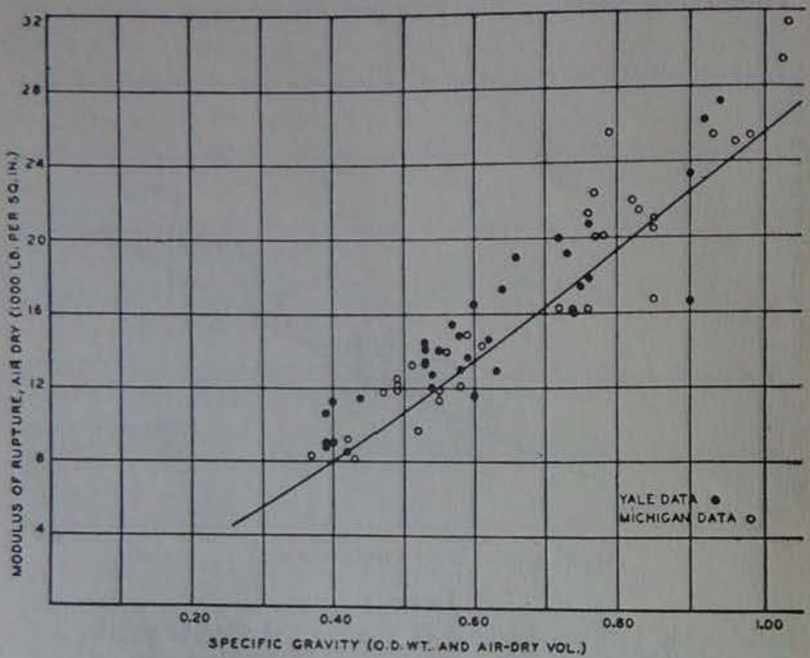

FIGURE 2

Relationship between modulus of rupture and specific gravity for air-dry tropical woods compared with domestic woods. (Curve representing U. S. woods prepared from data of the Forest Products Laboratory.)

tropical woods than for domestic hardwoods. Greatest improvement among the tropical wood properties is shown in elastic resilience in static bending and in maximum crushing strength, but these are properties in which even greater improvement upon drying is shown normally by domestic woods. The lowest ratios, actually less than unity, for tropical woods are in tensile strength across the grain and cleavage resistance. Domestic woods are also generally characterized by low ratios of air-dry to green strength in these properties although in the case of domestic woods the ratio for tensile strength, at least, exceeds unity. Upon drying, tropical woods show considerable improvement in compression both parallel and perpendicular to the grain, but these

properties are nevertheless among those which are least favorably affected by drying relative to the strength increases generally shown by domestic woods.

TABLE 3. RATIOS OF AIR-DRY TO GREEN STRENGTH PROPERTIES OF TROPICAL AND DOMESTIC HARDWOODS

Property	Tropical Woods	Domestic Hardwoods[1]
Static bending		
Fiber stress at proportional limit	1.52	1.80
Modulus of rupture	1.44	1.59
Modulus of elasticity	1.16	1.31
Work to proportional limit	1.98	2.49
Work to maximum load	1.42	1.05
Compression parallel to grain		
Fiber stress at proportional limit	1.58	1.74
Maximum crushing strength	1.63	1.95
Modulus of elasticity	1.13	—
Hardness		
End	1.36	1.55
Side	1.17	1.33
Compression perpendicular to grain	1.51	1.84
Tension perpendicular to grain	0.86	1.20
Shear	1.24	1.43
Cleavage	0.85	—

[1]U. S. Dept. Agr. Tech. Bul. 479 (12).

The only property of tropical woods that was more favorably affected by drying than its counterpart for domestic woods is work to maximum load, indicative of shock resistance. Most unseasoned tropical woods are relatively low in shock resistance when compared with domestic woods of equal weight. Hence the effect of drying is to raise them to a level more nearly comparable to domestic woods in this respect. The outstanding improvement shown by the tropical woods in shock resistance is apparently related to the fact that they show lower increases than domestic woods in stiffness and compressive strength. The effects of drying upon the properties of individual species are discussed under *Species Descriptions*.

Shrinkage

Shrinkage values for tropical woods are given in Table 4. These revised results summarize all shrinkage data collected on these woods in this study. Shown in the table are average values for radial, tangential, longitudinal, and volumetric shrinkage. Data for a number of well-known tropical and domestic woods are included in the table for comparison. It is apparent that the tropical woods generally exhibit lower shrinkage values than domestic woods of similar density.

Figure 3 shows the relationship between volumetric shrinkage and specific gravity for these tropical woods compared with domestic woods. The plotted points in the graph represent average shrinkage values for individual species of tropical woods, whereas the regression line represents the relationship established by the Forest Products Laboratory

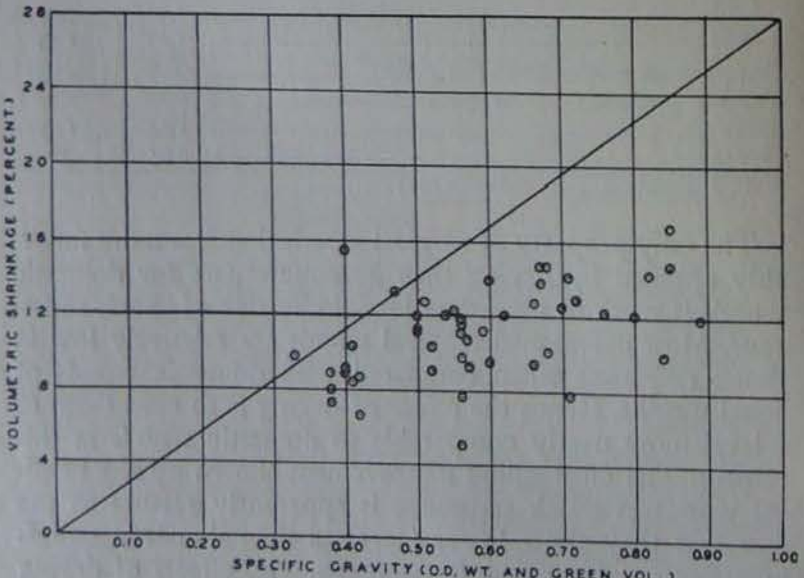

FIGURE 3

Relationship between volumetric shrinkage and specific gravity for tropical woods compared with domestic woods. (Curve representing U. S. woods prepared from data of the Forest Products Laboratory.)

TABLE 4. SHRINKAGE PROPERTIES OF TROPICAL AMERICAN WOODS[1]

Species	Source	No. of Logs[2]	Specific Gravity[3] green volume basis	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Almendro (*Coumarouna oleifera*) (*Coumarouna odorata*)	Panama, Brazil	4	0.89	5.0	7.6	0.13	12.0
Bulletwood (*Manilkara bidentata*)	British Guiana, Puerto Rico, Surinam	7	0.85	6.3	9.4	0.23	16.9
Gonçalo Alves (*Astronium graveolens*)	Venezuela, Honduras	4	0.84	4.0	7.6	0.43	10.0
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	0.82	4.9	10.5	0.34	14.4
Guayacán (*Tabebuia guayacan*) (*Tabebuia heterotricha*)	Panama, Honduras	6	0.82	6.2	8.6	0.18	13.5
Muirá-juba (*Apuleia molaris*)	Brazil	2	0.76	4.6	6.8	0.07	12.3
Piquiá (*Caryocar villosum*)	Brazil	3+[4]	0.72	5.0	8.0	0.20	13.0
Mylady (*Aspidosperma cruentum*)	British Honduras	3	0.71	5.2	8.7	0.18	14.3
Courbaril (*Hymenaea courbaril*)	Panama, Puerto Rico, Honduras, Surinam	9	0.71	4.5	8.5	0.27	12.7
(*Hymenaea Davisii*)	British Guiana	3	0.67	4.1	7.6	0.51	14.8
Mora Amarilla (*Chlorophora tinctoria*)	Guatemala, Honduras, Venezuela	4	0.71	3.4	5.4	0.41	7.8
Chupón (*Pouteria carabobensis*)	Venezuela	3	0.68	4.4	10.5	0.21	14.8
Tatajuba (*Bagassa guianensis*)	Brazil	2+[4]	0.68	5.2	6.6	0.09	10.2
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	0.67	4.4	8.5	0.18	13.9
Carabali (*Albizzia caribaea*)	Venezuela	3	0.66	4.2	6.5	0.17	9.5

TABLE 4—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3] green volume basis	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Shagbark Hickory[5] *(Carya ovata)*	United States		0.64	7.0	10.5	—	16.7
Nargusta *(Terminalia amazonia)*	British Guiana, Panama, British Honduras	9	0.64	4.8	7.9	0.18	12.7
Brazilian Louro *(Aniba cf. riparia)* *(Ocotea sp.)* *(Aniba Duckei)*	Brazil	3	0.62	4.6	7.0	0.36	12.1
White Oak[5] *(Quercus alba)*	United States		0.60	5.3	9.0	—	15.8
Angélique *(Dicorynia paraensis)*	Surinam	2	0.60	4.6	8.2	0.16	14.0
Yellow Sanders *(Buchenavia capitata)*	Puerto Rico	3	0.59	2.8	5.7	0.32	9.6
Brazil Nut *(Bertholletia excelsa)*	Brazil	2	0.59	3.9	8.3	0.26	11.2
Teak *(Tectona grandis)*							
Forest-grown	Burma[6]		0.58	2.3	4.2	—	6.8
Plantation-grown	Honduras	3	0.56	2.1	4.6	0.37	5.1
Sangre *(Pterocarpus vernalis)*	Venezuela	3	0.57	3.9	6.8	0.26	10.8
Guayabo de Monte *(Terminalia guyanensis)*	Venezuela	3	0.57	4.0	6.1	0.26	9.3
Hard Maple[5] *(Acer saccharum)*	United States		0.56	4.9	9.5	—	14.9
Fiddlewood *(Vitex Gaumeri)*	British Honduras	3	0.56	4.8	7.3	0.15	11.9
Angelino Aceituno *(Nectandra concinna)*	Venezuela	2	0.56	3.4	6.0	0.24	9.8
Hububalli *(Loxopterygium Sagotii)*	British Guiana, Surinam	4	0.56	3.4	7.2	0.34	11.1
Frijolillo *(Pseudosamanea guachapele)*	Honduras	3	0.56	2.9	4.5	0.37	7.6
Tauary *(Couratari pulchra)*	Brazil	2	0.56	4.1	7.3	0.21	11.3

TABLE 4—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3] green volume basis	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Ocote Pine *(Pinus oocarpa)*	Honduras	3	0.55	4.6	7.5	0.10	12.3
Andiroba *(Carapa guianensis)* *(Carapa procera)*	Brazil, Surinam	4	0.54	3.9	8.0	0.12	12.1
Rajate Bién *(Vitex Cooperi)* Flor Azul *(Vitex Kuylenii)*	Guatemala, Honduras	4	0.53	3.2	6.4	0.16	10.4
Determa *(Ocotea rubra)*	British Guiana, Surinam	5	0.52	3.7	7.7	0.27	10.4
Roble Blanco *(Tabebuia pentaphylla)*	Honduras, Panama, British Honduras	10	0.52	3.6	6.1	0.14	9.5
Black Walnut[5] *(Juglans nigra)*	United States		0.51	5.2	7.1	—	11.3
Gronfoeloe *(Qualea albiflora)* Wiswiskwalie *(Qualea sp.)*	Surinam	2	0.50	3.4	9.2	0.13	12.0
Vaco *(Magnolia sororum)*	Panama	3	0.50	3.6	7.0	0.23	11.2
Candelera *(Cordia Collococca)*	Venezuela	3	0.47	4.8	9.2	0.15	13.3
Mahogany *(Swietenia macrophylla)*							
Forest-grown	Central America[5]		0.45	3.5	4.8	—	7.7
Plantation-grown	Honduras	3	0.42	2.4	4.2	0.42	6.6
Cedro Espino *(Bombacopsis quinata)*	Honduras, Panama	6	0.45	3.5	6.1	0.20	10.1
Laurel Blanco *(Cordia alliodora)*	Honduras, Nicaragua, British Honduras, Panama	13	0.44	3.4	7.1	0.16	9.2
Cedro Granadino *(Cedrela Tonduzii)*	Panama	3	0.41	4.2	6.3	0.16	10.3

TABLE 4—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3] green volume basis	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Espavé (*Anacardium excelsum*)	Panama, Venezuela	6	0.41	2.8	5.2	0.36	8.4
Chestnut[5] (*Castanea dentata*)	United States		0.40	3.4	6.7	—	11.6
Cativo (*Prioria Copaifera*)	Panama	3	0.40	2.4	5.3	0.08	8.9
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	4	0.40	3.1	5.1	0.24	9.1
Quaruba (*Vochysia guianensis*)	Brazil, Surinam	2	0.40	4.8	8.2	0.07	15.4
(*Vochysia hondurensis*)	Nicaragua	3	0.33	2.0	8.0	0.17	9.8
Possumwood (*Hura crepitans*)	Venezuela, Panama, Surinam	7	0.38	2.7	4.5	0.48	7.3
Cedro Branco (*Cedrela Huberi*)	Brazil	2	0.38	3.9	5.9	0.16	8.9
Simaruba (*Simaruba amara*)	Surinam	2	0.38	2.3	5.0	0.27	8.0
Butternut[5] (*Juglans cinerea*)	United States		0.36	3.3	6.1	—	10.3

[1]Shrinkage values represent shrinkage from green to oven-dry conditions expressed as a percentage of the green dimension.
[2]Represents only logs used in shrinkage determinations.
[3]Based upon values for logs included in col. 3.
[4]Material tested included plank representing an unknown number of trees.
[5]Forest Products Laboratory, Madison, Wisconsin.
[6]Handbook of Empire Timbers (8).

from tests of a large number of domestic woods (13). With only one notable exception, *Vochysia guianensis*, the tropical woods are characterized by lower volumetric shrinkage than would be anticipated on the basis of the relationship for domestic woods. It seems probable that the abnormally high volumetric shrinkage shown by *Vochysia guianensis* in this study is associated with collapse which was observed in the drying of some of the material of this genus.

Shrinkage characteristics of individual species were discussed in previous reports, (7, 10) and only in those instances

where new data are presented here are these summarized under *Species Descriptions*.

Decay Resistance[1]

Results of decay resistance tests appear in Table 5. These results include and supersede those published previously (7, 10). As noted in previous reports these decay resistance tests are patterned after those conducted at the Forest Products Laboratory by Scheffer and Duncan (14). Percentage weight losses shown in the table were determined on small heartwood specimens after four months of exposure to attack by pure cultures of white-rot and brown-rot organisms.

Both average weight loss for all specimens of a species and maximum weight loss shown by an individual specimen are given, together with durability ratings based on these weight losses. Decay resistance of individual species is discussed under *Species Descriptions* in all cases where a change from previous ratings is indicated. In that discussion emphasis is placed upon the species rating based upon average weight loss, and, where variation is indicated, it is that associated with differences between trees rather than the variation within the heartwood of a single log.

Seasoning Characteristics[2]

Air-seasoning characteristics are presented in Table 6. The rating of seasoning defects is explained in table footnotes. Table 7 presents a classification of these woods based upon ease of seasoning. The results shown in these tables involve observation of considerably more material than was available at the time of the previous publications and supersede the ratings given in earlier reports (7, 10). The seasoning characteristics of individual species are briefly summarized under *Species Descriptions*.

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

[2]Seasoning studies were carried out under the direction of Professor Fred E. Dickinson.

TABLE 5. WEIGHT LOSS AND DECAY RESISTANCE OF TROPICAL AMERICAN WOODS IN PURE CULTURE TESTS

Species	Source	No. of Logs[2]	Specific Gravity[3]	White Rot[1]				Brown Rot[1]			
				Average		Maximum		Average		Maximum	
				Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Almendro											
(*Coumarouna odorata*)	Brazil	1	0.91	2.6	A	3.6	A	1.2	A	4.5	A
(*Coumarouna oleifera*)	Panama	3	0.87	7.6	A	39.7	C	1.1	A	10.5	B
Bulletwood (*Manilkara bidentata*)	British Guiana, Puerto Rico, Surinam	7	0.85	4.2	A	19.3	B	0.5	A	2.3	A
Gonçalo Alves (*Astronium graveolens*)	Venezuela, Honduras	4	0.84	3.3	A	5.1	A	2.2	A	3.5	A
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	0.82	1.8	A	7.9	A	0.5	A	1.7	A
Guayacán (*Tabebuia guayacan*) (*Tabebuia heterotricha*)	Honduras, Panama	6	0.82	1.1	A	3.1	A	0.8	A	5.8	A
Muirá-juba (*Apuleia molaris*)	Brazil	2	0.76	3.1	A	8.8	A	0.4	A	1.4	A
Piquiá (*Caryocar villosum*)	Brazil	3+[5]	0.72	2.6	A	6.5	A	3.2	A	7.7	A
Mylady (*Aspidosperma cruentum*)	British Guiana	3	0.71	2.0	A	4.2	A	1.9	A	5.7	A

TABLE 5—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3]	White Rot[1]				Brown Rot[1]			
				Average		Maximum		Average		Maximum	
				Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Courbaril (*Hymenaea courbaril*)	Panama, Puerto Rico, Honduras, Surinam	9	0.71	3.0	A	17.3	B	6.3	A	38.5	C
(*Hymenaea Davisii*)	British Guiana	3	0.67	20.6	B	59.8	D	11.3	B	52.1	D
Mora Amarilla (*Chlorophora tinctoria*)	Honduras, Guatemala Venezuela	6	0.71	1.7	A	3.7	A	1.1	A	4.0	A
Chupón (*Pouteria carabobensis*)	Venezuela	3	0.68	17.7	B	38.0	C	3.3	A	8.8	A
Tatajuba (*Bagassa guianensis*)	Brazil	2+[5]	0.68	1.9	A	3.6	A	1.9	A	3.7	A
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	0.67	7.1	A	38.9	C	11.1	B	54.3	D
Carabali (*Albizzia caribaea*)	Venezuela	2	0.65	19.3	B	49.0	D	2.9	A	6.5	A
Nargusta (*Terminalia amazonia*)	British Guiana, Panama, British Honduras	9	0.64	5.6	A	49.2	D	2.8	A	28.0	C
Brazilian Louro (*Aniba* cf. *riparia*) (*Ocotea* sp.) (*Aniba Duckei*)	Brazil	3	0.62	1.4	A	3.5	A	2.4	A	4.5	A

TABLE 5—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3]	White Rot[1] Average Weight Loss	White Rot[1] Average Resistance Class[4]	White Rot[1] Maximum Weight Loss	White Rot[1] Maximum Resistance Class[4]	Brown Rot[1] Average Weight Loss	Brown Rot[1] Average Resistance Class[4]	Brown Rot[1] Maximum Weight Loss	Brown Rot[1] Maximum Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Angélique *(Dicorynia paraensis)*	Surinam	2	0.60	10.8	B	42.4	C	16.2	B	48.2	D
Yellow Sanders *(Buchenavia capitata)*	Puerto Rico	3	0.59	1.4	A	2.8	A	1.4	A	4.7	A
Brazil Nut *(Bertholletia excelsa)*	Brazil	2	0.59	9.3	A	24.2	B	0.4	A	2.5	A
Teak *(Tectona grandis)*											
Forest-grown	Burma	1+[6]	0.57	0.2	A	0.7	A	0.7	A	1.3	A
Plantation-grown	Honduras	3	0.56	3.3	A	31.8	C	3.7	A	34.0	C
Sangre *(Pterocarpus vernalis)*	Venezuela	3	0.57	37.3	C	69.1	D	9.9	A	15.7	B
Guayabo de Monte *(Terminalia guyanensis)*	Venezuela	3	0.57	14.5	B	68.5	D	2.1	A	6.0	A
Fiddlewood *(Vitex Gaumeri)*	British Honduras	3	0.56	13.5	B	36.7	C	4.0	A	10.4	A
Angelino Aceituno *(Nectandra concinna)*	Venezuela	2	0.56	0.8	A	2.6	A	0.5	A	7.4	A
Hububalli *(Loxopterygium Sagotii)*	British Guiana, Surinam	4	0.56	11.5	B	43.3	C	3.8	A	49.7	D
Frijolillo *(Pseudosamanea guachapele)*	Honduras	3	0.56	7.9	A	36.9	C	4.2	A	22.2	B

TABLE 5—*Continued*

Species	Source	No. of Logs[2]	Specific Gravity[3]	White Rot[1] Average Weight Loss	White Rot[1] Average Resistance Class[4]	White Rot[1] Maximum Weight Loss	White Rot[1] Maximum Resistance Class[4]	Brown Rot[1] Average Weight Loss	Brown Rot[1] Average Resistance Class[4]	Brown Rot[1] Maximum Weight Loss	Brown Rot[1] Maximum Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Andiroba											
(Carapa guianensis)	Brazil	2	0.56	8.6	A	46.5	D	1.5	A	9.5	A
(Carapa procera)	Surinam	2	0.53	54.0	D	65.7	D	36.2	C	57.0	D
Ocote Pine *(Pinus oocarpa)*	Honduras	3	0.55	4.6	A	10.1	A	33.0	C	49.8	D
Rajate Bién *(Vitex Cooperi)* Flor Azul *(Vitex Kuylenii)*	Guatemala, Honduras	4	0.53	4.3	A	12.0	B	3.0	A	7.3	A
Determa *(Ocotea rubra)*	British Guiana, Surinam	5	0.52	10.7	B	32.4	C	15.0	B	58.3	D
Roble Blanco *(Tabebuia pentaphylla)*	Honduras, Panama, British Honduras	10	0.52	30.1	C	70.7	D	5.8	A	21.5	B
Tauary *(Couratari pulchra)*	Brazil, British Guiana	3	0.50	16.6	B	50.9	D	9.4	A	45.9	D
Gronfoeloe *(Qualea albiflora)* Wiswiskwalie *(Qualea sp.)*	Surinam	2	0.50	1.1	A	2.8	A	39.5	C	51.0	D
Vaco *(Magnolia sororum)*	Panama	3	0.50	5.8	A	24.3	B	1.4	A	14.4	B

TABLE 5—*Continued*

				White Rot[1]				Brown Rot[1]			
				Average		Maximum		Average		Maximum	
Species	Source	No. of Logs[2]	Specific Gravity[3]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Candelera *(Cordia Collococca)*	Venezuela	3	0.47	13.4	B	69.9	D	2.9	A	9.4	A
Mahogany *(Swietenia macrophylla)*											
Forest-grown	Central America	1+[6]	0.46	22.6	B	41.0	C	0.2	A	1.2	A
Plantation-grown	Honduras	3	0.42	9.4	A	37.5	C	0.2	A	1.7	A
Cedro Espino *(Bombacopsis quinata)*	Honduras, Panama	9	0.45	11.0	B	77.2	D	2.9	A	35.2	C
Laurel Blanco *(Cordia alliodora)*	Honduras, Nicaragua, British Honduras, Panama	13	0.44	6.1	A	77.6	D	0.6	A	6.1	A
Espavé *(Anacardium excelsum)*	Panama	2	0.42	15.0	B	43.0	C	12.8	B	44.3	C
Cedro Granadino *(Cedrela Tonduzii)*	Panama	3	0.41	37.5	C	63.2	D	28.7	C	48.4	D
Cativo *(Prioria Copifera)*[7]	Panama	3	0.40	40.0	C	66.6	D	21.0	B	50.9	D
Primavera *(Tabebuia Donnell-Smithii)*	Honduras	3	0.40	10.0	A	42.1	C	6.5	A	31.3	C
Possumwood *(Hura crepitans)*	Venezuela, Panama, Surinam	7	0.38	23.3	B	62.6	D	20.0	B	52.2	D

TABLE 5—*Continued*

				White Rot[1]				Brown Rot[1]			
				Average		Maximum		Average		Maximum	
Species	Source	No. of Logs[2]	Specific Gravity[3]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]	Weight Loss	Resistance Class[4]
			green vol. basis	percent		percent		percent		percent	
Cedro Branco *(Cedrela Huberi)*	Brazil	2	0.38	24.6	C	52.8	D	21.7	B	49.6	D
Simaruba *(Simaruba amara)*	Surinam	2	0.38	28.3	C	67.9	D	18.5	B	41.9	C
Quaruba *(Vochysia guianensis)*	Brazil, Surinam	2	0.40	8.5	A	33.2	C	41.5	C	59.5	D
(Vochysia hondurensis)	Nicaragua	3	0.33	25.1	C	58.4	D	38.7	C	61.5	D

[1]White rot—*Polyporus versicolor* (No. 720); Brown rot—*Poria monticola* (Madison No. 698, Davidson's No. 106).
[2]Represents only logs used in determining decay resistance.
[3]Based upon values for logs included in col. 3.
[4]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; non-durable.
[5]Material tested included plank representing an unknown number of trees.
[6]Plank material tested as control represented an unknown number of trees.
[7]The heartwood of this species was very small and the decay specimens included material taken from the sapwood.

TABLE 6. AIR-SEASONING CHARACTERISTICS OF TROPICAL AMERICAN WOODS

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Almendro (*Coumarouna oleifera*) (*Coumarouna odorata*)	Panama, Brazil	4	0.89	Fast	A-C	A	A	B	B	A-B
Bulletwood (*Manilkara bidentata*)	Puerto Rico, British Guiana, Surinam	5	0.85	Fast to Slow	B	A	B	B-D	B-D	A-C
Guayacán (*Tabebuia guayacan*)	Honduras	3	0.85	Fast to Moderate	B	B	A	A-C	B-D	A-D
(*Tabebuia heterotricha*)	Panama	3	0.80	Fast	B	A	A	B	B	B
Gonçalo Alves (*Astronium graveolens*)	Venezuela, Honduras	4	0.84	Fast to Moderate	C	—	B	B	B	A
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	0.82	Moderate	B	A	A	B	A	A
Muirá-juba (*Apuleia molaris*)	Brazil	2	0.76	Fast to Moderate	B	A	B	B	B	A
Mora Amarilla (*Chlorophora tinctoria*)	Guatemala, Venezuela	3	0.75	Fast to Moderate	B	A	A	B	B	A
Piquiá (*Caryocar villosum*)	Brazil	2	0.74	Slow	B	—	B	B	B	B
Courbaril (*Hymenaea courbaril*)	Panama, Puerto Rico Honduras, Surinam	8	0.72	Fast to Moderate	B	B	B	B	B	B
(*Hymenaea Davisii*)	British Guiana	3	0.67	Moderate	B	A	B	B	C	A

TABLE 6—*Continued*

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Mylady (*Aspidosperma cruentum*)	British Honduras	3	0.71	Fast	B	A	A	B	B	A
Chupón (*Pouteria carabobensis*)	Venezuela	3	0.68	Fast	A-C	A	A	A-D	A-C	A
Tatajuba (*Bagassa guianensis*)	Brazil	1	0.67	Moderate	B	A	B	A	A	A
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	0.67	Moderate	B	A	A	C	C	A
Carabali (*Albizzia caribaea*)	Venezuela	3	0.66	Fast to Moderate	C	A	A	A-C	B	A
Nargusta (*Terminalia amazonia*)	British Guiana, Panama, British Honduras	9	0.64	Fast to Moderate	B	A	B	B-D	B-D	A
Brazilian Louro (*Aniba* cf. *riparia*) (*Ocotea* sp.) (*Aniba Duckei*)	Brazil	3	0.62	Moderate	A	A	A	B	B	A
Angélique (*Dicorynia paraensis*)	Surinam	2	0.60	Fast	B	A	B	A-C	C	A
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	3	0.59	Fast	B	A	A	B	B	A

TABLE 6—*Continued*

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Brazil Nut (*Bertholletia excelsa*)	Brazil	2	0.59	Fast to Moderate	B	A	A	B	B	B
Sangre (*Pterocarpus vernalis*)	Venezuela	3	0.57	Fast	C	A	A	B	B	B
Guayabo de Monte (*Terminalia guyanensis*)	Venezuela	3	0.57	Fast	B	A	A	B	B	A
Fiddlewood (*Vitex Gaumeri*)	British Honduras	3	0.56	Fast to Slow	B	A	A	B	C	A
Angelino Aceituno (*Nectandra concinna*)	Venezuela	2	0.56	Fast to Moderate	A-C	A	A	B	B	A
Hububalli (*Loxopterygium Sagotii*)	British Guiana, Surinam	4	0.56	Fast to Moderate	B	A	B	B-D	A-D	A
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	0.56	Moderate	A-C	A	A	B	B	A
Teak (plantation-grown) (*Tectona grandis*)	Honduras	3	0.56	Fast	A	A	A	A	A	A
Andiroba (*Carapa guianensis*)	Brazil	2	0.56	Moderate	B	A	A	B	B	A
(*Carapa procera*)	Surinam	2	0.53	Fast to Slow	B	A	A	A-D	A-C	A

TABLE 6—*Continued*

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Ocote Pine (*Pinus oocarpa*)	Honduras	3	0.55	Fast to Moderate	B	A	B	B	B	A
Rajate Bién (*Vitex Cooperi*) / Flor Azul (*Vitex Kuylenii*)	Guatemala / Honduras	4	0.53	Fast to Slow	A-B	A	A-B	B-D	B-D	A
Determa (*Ocotea rubra*)	British Guiana, Surinam	5	0.52	Moderate	C	A	B	B	B	B
Roble Blanco (*Tabebuia pentaphylla*)	Honduras, Panama British Honduras	9	0.51	Fast	B	B	A	B	B	A
Tauary (*Couratari pulchra*)	Brazil, British Guiana	3	0.50	Moderate	B	A	A	C	B	A
Gronfoeloe (*Qualea albiflora*) / Wiswiskwalie (*Qualea* sp.)	Surinam	2	0.50	Moderate	B	B	B	B	A	A
Vaco (*Magnolia sororum*)	Panama	3	0.50	Fast	B	A	A	A	B	A
Candelera (*Cordia Collococca*)	Venezuela	3	0.47	Fast	B	A	B	B	B	A

TABLE 6—*Continued*

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Cedro Espino (*Bombacopsis quinata*)	Honduras, Panama	6	0.45	Fast to Slow	B	A	A	B	B	A
Laurel Blanco (*Cordia alliodora*)	Honduras, Nicaragua, British Honduras, Panama	13	0.44	Fast	B	B	B	B	B	A
Mahogany (plantation-grown) (*Swietenia macrophylla*)	Honduras	3	0.42	Fast	B	A	A	A	A	A
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	0.41	Fast	A	A	A	A	A	A
Espavé (*Anacardium excelsum*)	Panama, Venezuela	6	0.41	Fast to Slow	C	A	A	B	B	A
Cativo (*Prioria Copaifera*)	Panama	3	0.40	Fast	B	A	A	A	A	A
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	3	0.40	Fast	B	A	B	A	A	A
Possumwood (*Hura crepitans*)	Venezuela, Panama, Surinam	7	0.38	Fast	A-D	A	B	B	B	A

TABLE 6—*Continued*

Species	Source	No. of Logs[1]	Specific Gravity[2] green volume basis	Rate of Drying[3]	Warp[4] Crook and Bow	Warp[4] Cup	Warp[4] Twist	Checking and Splitting[4] End	Checking and Splitting[4] Surface	Case-hardening[5]
Cedro Branco (*Cedrela Huberi*)	Brazil	2	0.38	Fast to Moderate	A	A	A	A	B	A
Simaruba (*Simaruba amara*)	Surinam	2	0.38	Fast	A	A	A	B	A	A
Quaruba (*Vochysia guianensis*) (*Vochysia hondurensis*)	Brazil, Surinam, Nicaragua	5	0.37	Fast to Slow	B	B	B-C	A-B	B	A-B

[1]Represents only logs used in seasoning studies.
[2]Based upon values for logs included in col. 3.
[3]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 percent moisture content.
Slow: Over 200 days from green condition to 16 percent moisture content.
[4]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.
[5]Casehardening:
None (A) — none observed.
Slight (B) — slight stress.
Severe (C) — fully casehardened.

TABLE 7. CLASSIFICATION OF TROPICAL AMERICAN WOODS AS TO THEIR EASE OF SEASONING

Group I

(Easy to season)

Species	Specific Gravity green volume basis
Almendro (*Coumarouna oleifera, C. odorata*)	0.89
Guayacán (*Tabebuia heterotricha*)	0.80
Muirá-juba (*Apuleia molaris*)	0.76
Mora Amarilla (*Chlorophora tinctoria*)	0.75
Mylady (*Aspidosperma cruentum*)	0.71
Yellow Sanders (*Buchenavia capitata*)	0.59
Brazil Nut (*Bertholletia excelsa*)	0.59
Sangre (*Pterocarpus vernalis*)	0.57
Guayabo de Monte (*Terminalia guyanensis*)	0.57
Angelino Aceituno (*Nectandra concinna*)	0.56
Teak (plantation-grown) (*Tectona grandis*)	0.56
Ocote Pine (*Pinus oocarpa*)	0.55
Roble Blanco (*Tabebuia pentaphylla*)	0.51
Vaco (*Magnolia sororum*)	0.50
Candelera (*Cordia Collococca*)	0.47
Shortleaf Pine (*Pinus echinata*)	**0.46**
Laurel Blanco (*Cordia alliodora*)	0.44
Mahogany (plantation-grown) (*Swietenia macrophylla*)	0.42
Cedro Granadino (*Cedrela Tonduzii*)	0.41
Cativo (*Prioria Copaifera*)	0.40
Primavera (*Tabebuia Donnell-Smithii*)	0.40
Cedro Branco (*Cedrela Huberi*)	0.38
Simaruba (*Simaruba amara*)	0.38
Yellow Poplar (*Liriodendron tulipifera*)	**0.38**

Group II

(Moderately difficult to season)

Species	Specific Gravity green volume basis
Guayacán (*Tabebuia guayacan*)	0.85
Conçalo Alves (*Astronium graveolens*)	0.84
Black Kakeralli (*Eschweilera Sagotiana*)	0.82
Courbaril (*Hymenaea courbaril, H. Davisii*)	0.70
Chupón (*Pouteria carabobensis*)	0.68
Tatajuba (*Bagassa guianensis*)	0.67
Masa (*Tetragastris balsamifera*)	0.67
Carabali (*Albizzia caribaea*)	0.66
Nargusta (*Terminalia amazonia*)	0.64
Brazilian Louro (*Aniba* cf. *riparia, A. Duckei, Ocotea* sp.)	0.62
Angélique (*Dicorynia paraensis*)	0.60

TABLE 7—*Continued*

Group II—*Continued*

(Moderately difficult to season)

Species	Specific Gravity green volume basis
Fiddlewood (*Vitex Gaumeri*)	0.56
Hububalli (*Loxopterygium Sagotii*)	0.56
Frijolillo (*Pseudosamanea guachapele*)	0.56
Andiroba (*Carapa guianensis*)	0.56
Rajate Bien (*Vitex Cooperi*)	
Flor Azul (*Vitex Kuylenii*)	0.53
Determa (*Ocotea rubra*)	0.52
Walnut (*Juglans nigra*)	**0.51**
Tauary (*Couratari pulchra*)	0.50
Gronfoeloe (*Qualea albiflora*)	
Wiswiskwalie (Qualea sp.)	0.50
Paper Birch (*Betula papyrifera*)	**0.48**
Cedro Espino (*Bombacopsis quinata*)	0.45
Espavé (*Anacardium excelsum*)	0.41
Possumwood (*Hura crepitans*)	0.38
Quaruba (*Vochysia guianensis, V. hondurensis*)	0.37

Group III

(Difficult to season)

Species	Specific Gravity green volume basis
Bulletwood (*Manilkara bidentata*)	0.85
Piquiá (*Caryocar villosum*)	0.74
White Oak (*Quercus alba*)	**0.60**
Andiroba (*Carapa procera*)	0.53

Species Descriptions

Previous reports in this series have included under this heading detailed descriptions of each species (7, 10). Included in those descriptions were discussions of the tree–its size, form, and occurrence–and of the characteristics, properties, and uses of its wood. In this report the discussion presented in this section is intended to supplement that information with the results of subsequent tests. The reader is referred to the pertinent earlier report for further details including a more complete bibliography concerning the properties and uses of the individual species.

CARABALI *Albizzia caribaea* (Urban) Britton & Rose
Occurrence: In the monsoon forests of Venezuela.

The tree and wood of Carabali were described in a previous publication which included a discussion of the properties and potential uses of the wood.[1] The mechanical properties of the air-dry wood have been subsequently determined and are presented in the accompanying table together with green properties for comparison.

The air-dry strength properties of Carabali are considerably below those of Shagbark Hickory. Insofar as comparable data are available, Carabali most nearly approaches Hickory in stress at proportional limit in static bending, stiffness, and crushing strength. It is only about two-thirds as strong as Hickory in maximum bending strength and shear, and has only about half the shock resistance of Hickory. A more nearly equal comparison may be made with White Oak. Carabali and Oak are much alike in all static-bending properties including work to maximum load, and also in compression parallel to the grain, side hardness, and tension across the grain. White Oak exceeds Carabali in end hardness, compression across the grain, and shear.

Upon air drying, Carabali increased moderately in static-bending properties, compression parallel to grain, and shear, but either showed no improvement or actually lost strength in such properties as hardness, compression and tension across the gain, and cleavage. Only in work to maximum load (indicative of shock resistance) did improvement upon air drying exceed that shown generally by domestic hardwoods. Particularly unusual was the reduction in compressive strength across the grain which accompanied drying and amounted to 30 percent.

As previously reported, Carabali is moderately difficult to season. The wood generally seasons rapidly but in so doing it is subject to moderate end checking and slight surface checking. A moderate amount of warp was also observed.

[1] *Tropical Woods* 97: 27-30.

Species	Source	No. of Logs	Condition	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.
Carabali (*Albizzia caribaea*)	Venezuela	3	Green	78.3	0.73	0.66	5,820	11,210	1,560	1.26	8.4
			Air Dry[1]	12.3			9,070	14,480	1,800	2.57	13.5
Shagbark Hickory[2] (*Carya ovata*)	United States		Green	60	0.78	0.64	5,900	11,000	1,570	1.28	23.7
			Air Dry	12			10,700	20,200	2,160	3.01	25.8

Species	Condition	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
Carabali (*Albizzia caribaea*) Venezuela	Green	3,420	4,830	1,670	1320	1370	1540	840	1500	400	197.0
	Air-Dry[1]	4,360	7,220	1,980	1150*	1330*	1070*	780*	1710	380*	
Shagbark Hickory[2] (*Carya ovata*) United States	Green	3,430	4,580	—	—	—	1040	—	1520	—	—
	Air Dry	—	9,210	—	—	—	2170	—	2430	—	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

If air seasoned at a slower rate, most of these defects could undoubtedly be avoided.

Additional data obtained from durability tests verify the high rating previously given to Carabali heartwood in resistance to a brown-rot fungus. Subsequent tests using a white-rot fungus indicate considerable variability although, on the average, the wood may be considered durable in this respect. The wood weathers well showing very little checking upon outdoor exposure without paint protection.

Carabali is rated only fair in steam-bending quality based upon strength loss and appearance.

Potential uses for this wood appear to be unaltered from those suggested in the previous report (10).

ESPAVÉ *Anacardium excelsum* (Bert. & Balb.) Skeels

Other common names: Caracolí, Marañón, Mijao, Espavel, and Wild Cashew.

Occurrence: Costa Rica south through Panama to Colombia, Venezuela, and Ecuador.

The tree and wood of Espavé were described in a previous publication which included a discussion of the properties and uses of the wood.[1] Subsequent tests to determine the strength properties of the air-dry wood yielded the results presented in the accompanying table. The properties of the green wood are included for comparison.

In the air-dry condition Espavé is inferior to the slightly denser Mahogany in all mechanical properties, the most significant differences in these woods occurring in static-bending strength, elastic resilience, maximum crushing strength, hardness, and compression across the grain. Espavé is also surpassed in most properties by Yellow Poplar of nearly comparable density. The differences between these woods are rather small but favorable to Yellow Poplar except in hardness where Espavé enjoys a slight advantage.

[1] *Tropical Woods* 97: 31-35.

Upon air drying, Espavé improved considerably in most strength properties, but only in work to maximum load and proportional limit stress in compression parallel to the grain did the increase exceed that shown generally by domestic hardwoods. Among other properties greatest proportionate improvement was shown in elastic resilience, followed by maximum crushing strength, proportional limit stress and maximum stress in static bending, end hardness, compression across the grain, shear, stiffness, and side hardness. Both cleavage resistance and tensile strength across the grain decreased measurably upon air drying.

Espavé is rated moderately difficult to dry on the basis of completed air-seasoning studies. A variable rate of drying was observed, the material that dried rapidly showing moderate warp and a slight tendency to check. These defects could doubtless be minimized through slower drying.

Decay resistance tests now completed for the species show the heartwood to be durable upon exposure to both white-rot and brown-rot fungi.

The wood weathers well, showing only slight surface checking upon exposure in the unpainted condition. The heartwood absorbs moisture very readily.

No change in the uses recommended previously for Espavé is indicated on the basis of these data (10).

BRAZILIAN LOURO *Aniba Duckei* Kosterm.
Ocotea sp.
Aniba cf. *riparia* (Nees) Mez

Other common names: Louro Rosa, Louro Faia, and Pau Rosa.

Occurrence: Amazon region of Brazil.

This group of species characterized by similar woods was described in an earlier report which included a discussion of the properties and potential uses of the wood.[1] The strength properties of the air-dry wood have been determined in

[1] *Tropical Woods* 97: 35-40.

Species	Source	No. of Logs	Condition	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.
Espavé (*Anacardium excelsum*)	Panama	3	Green	117.7	0.47	0.43	3,170	5,320	1,060	0.55	4.6
			Air Dry[1]	12.2			6,030	8,420	1,320	1.57	6.3
	Venezuela	3	Green	100.4	0.42	0.39	3,330	5,310	1,050	0.69	3.6
			Air Dry[1]	9.9			5,240	7,490	1,230	1.31	4.9
	Average	6	Green	109.0	0.44	0.41	3,250	5,320	1,060	0.62	4.1
			Air Dry[1]	11.0			5,640	7,960	1,280	1.44	5.6
Mahogany[2] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5
Yellow Poplar[3] (*Liriodendron tulipifera*)	United States		Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
			Air Dry	12			6,100	9,200	1,500	1.43	6.8

Species	Condition	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
Espavé (*Anacardium excelsum*)											
Panama	Green	1,700	2,410	1,280	370	410	400	340	730	180	69.4
	Air Dry[1]	3,840	4,740	1,410	550	500	580	310*	880	170*	
Venezuela	Green	1,720	2,510	1,110	450	380	310	400	750	200	45.2
	Air Dry[1]	3,330	4,320	1,330	640	440	440	320*	930	150*	
Average	Green	1,710	2,460	1,200	410	400	360	370	740	190	57.3
	Air Dry[1]	3,580	4,530	1,370	600	470	510	320*	900	160*	
Mahogany[2] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	
Yellow Poplar[3] (*Liriodendron tulipifera*) United States	Green	1,930	2,420	—	390	340	330	450	740	220	—
	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.
[3] U. S. Dept. Agr. Tech. Bul. 479 (12).

Species	Source	No. of Logs	Condition	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.
Pau Rosa	Brazil	1	Green	61.0	0.72	0.63	9,300	12,560	2,180	2.22	10.0
(Aniba Duckei)			Air Dry[1]	13.5			12,270	18,970	2,390	3.25	16.6
Louro Rosa											
(Aniba cf.	Brazil	1	Green	50.5	0.71	0.62	10,340	14,360	2,280	2.63	10.5
riparia)			Air Dry[1]	13.9			11,650	19,590	2,540	2.97	20.2
Louro Faia	Brazil	1	Green	52.2	0.71	0.62	10,250	12,840	2,040	2.95	8.6
(Ocotea sp.)			Air Dry[1]	13.2			11,360	18,540	2,780	3.13	17.1
	Average	3	Green	54.6	0.71	0.62	9,960	13,250	2,170	2.60	9.7
			Air Dry[1]	13.5			11,760	19,030	2,570	3.12	18.0
White Oak[2]	United		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
(Quercus alba)	States		Air Dry	12			8,200	15,200	1,780	2.27	14.8
Teak[3]											
(Tectona	Burma		Green	52.0	0.62	0.58	7,250	11,380	1,580	1.89	10.0
grandis)			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	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
Pau Rosa											
(Aniba Duckei)	Green	5,470	6,460	2,690	1160	1090	970	900	1520	430	155.0
Brazil	Air Dry[1]	7,770	9,810	2,650	1340	1480	1110	530*	1800	240*	
Louro Rosa											
(Aniba cf. riparia)	Green	6,440	7,220	2,640	1250	1280	1140	780	1380	490	212.7
Brazil	Air Dry[1]	8,330	10,520	2,560	1600	1560	1190	740*	1930	380*	
Louro Faia											
(Ocotea sp.)	Green	5,130	6,000	2,320	1060	1130	1080	570	1360	380	159.8
Brazil	Air Dry[1]	7,630	9,710	2,580	1370	1380	1040	400*	1780	250*	
Average	Green	5,680	6,560	2,550	1160	1160	1060	750	1420	430	175.8
	Air Dry[1]	7,910	10,010	2,600	1440	1470	1110	560*	1840	290*	
White Oak[2]											
(Quercus alba)	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
United States	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Teak[3]											
(Tectona grandis)	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
Burma	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.
[4]Value obtained for plank material received from the New York Naval Shipyard.

subsequent tests and are presented in the accompanying table. Included for comparison are strength data for the green wood.

Based on average air-dry properties these species of Brazilian Louro exceed White Oak of like density in all strength properties except end hardness, compression and tension across the grain, shear, and cleavage resistance. In this comparison with Oak, Brazilian Louro is outstanding in its stiffness, crushing strength, bending strength, and elastic resilience. Its shock resistance is also distinctly greater than that of White Oak. Brazilian Louro is much stronger than Teak in all static-bending and compression parallel to grain properties, hardness, shear, and toughness. Brazilian Louro is comparable to Teak in compression across the grain, but Teak is clearly superior in tension across the grain and cleavage resistance.

Upon air drying, the wood improved moderately in most strength properties. Only in work to maximum load was the increase greater than that generally shown by domestic hardwoods. Greatest proportionate increase among other properties occurred in maximum crushing strength, modulus of rupture, stress at proportional limit in compression parallel to the grain, shear, hardness, elastic resilience, and compression perpendicular to the grain. Strength in tension across the grain and cleavage resistance decreased considerably upon air drying.

As reported previously, the wood is considered moderately difficult to season, drying at a moderate rate during the air-seasoning studies. Seasoning defects were limited to slight checking.

Brazilian Louro heartwood is highly resistant to moisture absorption and is comparable to Teak in this respect. The wood is rated excellent in weathering characteristics based upon the results of exposure in the unpainted condition.

The information presented here does not alter the uses proposed for Brazilian Louro in a previous report (10).

MUIRÁ-JUBA *Apuleia molaris* Spruce

Other common names: Amarelão, Muiratanã, Muiraruira, Cumararana, and Pau Mulato.

Occurrence: In the Amazon valley of South America.

The tree and wood of Muirá-juba were described in a previous publication which included a discussion of the properties and uses of the wood.[1] In later tests to determine the mechanical properties of the air-dry wood, the values shown in the accompanying table were determined. Green strength properties are included for comparison.

As in the case of its green strength properties, the air-dry properties of *Apuleia molaris* exceed those of most well known domestic woods. Air-dry Muirá-juba is surpassed by Greenheart in all properties except compression across the grain, tension across the grain, shear, and elastic resilience. The woods are nearly identical in shock resistance. Muirá-juba is only slightly below Greenheart in crushing strength and moderately so in bending strength, although its stiffness is only two-thirds that of Greenheart.

With the exception of work to maximum load (indicative of shock resistance), air-drying effected only a moderate increase in most of the properties of *Apuleia molaris*. Only in shock resistance was the proportionate increase greater than that characteristic of domestic hardwoods. The greatest proportionate increase among other properties occurred in elastic resilience, followed by proportional limit stress in static bending, maximum crushing strength, modulus of rupture, compression across the grain, stiffness, hardness, and shear. Tension across the grain and cleavage resistance decreased slightly upon drying.

A further comparison of Muirá-juba is made with White Oak *(Quercus alba)* in the following tabulation. Relative air-dry values are shown taking the value for Oak as 100.

[1] *Tropical Woods* 97: 40-43.

Species	Source	No. of Logs	Condition	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.
Muirá-juba (*Apuleia molaris*)	Brazil	2	Green	55.0	0.86	0.76	9,800	15,360	2,180	2.50	13.4
			Air Dry[1]	12.1			14,470	20,960	2,510	4.62	20.4
Greenheart[2] (*Ocotea Rodiaei*)	British Guiana	2	Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
			Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Muirá-juba (*Apuleia molaris*) Brazil	Green	6,100	7,330	2,480	1780	2060	1690	1180	1860	560	277.3
	Air Dry[1]	7,240	10,530	2,480	1880	2280	2040	1130*	1970	510*	
Greenheart[2] (*Ocotea Rodiaei*) British Guiana	Green	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
	Air Dry[1]	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]**Value obtained for plank material received from the New York Naval Shipyard.**

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
121	138	141	138	142

Side hardness	Shear	Bearing strength	Cleavage resistance
168	98	155	113

It is evident that Muirá-juba surpasses White Oak on a weight for weight basis in all of the above properties except shear and cleavage resistance.

On the basis of completed air-seasoning studies the wood is considered easy to season. Drying was fast to moderate with only minor checking and warping.

Additional durability data substantiate earlier results indicating high resistance to attack by both white-rot and brown-rot fungi. Muirá-juba displays excellent weathering characteristics with a minimum development of surface checks upon exposure to the weather without paint protection.

No changes are indicated in the potential uses for this wood as given in a previous report (10).

MYLADY *Aspidosperma cruentum* Woodson

Other common names: Colorado, Volador, Canamito, Chaperno, and Alcarreto.

Occurrence: Mexico and Central America.

Descriptions of the tree and wood of Mylady, together with a discussion of the properties and uses of the wood, were presented in an earlier publication.[1] Testing of air-dry material has now been completed and results of these tests are shown together with green strength data in the accompanying table.

In the air-dry condition, Mylady is superior to Persimmon in all static-bending properties and in compression parallel to the grain. In contrast, Mylady is exceeded by Persimmon in shear, hardness, cleavage, and in both tension and com-

[1]*Tropical Woods* 95: 33-37.

pression across the grain. Mylady is also surpassed by White Oak in shear, cleavage, and tension across the grain, but is equivalent to White Oak in compression across the grain.

Upon air drying, Mylady increased moderately in most of its strength properties but only in work to maximum load did this increase exceed that generally associated with the drying of domestic woods. Greatest improvement occured in elastic resilience followed by crushing strength, bending strength, hardness, compression across the grain, and shear. In tension across the grain and in cleavage air-dry strength is substantially less than that in the green condition.

In the following tabulation the relative air-dry properties of Mylady are shown in comparison with White Oak for which a value of 100 is taken.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
118	137	155	114	150

Side hardness	Shear	Bearing strength	Cleavage resistance
134	85	100	58

Mylady appears to be a relatively easy wood to air season. Drying was uniformly rapid. Seasoning defects were limited to slight checking and slight warp. This is somewhat at variance with earlier observations made on a limited amount of material in which checking appeared to be more prevalent.

Final results of decay resistance tests of the heartwood of *Aspidosperma cruentum* support earlier data showing that the wood is very durable in resistance to both white-rot and brown-rot fungi. The wood is rated only fair in resistance to weathering in the unpainted condition, chiefly on the basis of surface checking.

The wood of Mylady does not appear to be adapted to steam bending.

No changes in the proposed uses of the wood as given in a previous report appear to be warranted on the basis of the additional information presented here (7).

Species	Source	No. of Logs	Condition	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.
Mylady (*Aspidosperma cruentum*)	British Honduras	3	Green	57.2	0.82	0.71	9,070	14,100	2,500	1.83	8.9
			Air Dry[1]	11.4			14,150	20,790	2,760	4.12	16.9
Persimmon[2] (*Diospyros virginiana*)	United States		Green	58	0.78	0.64	5,600	10,000	1,370	1.35	13.0
			Air Dry	12			10,900	17,700	2,010	3.49	15.4
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Mylady (*Aspidosperma cruentum*) British Hondruas	Green	5,360	6,650	2,840	1500	1470	1100	760	1500	420	152.8
	Air Dry[1]	8,380	11,110	3,270	1950	1820	1320	460*	1700	260*	
Persimmon[2] (*Diospyros virginiana*) United States	Green	3,160	4,170	—	1240	1280	1110	770	1470	410	—
	Air Dry	6,390	9,170	—	2520	2300	2460	1200	2160	590	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]Value obtained for plank material received from the New York Naval Shipyard.

GONÇALO ALVES *Astronium graveolens* Jacq.

Other common names: Ciruelillo, Gateado, Ronrón, Gusanero, Zebrawood.

Occurrence: Common in upland forests from Mexico, through Central America, to northern South America.

Descriptions of the tree and wood of Gonçalo Alves as well as a discussion of the properties and uses of the wood have been presented in a previous publication.[1] Results of air-dry testing are now available and these results, together with green strength data, are presented in the acompanying table.

Air-dry strengths of Gonçalo Alves from Honduras and Venezuela are in generally good agreement on the basis of tests reported here. Both, however, are considerably below those determined from a single Venezuelan log for which data are available for comparison as shown in the table.

On the basis of the results of Yale tests, Gonçalo Alves is generally weaker than most woods of comparable high density. It is, however, superior to domestic Dogwood in static-bending strength, crushing strength, and stiffness in the air-dry condition. It is approximately comparable to Dogwood in side hardness and compression across the grain and slightly below Dogwood in shear strength, but possesses only half the shock resistance of the latter.

Upon air drying, Gonçalo Alves increased only moderately in most mechanical properties. In only one property—work to maximum load—did the increase in strength exceed that generally shown by domestic hardwoods, and strength in tension across the grain decreased as a result of drying. Other properties, particularly compression across the grain, proportional limit stress in static bending, hardness, crushing strength, and shear, improved considerably less than anticipated on the basis of domestic wood behavior.

Completion of the air-seasoning study shows Gonçalo Alves to be moderately difficult to season. Moderate crook

[1] *Tropical Woods* 95: 37-41.

or bow was accompanied by a slight tendency to twist. Checking was slight and, as in the case of twist, most pronounced in the material from Honduras represented by a single log. Drying was fast to moderate in rate.

Previously unreported results of decay resistance tests conducted as a part of the present study show the heartwood of Gonçalo Alves to be very durable in resistance to both white-rot and brown-rot organisms. These results substantiate the reputed high durability of this species.

These results indicate no substantial change from the proposed uses for the wood as given previously (7).

TATAJUBA *Bagassa guianensis* Aubl.

Other common names: Bagasse, Gele Bagasse.

Occurrence: The Guianas, Surinam, and the lower Amazon region.

The tree and wood of Tatajuba were described in a previous publication that included a discussion of the properties and uses of the wood.[1] Subsequent tests have yielded the data on air-dry strength properties given in the accompanying table. Strength properties of the green wood are included for comparison.

Air-dry strength of Tatajuba compares favorably with that of Shagbark Hickory in all static-bending properties except work to maximum load. In the latter property which measures shock resistance, Hickory is nearly twice as strong as Tatajuba. *Bagassa guianensis* is much higher than Hickory in crushing strength but is surpassed by Hickory in compression across the grain and shear. Tatajuba exceeds White Oak by a considerable margin in all properties except work to maximum load (shock resistance), shear, tension across the grain, and cleavage resistance. Of these, only cleavage resistance is appreciably deficient.

Upon air drying, Tatajuba increased moderately in most strength properties but only in shock resistance did this

[1] *Tropical Woods* 95: 41-45.

Species	Source	No. of Logs	Condition	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.
Gonçalo Alves (*Astronium graveolens*)	Venezuela	3	Green	43.2	0.97	0.87	9,340	12,650	1,850	2.66	8.0
			Air Dry[1]	13.6			12,640	17,530	2,100	4.27	10.8
	Honduras	1	Green	49.2	0.92	0.81	7,680	11,640	2,040	1.90	5.4
			Air Dry[1]	13.2			10,000	15,700	2,360	2.41	9.9
	Average	4	Green	46.2	0.94	0.84	8,510	12,140	1,940	2.28	6.7
			Air Dry[1]	13.4			11,320	16,620	2,230	3.34	10.4
	Venezuela[2]	1	Green	32.5	1.11	0.99	11,200	16,500	2,580	2.75	15.4
			Air Dry[1]	13.2			15,800*	29,600*	3,300*	4.22*	19.5*
Dogwood[3] (*Cornus florida*)	United States		Green	62	0.80	0.64	4,800	8,800	1,180	1.11	21.0
			Air Dry	12			9,200	14,900	1,530	3.10	19.5

Species	Condition	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
Gonçalo Alves (*Astronium graveolens*) Venezuela	Green	5,000	7,170	1,990	1850	2090	2140	1150	1920	530	127.4
	Air Dry[1]	8,170	10,800	2,350	2130	2300	2300	970*	2160	510*	
Honduras	Green	4,230	6,000	2,470	1430	1730	1530	840	1610	320	150.6
	Air Dry[1]	7,420	9,830	2,890	1910	2020	1920	720*	1760	390	
Average	Green	4,620	6,580	2,230	1640	1910	1840	1000	1760	420	139.0
	Air Dry[1]	7,800	10,320	2,620	2020	2160	2110	840*	1960	450	
Venezuela[2]	Green	8,660	9,500	2,870	1690	2100	2490	940	1770	450	—
	Air Dry[1]	10,180*	13,060*	3,370*	2630*	2570*	3200*	—	1910*	—	
Dogwood[3] (*Cornus florida*) United States	Green	—	3,640	—	1410	1410	1030	—	1520	—	—
	Air Dry	—	7,700	—	2430	2150	1920	—	2260	—	—

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).

improvement exceed that shown generally by domestic hardwoods. Among other properties the greatest proportionate increase occurred in compressive strength properties parallel to the grain, followed by elastic resilience, compression across the grain, bending strength, end hardness, shear, tension across the grain, stiffness, and side hardness. Cleavage resistance decreased appreciably upon air drying.

As previously reported, the wood air seasons at a moderate rate and primarily for that reason is classified as moderately difficult to season. Completed studies of a limited quantity of material indicate that the wood dries free of checking and with only a slight tendency to warp.

Previously unreported durability data from this study show the heartwood of *Bagassa guianensis* to be very durable in resistance to white-rot and brown-rot fungi. Tatajuba is moderately resistant to deterioration by marine borers. In tests conducted at Harbor Island, North Carolina, small specimens of *Bagassa guianensis* showed no evidence of marine-borer activity after 10 months of exposure. However, after 15 months, fairly heavy attack, principally by teredo, was noted, and the wood appears to be comparable to Teak in this respect. Under similar conditions of exposure a number of domestic woods including Southern Pine, Douglas Fir, White Oak, and Red Oak were heavily attacked within six months (4, 5).

Weathering characteristics are poor, chiefly as a result of the prevalence of checking which develops upon exposure of the wood without the protection of paint. It appears desirable, on the basis of these results, to exclude boat decking from the list of potential uses of this species that was presented previously (7).

Species	Source	No. of Logs	Condition	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.
Tatajuba (*Bagassa guianensis*)	Brazil	2+[2]	Green	58.0	0.76	0.68	10,340	14,510	2,300	2.84	11.3
			Air Dry[1]	12.0			13,900	20,050	2,580	4.18	14.4
Shagbark Hickory[3] (*Carya ovata*)	United States		Green	60	0.78	0.64	5,900	11,000	1,570	1.28	23.7
			Air Dry	12			10,700	20,200	2,160	3.01	25.8
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Tatajuba (*Bagassa guianensis*) Brazil	Green	6,060	7,900	2,510	1620	1670	1200	650	1670	370	195.5
	Air Dry[1]	9,670	11,560	2,850	2140	1730	1690	740	1940	290*	
Shagbark Hickory[3] (*Carya ovata*) United States	Green	3,430	4,580	—	—	—	1040	—	1520	—	—
	Air Dry	—	9,210	—	—	—	2170	—	2430	—	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.

[2] Based upon tests of one log and a shipment of plank material representing an unknown number of trees.

[3] U. S. Dept. Agr. Tech. Bul. 479 (12).

[4] Value obtained for plank material received from the New York Naval Shipyard.

BRAZIL NUT *Bertholletia excelsa* Humb. and Bonpl.

Other common names: Castanha Verdadeira, Castanha do Pará, Tucary, Nhá, Juvia, Yuvia, and Totoka.

Occurrence: Common throughout the Amazon region of Brazil, Venezuela (on the upper Orinoco and Rio Negro), Colombia, and Peru.

The tree and wood of Brazil Nut were described in an earlier publication which also included a discussion of the properties and uses of the wood.[1] The properties of the air-dry wood have subsequently been determined and are presented, together with green strength values for comparison, in the accompanying table.

When air dry, the wood of Brazil Nut is approximately equivalent to that of White Oak in static-bending properties and compression parallel to the grain. In shock resistance, measured by toughness and work to maximum load in bending, these woods are also nearly equal. Brazil Nut is distinctly surpassed by Oak in hardness, compression across the grain, shear, tension across the grain, and cleavage. *Bertholletia excelsa* may also be compared with Teak. These woods compare closely in bending strength, stiffness, hardness, shear, and cleavage resistance. Brazil Nut is markedly superior to Teak in shock resistance, but is slightly lower than Teak in compressive strength parallel to the grain and considerably below Teak in compression and tension across the grain.

Upon air drying, Brazil Nut improved markedly in most properties but only in work to maximum load was the increase greater than that commonly shown by domestic hardwoods. Among other properties the greatest proportionate increase was shown in elastic resilience, followed by proportional limit stress in bending, modulus of rupture, compression parallel to the grain, hardness, shear, stiffness, and compression perpendicular to the grain. Cleavage was unaffected by drying, and tensile strength across the grain decreased slightly.

[1] *Tropical Woods* 97: 43-46.

Species	Source	No. of Logs	Condition	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.
Brazil Nut											
(Bertholletia	Brazil	2	Green	69.9	0.66	0.59	5,280	9,740	1,610	1.01	8.4
excelsa)			Air Dry[1]	13.9			8,480	14,680	1,760	2.05	15.3
White Oak[2]	United		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
(Quercus alba)	States		Air Dry	12			8,200	15,200	1,780	2.27	14.8
Teak[4]											
(Tectona	Burma		Green	52	0.62	0.58	7,250	11,380	1,580	1.89	10.0
grandis)			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	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
Brazil Nut											
(Bertholletia excelsa)	Green	3,250	4,530	1,280	1000	940	850	680	1140	310	143.3
Brazil	Air Dry[1]	4,750	6,890	1,750	1330	1150	890	620*	1380	310*	
White Oak[2]											
(Quercus alba)	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
United States	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Teak[4]											
(Tectona grandis)	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
Burma	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] Value obtained for plank material received from the New York Naval Shipyard.
[4] A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.

Brazil Nut is easy to air season. Earlier results, supplemented by observations on additional material, indicate fast to moderate rates of drying with only slight checking. Warp was slight and a minimum of casehardening occurred.

Durability studies now completed indicate that the heartwood is very durable to durable in resistance to a white-rot fungus and very durable upon exposure to a brown-rot organism. The wood displays good weathering characteristics retaining a relatively smooth surface with only a slight amount of checking upon exposure in the unpainted condition.

Brazil Nut is rated as a good steam-bending wood on the basis of retention of strength and appearance.

On the basis of information now available, it appears that consideration may well be given to the possibilities of Brazil Nut for boat and ship decking and for steam-bending applications in addition to the uses discussed in a previous report (10).

CEDRO ESPINO *Bombacopsis quinata* (Jacq.) Dugand

Other common names: Pochote, Tolú, and Saqui-saqui.

Occurrence: Western Nicaragua through Costa Rica and Panama to Colombia and Venezuela.

The tree and wood of Cedro Espino were described in an earlier publication which also included a discussion of the properties and uses of the wood.[1] Subsequent tests have been conducted to determine the green strength properties of Cedro Espino from Panama. The results shown in the accompanying table reveal considerable variation in the density and mechanical properties of this wood. The Panama material was lighter and generally weaker than the wood previously tested which originated in Honduras, and consequently the species average values given here are, in the main, lower than those presented previously. With the exception of elastic resilience, work to maximum load, and

[1] *Tropical Woods* 95: 45-49.

toughness, Cedro Espino is somewhat weaker than Central American Mahogany of the same density. Average values for *Bombacopsis quinata* exceed published values for the closely related *Bombacopsis sepium* from Venezuela.

Air-dry strength values for Cedro Espino are now available and are also shown in the table. As in the green condition, the air-dry wood of Cedro Espino is somewhat weaker than Mahogany in most respects. Greatest differences are indicated in compression and tension across the grain. Cedro Espino is slightly higher than Mahogany in shock resistance.

Upon air drying, Cedro Espino improved moderately in most properties. In no respect was this improvement equal to that shown by most domestic hardwoods. Greatest relative increase was shown in elastic resilience followed by compressive strength parallel to the grain, static-bending strength, compression across the grain, hardness, stiffness, shear, and work to maximum load. Tension across the grain and cleavage resistance decreased substantially upon air drying.

Completed air-seasoning studies modify somewhat the results presented in an earlier report. Material from Panama exhibited a variable rate of drying, and the species is considered moderately difficult to dry. Defect appeared identical for material from Honduras and Panama and was limited to slight checking and slight warp. Cedro Espino has a reputation for air seasoning very slowly with a minimum of checking and splitting, although the wood is reported to have been successfully kiln dried with a reasonably short drying schedule.

Radial and tangential shrinkage values for material from Panama are lower than those reported earlier for material from Honduras. New average values for the species are consequently revised downward. In each case, results are based on studies of three logs. Values for material from Panama agree closely with shrinkage values for a related species (*B. sepium*) as reported by Kynoch and Norton. Results are presented in the following table:

Species	Source	No. of Logs	Condition	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	Green	86.0	0.58	0.51	4,650	8,060	1,380	0.95	7.8
			Air Dry[1]	9.5			8,410	12,160	1,550	2.49	10.5
	Panama	3	Green	147.4	0.41	0.39	4,910	7,060	1,130	1.26	9.7
			Air Dry[1]	15.4			5,550	8,820	1,250	1.40	7.9*
	Average	6	Green	116.7	0.50	0.45	4,780	7,560	1,260	1.11	8.8
			Air Dry[1]	12.5			6,980	10,490	1,400	1.95	9.2
(Bombacopsis sepium)[2]	Venezuela	1	Green	204.2	0.39	0.36	4,300	6,500	1,070	0.98	6.7
			Air Dry[1]	14.1			—	—	—	—	—
Mahogany[3] *(Swietenia macrophylla)*	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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 Espino *(Bombacopsis quinata)*											
Honduras	Green	2,790	3,690	1,520	840	790	660	760	1110	340	127.9
	Air Dry[1]	4,750	6,620	1,780	1190	930	840	380*	1320	240*	
Panama	Green	2,680	3,190	1,170	470	510	460	450	820	220	77.4
	Air Dry[1]	4,020	4,700	1,270	470	500*	640	260*	770*	220*	
Average	Green	2,740	3,440	1,340	660	650	560	600	960	280	102.7
	Air Dry[1]	4,380	5,660	1,520	830	720	740	320*	1040	230*	
(Bombacopsis sepium)[2]											
Venezuela	Green	2,710	2,930	1,220	660	600	1000	490	760	230	—
	Air Dry[1]	3,000*	4,010*	1,210*	360*	400*	550*	—	—	—	
Mahogany[3] *(Swietenia macrophylla)*											
Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

Species and Source	Shrinkage (percent) Radial	Tangential	Longitudinal	Volumetric
Cedro Espino				
(Bombacopsis quinata)				
Honduras	4.1	7.6	0.10	12.8
Panama	2.8	4.7	0.30	7.3
Average	3.4	6.2	0.20	10.0
(Bombacopsis sepium)[1]				
Venezuela	3.0	4.4	—	6.4

[1] Kynoch and Norton (11).

As noted in an earlier report, the heartwood of Cedro Espino is variable in resistance to a white-rot fungus. When earlier results were supplemented by the addition of material from Panama, the wood was given an average rating of durable in its resistance to a white-rot organism and was found to be very durable in resistance to a brown-rot fungus.

Cedro Espino is rated only fair in resistance to weathering. When exposed to the weather in an unpainted condition, surface smoothness is lost rather quickly and a considerable amount of checking occurs.

The wood does not appear to be adapted to steam bending.

No change in the previously published list of proposed uses is indicated (7).

YELLOW SANDERS *Buchenavia capitata* (Vahl) Eichl.

Other common names: Granadillo, Bois Gris-gris, Olivier, Almendro, Amarillo Boj and Periquiteira.

Occurrence: In the West Indies and northern South America. Closely related species are found in the Amazon Valley of Brazil.

The tree and wood of Yellow Sanders were described in an earlier publication which also included a discussion of the properties and uses of the wood.[1] Subsequent tests have yielded the air-dry mechanical properties that are presented in the accompanying table. Green strength data are also shown for comparison.

[1] *Tropical Woods* 95: 49-52.

Species	Source	No. of Logs	Condition	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.
Yellow Sanders (*Buchenavia capitata*)	Puerto Rico	3	Green	65.1	0.66	0.59	6,330	10,050	1,460	1.62	8.8
			Air Dry[1]	14.2			7,670	12,970	1,650	2.04	8.2*
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	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
Yellow Sanders (*Buchenavia capitata*) Puerto Rico	Green	3,790	5,130	1,570	1350	1230	1070	800	1340	430	122.8
	Air Dry[1]	5,200	7,440	1,700	1830	1220*	1280	460*	1880	290*	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	—

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] Value obtained for plank material received from the New York Naval Shipyard.

In the air-dry condition, the strength properties of Yellow Sanders are generally below those of White Oak and Hard Maple. Only in compression parallel to the grain and end hardness does Yellow Sanders equal or exceed Oak. Differences between these woods are particularly pronounced in work to maximum load (shock resistance), tension across the grain, and cleavage resistance. Yellow Sanders compares closely with Teak in static-bending and compression parallel to grain properties when air dry. It surpasses Teak by a wide margin in end hardness, toughness, and shearing strength, and by a slight margin in side hardness and compression perpendicular to the grain. Yellow Sanders is distinctly below Teak in tension across the grain and cleavage resistance.

Air drying effected relatively slight increases in most of the properties of Yellow Sanders, although very substantial decreases occurred in tension perpendicular to the grain and cleavage resistance. In no property was the increase associated with drying as great as that generally found among domestic hardwoods. Greatest proportionate increase occurred in compressive properties parallel to the grain and shear, followed by end hardness, modulus of rupture, elastic resilience, compression across the grain, and stiffness. Side hardness remained virtually unchanged and work to maximum load decreased slightly upon air drying.

Completed air-seasoning studies of Yellow Sanders indicate no change from the conclusions drawn in an earlier phase of the study. The wood proved to be easy to air season, drying at a rapid rate with only slight checking and little warping.

The wood weathers well. Unpainted material exposed to the weather without paint protection retained surface smoothness, remained free from warp, and developed only slight surface checking.

Yellow Sanders heartwood is relatively high in resistance to moisture absorption and is comparable to White Oak in this respect. The wood is rated as fair in its steam-bending

characteristics on the basis of strength retention and appearance.

The foregoing results indicate no change in the potential uses for this species as previously listed (7).

ANDIROBA

Carapa guianensis Aubl.
Carapa procera DC.

Other common names: Crabwood, Krappa, Najesi, Carapa, Figueroa, Tangaré, and Cedro Macho.

Occurrence: British Honduras through Central America and northern South America and in the West Indies.

The tree and wood of Andiroba were described in an earlier publication that included a discussion of the properties and uses of the wood.[1] The mechanical properties of the air-dry wood have been determined subsequently and are presented in the accompanying table which includes strength data in the green condition for comparison. As in the case of the properties of the unseasoned wood, air-dry properties of Andiroba as given here are applicable only to timber from the Amazon region and the Guianas and specifically to wood of density comparable to that shown in the table.

Average air-dry strength values based upon material from Brazil and Surinam are in close agreement with previously determined values for Andiroba from British Guiana. Andiroba compares closely with Yellow Birch in most of its air-dry strength properties. Shock resistance, compression across the grain, tension across the grain, shear, and cleavage resistance are, however, distinctly lower in the case of Andiroba. In comparison with Central American Mahogany, Andiroba is markedly superior in all static-bending properties, compression parallel to the grain, hardness, shear and toughness. Mahogany surpasses Andiroba in compression and tension across the grain and cleavage resistance.

Upon air drying, most of the properties of Andiroba exhibited substantial improvement, but only shock resistance

[1] *Tropical Woods* 97: 46-52.

Species	Source	No. of Logs	Condition	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.
Andiroba (*Carapa guianensis*)	Brazil	2	Green	72.4	0.61	0.56	7,190	11,110	1,560	1.92	11.4
			Air Dry[1]	13.5			9,650	15,620	1,850	2.85	13.4
(*Carapa procera*)	Surinam	2	Green	57.7	0.60	0.53	6,090	9,480	1,820	1.04	8.2
			Air Dry[1]	12.6			10,830	15,450	2,140	2.89	14.7
	Average	4	Green	65.0	0.60	0.54	6,640	10,300	1,690	1.48	9.8
			Air Dry[1]	13.0			10,240	15,540	2,000	2.84	14.0
(*Carapa guianensis*)[2]	British Guiana	—	Green	58	—	0.52	—	9,900	1,960	—	—
			Air Dry[1]	12			—	14,600	2,120	—	—
Yellow Birch[3] (*Betula lutea*)	United States		Green	67	0.66	0.55	4,200	8,300	1,500	0.70	16.1
			Air Dry	12			10,100	16,600	2,010	2.89	20.8
Mahogany[4] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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
Andiroba											
(*Carapa guianensis*)	Green	3,980	4,930	1,170	1150	1060	960	500	1320	350	129.9
Brazil	Air Dry[1]	5,810	7,900	2,030	1670	1220	850*	550	1680	280*	
(*Carapa procera*)	Green	4,100	4,640	2,280	740	710	500	620	1120	320	94.0
Surinam	Air Dry[1]	6,350	8,340	2,460	1330	1040	810	330*	1340	210*	
Average	Green	4,040	4,780	1,720	940	880	730	560	1220	340	112.0
	Air Dry[1]	6,080	8,120	2,240	1500	1130	830	440*	1510	240*	
(*Carapa guianensis*)[2]	Green	—	5,120	—	1020	830	—	—	—	320	—
British Guiana	Air Dry[1]	—	8,590	—	1550	1130	—	—	—	440	
Yellow Birch[3]											
(*Betula lutea*)	Green	2,620	3,380	—	810	780	530	430	1110	270	—
United States	Air Dry	6,130	8,170	—	1480	1260	1190	920	1880	520	—
Mahogany[4]											
(*Swietenia macrophylla*)	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
Central America	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Handbook of Empire Timbers (8).
[3] U. S. Dept. Agr. Tech. Bul. 479 (12).
[4] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

and end hardness increased by an amount greater than is normally shown by domestic hardwoods. Greatest improvement in other properties was shown in elastic resilience, followed by crushing strength, bending strength, proportional limit stress in static bending, side hardness, shear, stiffness, and compression across the grain. Strength in tension across the grain and cleavage resistance decreased 20-30 percent upon air drying.

The two species exhibited somewhat different characteristics in air-seasoning studies. In an earlier report both were classified as difficult to season, but subsequent results show *Carapa guianensis* to be only moderately difficult to air season. This species dried at a moderate rate with only slight checking and warp. *Carapa procera*, on the other hand, showed a variable rate of drying, the faster drying material developing severe end checking and moderate surface checking. Warp in the form of crook or bow was slight.

A striking difference in durability is shown by the two species. The present study, supplemented since an earlier report by additional data, shows *Carapa guianensis* to be very durable to durable upon exposure to a white-rot fungus and very durable with respect to a brown rot. *Carapa procera* was found to be non-durable in resistance to a white-rot fungus and only moderately durable with respect to a brown-rot organism. Andiroba has good weathering characteristics with some surface roughness and a minor amount of surface checking developing as a result of exposure of unpainted material.

Heartwood is highly resistant to moisture absorption, and the wood is rated intermediate to Teak and White Oak in this property. The wood glues easily. Andiroba does not appear to be adapted to steam bending.

No changes are suggested in the list of uses for Andiroba as previously proposed (10).

PIQUIÁ *Caryocar villosum* (Aubl.) Pers.

Other common names: Piquiá Bravo, Souari, Bats Souari, and Arbe à Beurre.

Occurrence: Widely distributed in upland forests of the Amazon valley, Maranhão (Brazil), and the Guianas.

Descriptions of the tree and wood of Piquiá together with a discussion of its properties and uses have been presented previously.[1] Air-dry strength data are shown, together with green strength properties, in the accompanying table.

In most air-dry strength properties for which comparable data are available, Piquiá is intermediate between Shagbark Hickory and White Oak. This is in contrast to its properties in the green condition which, except for shock resistance, exceed those of both these domestic woods. When air dry, Piquiá compares closely with Hickory in stiffness and elastic resilience; it occupies a position mid-way between Hickory and White Oak in bending and crushing strength, hardness, and compression across the grain, and resembles Oak in toughness, shearing strength, cleavage, and tension perpendicular to the grain.

Upon air drying, Piquiá showed far less improvement in strength than is generally exhibited by domestic hardwoods. Only in work to maximum load indicative of shock resistance was an outstanding increase observed. Among other properties greatest improvement was shown in elastic resilience, followed by modulus of rupture, maximum crushing strength, proportional limit stress in static bending, shear, and stiffness. The change in hardness was negligible and appreciable decreases in strength occurred in compression across the grain, tension across the grain, and cleavage.

The following tabulation illustrates the relative properties of Piquiá and White Oak (values for Oak taken as 100).

[1] *Tropical Woods* 95: 53-56.

Species	Source	No. of Logs	Condition	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.
Piquiá (*Caryocar villosum*)	Brazil	3+[2]	Green	61.3	0.84	0.72	8,260	12,450	1,820	2.17	8.4
			Air Dry[1]	13.8			10,990	17,060	2,160	3.07	15.8
Shagbark Hickory[3] (*Carya ovata*)	United States		Green	60	0.78	0.64	5,900	11,000	1,570	1.28	23.7
			Air Dry	12			10,700	20,200	2,160	3.01	25.8
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Piquiá (*Caryocar villosum*) Brazil	Green	4,900	6,290	2,210	1450	1720	2080	990	1640	430	150.5
	Air Dry[1]	5,140	8,410	2,260	1610	1720	1620*	780*	1990	380*	
Shagbark Hickory[3] (*Carya ovata*) United States	Green	3,430	4,580	—	—	—	1040	—	1520	—	—
	Air Dry	—	9,210	—	—	—	2170	—	2430	—	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Based upon tests of two logs and a shipment of plank material representing an unknown number of trees.
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
120	112	121	107	108

Side hardness	Shear	Bearing strength	Cleavage resistance
126	100	123	84

It is evident that on the basis of equivalent weight Piquiá exceeds White Oak only slightly in hardness and bearing strength across the grain and that it is generally less efficient than Oak in other strength properties.

Completed studies of the air-seasoning characteristics of the wood indicate a slow rate of drying. Purely on the basis of this observation Piquiá must be classified as difficult to season. Despite the slowness of drying, seasoning defects of various types were evident in the form of warping, checking, and casehardening. All of these defects were of minor degree, however.

Upon exposure to a brown-rot and white-rot fungus as a part of the present testing program, the heartwood of Piquiá proved to be very durable in each case.

Piquiá is rated only fair in its resistance to weathering on the basis of tests conducted as part of this study, which contradicts its favorable reputation in the tropics. Unpainted wood developed surface roughness, warp, and a considerable amount of surface checking upon exposure in the unpainted condition.

No change is indicated in the previous list of uses for which this wood appears to be adapted (7).

CEDRO BRANCO

Cedrela Huberi Ducke

Other common names: Cedro, Spanish Cedar.

Occurrence: In the Amazon region of Brazil.

The tree and wood of Cedro Branco were described in an earlier publication which included a discussion of the properties and uses of the wood.[1] The strength properties of the

[1]*Tropical Woods* 97: 52-56.

Species	Source	No. of Logs	Condition	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 Branco (*Cedrela Huberi*)	Brazil	2	Green	83.8	0.41	0.38	4,020	6,730	1,170	0.80	7.4
			Air Dry[1]	16.4			7,300	11,300	1,420	2.08	12.5
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	Green	67.4	0.46	0.41	4,520	7,510	1,310	0.94	7.1
			Air Dry[1]	11.8			7,940	11,530	1,440	2.45	9.4
Spanish Cedar[2] (*Cedrela* sp.)	Nicaragua		Green	73	0.38	0.34	3,360	5,220	870	—	7.4
			Air Dry	12			5,940	7,860	1,010	—	5.6
Mahogany[3] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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 Branco (*Cedrela Huberi*) Brazil	Green	2,220	3,100	1,340	460	450	390	450	790	260	82.2
	Air Dry[1]	5,260	6,010	1,460	790	570	710	390*	1200	250*	
Cedro Granadino (*Cedrela Tonduzii*) Panama	Green	2,770	3,370	1,330	650	550	600	430	990	260	106.2
	Air Dry	5,130	6,210	1,540	940	600	660	380*	1100	230*	
Spanish Cedar[2] (*Cedrela* sp.) Nicaragua	Green	—	2,760	—	380	350	310	—	720	—	—
	Air Dry	—	4,450	—	580	500	710	—	—	—	—
Mahogany[3] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Heck (9).
[3]Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

air-dry wood have been determined in subsequent tests and are presented in the accompanying table. Green strength values are included for comparison.

In the air-dry condition Cedro Branco shows a general strength superiority over published values for Spanish Cedar from Nicaragua. Cedro Branco is only slightly heavier than Spanish Cedar but shows a marked superiority in bending strength, stiffness, shock resistance, and crushing strength. Cedro Branco appears to be only slightly superior to Spanish Cedar in side hardness and comparable in compression across the grain. Cedro Branco compares closely with another Cedro *(Cedrela Tonduzii)*, also included in these tests, in nearly all air-dry properties. Cedro Branco is also similar to Central American Mahogany in bending and compression parallel to grain properties, shear strength, and toughness, but is surpassed by Mahogany in hardness, compression and tension across the grain, and cleavage resistance.

Upon air drying, Cedro Branco improved markedly in most strength properties, equalling or exceeding the increases shown generally by domestic hardwoods in work to maximum load, bending strength, compressive strength parallel to the grain, end hardness, compression across the grain, and shear. Side hardness increased moderately and stiffness improved slightly, whereas cleavage resistance and tensile strength across the grain both decreased upon air drying.

As previously reported, Cedro Branco is easy to air season. Drying was fast to moderate, accompanied by only slight surface checking.

Durability tests, completed since an earlier report, show the wood to be quite variable in its resistance to decay. The heartwood proved to be durable to moderately durable upon exposure to both a white-rot fungus and a brown-rot organism. These results do not confirm the reputation for durability that has been ascribed to woods of the genus *Cedrela*. It is interesting to note, however, that present results for Cedro Branco agree closely with those for *Cedrela Tonduzii*, which was also found to be variable in durability as reported previously.

Photo by Robert W. Hess

FIGURE 4

Cedro Granadino *(Cedrela Tonduzii)* growing at 7000 ft. elevation. Panama.

Cedro Branco displays excellent weathering characteristics, retaining a smooth surface and remaining warp-free and check-free upon exposure in the unpainted condition.

On the basis of the foregoing, no changes are indicated in the potential uses for the wood as previously listed (10).

CEDRO GRANADINO *Cedrela Tonduzii* C. DC.

Other common names: Cedro, Spanish Cedar.

Occurrence: In the highlands of Chiriqui Province, Panama.

The tree and wood of Cedro Granadino were described previously in a report which included a discussion of the properties and uses of the wood.[1] Subsequent determination of the properties of air-dry wood yielded the strength values shown in the accompanying table. Strength properties of the unseasoned wood are also given for comparison.

Cedro Granadino is considerably denser, and accordingly stronger in the air-dry condition, than the Spanish Cedar from Nicaragua for which strength determinations have been reported previously. Greatest differences appear in bending strength, stiffness, shock resistance, end hardness, and compression parallel to the grain. Only in compression across the grain is Cedro Granadino surpassed by the Nicaraguan Spanish Cedar. Cedro Granadino is, however, very similar in its air-dry strength properties to the slightly lighter Cedro Branco *(Cedrela Huberi)* of Brazil which is discussed in the preceding pages of this report. Air-dry Cedro Granadino closely resembles Mahogany in static-bending strength and stiffness, elastic resilience, compression parallel to the grain, and shear, and is superior to Mahogany in shock resistance. It is exceeded by Mahogany in side hardness, compression and tension across the grain, and cleavage resistance.

Upon air drying, *Cedrela Tonduzii* improved substantially in most strength properties. Elastic resilience, work to maximum load, and proportional limit stress in compression parallel to the grain increased more than do the correspond-

[1] *Tropical Woods* 95: 57-60.

Species	Source	No. of Logs	Condition	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.
Cedro Granadino (*Cedrela Tonduzii*)	Panama	3	Green	67.4	0.46	0.41	4,520	7,510	1,310	0.94	7.1
			Air Dry[1]	11.8			7,940	11,530	1,440	2.45	9.4
Cedro Branco (*Cedrela Huberi*)	Brazil	2	Green	83.8	0.41	0.38	4,020	6,730	1,170	0.80	7.4
			Air Dry[1]	16.4			7,300	11,300	1,420	2.08	12.5
Spanish Cedar[2] (*Cedrela* sp.)	Nicaragua		Green	73	0.38	0.34	3,360	5,220	870	—	7.4
			Air Dry[1]	12			5,940	7,860	1,010	—	5.6
Mahogany[3] (*Swietenia machophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	COMPRESSION PARALLEL TO GRAIN: Fiber Stress at Proportional Limit	Maximum Crushing Strength	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	Green	2,770	3,370	1,330	650	550	600	430	990	260	106.2
	Air Dry[1]	5,130	6,210	1,540	940	600	660	380*	1100	230*	
Cedro Branco (*Cedrela Huberi*) Brazil	Green	2,220	3,100	1,340	460	450	390	450	790	260	82.2
	Air Dry[1]	5,260	6,010	1,460	790	570	710	390*	1200	250*	
Spanish Cedar[2] (*Cedrela* sp.) Nicaragua	Green	—	2,760	—	380	350	310	—	720	—	—
	Air Dry	—	4,450	—	580	500	710	—	—	—	
Mahogany[3] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Heck (9).
[3]Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

ing properties of domestic hardwoods. Among other properties greatest proportionate increase was shown in maximum crushing strength, bending strength, end hardness, stiffness, shearing strength, compression across the grain, and side hardness. Losses upon air drying were shown in both tension across the grain and cleavage resistance.

Cedro Granadino air seasons readily. Drying was rapid without visible defect, and the wood compares favorably with Eastern White Pine *(Pinus strobus)* in its seasoning characteristics.

Completion of decay resistance studies shows the heartwood of Cedro Granadino to be moderately durable to nondurable in resistance to a white-rot organism and durable to moderately durable upon exposure to a brown rot. Weathering characteristics of Cedro Granadino are excellent, comparable to Mahogany. Unpainted material exposed to the weather remained free of warp and surface checking and retained its original surface smoothness.

Heartwood is resistant to moisture absorption, occupying a position intermediate to White Oak and Mahogany. The wood is easy to glue. Cedro Granadino is only fair in steam-bending quality.

No change is indicated in the potential uses for this wood as listed previously (7).

MORA AMARILLA *Chlorophora tinctoria* (L.) Gaud.
Other common names: Mora, Moral.

Occurrence: Widely distributed throughout Tropical America.

The tree and wood of Mora Amarilla were described in a previous publication which also included a discussion of the properties and uses of this wood.[1] Results of air-dry strength tests are now available and are presented in the accompanying table. Green strength data are included for comparison.

On the basis of the average air-dry values shown in the table, Mora Amarilla is comparable to Black Locust. These

[1]*Tropical Woods* 97: 56-61.

woods are approximately equal in static-bending properties, shock resistance, maximum crushing strength, tension across the grain, and cleavage. Mora Amarilla exceeds Black Locust in hardness but is somewhat lower than Locust in compression across the grain and shear. *Chlorophora tinctoria* is much stronger in all respects than the closely related Iroko *(Chlorophora excelsa)* of Africa.

Upon air drying, Mora Amarilla increased moderately in all strength properties except tension across the grain and cleavage. In both of these properties drying was accompanied by an appreciable decrease. Greatest improvement occurred in compression parallel to grain properties, but only in modulus of elasticity in static bending did the improvement exceed that anticipated on the basis of the behavior of domestic hardwoods. Of particular note is the relatively slight effect of drying upon compression across the grain, hardness, and shear.

On the basis of completed air-seasoning studies the wood of Mora Amarilla is rated as easy to season. This conclusion is based upon a fast to moderate rate of drying accompanied by only slight checking and slight warp. Included in the seasoning tests was material from Guatemala to supplement the limited amount of material from Venezuela that was considered in an earlier report.

Mora Amarilla is lacking in resistance to marine-borer activity. In contrast to its early apparent resistance as shown in tests at Kure Beach, North Carolina, as previously reported, subsequent exposure at Harbor Island, North Carolina, led to very heavy attack within a total period of 15 months. Mora Amarilla was comparable to Mahogany in these tests of small specimens. Similar specimens of such domestic woods as Southern Yellow Pine, Douglas Fir, Red Oak, and White Oak showed heavy attack within six months (4, 5).

Mora Amarilla weathers very well, retaining its surface smoothness, remaining free of warp, and showing little if any surface checking upon exposure of the unpainted wood.

Species	Source	No. of Logs	Condition	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.
Mora Amarilla (*Chlorophora tinctoria*)	Guatemala	2	Green	59.4	0.84	0.78	10,580	16,320	1,820	3.45	14.4
			Air Dry[1]	11.0			14,610	20,320	2,020	5.93	18.3
	Venezuela	1	Green	72.6	0.75	0.70	7,790	13,960	1,480	—	—
			Air Dry[1]	11.7			14,220	18,810	2,310	4.94*	16.5*
	Honduras	1	Green	62.1	0.72	0.65	9,580	14,250	1,460	—	—
			Air Dry[1]	—			—	—	—	—	—
	Average	4	Green	64.7	0.77	0.71	9,320	14,840	1,590	3.45	14.4
			Air Dry[1]	11.4			14,420	19,560	2,160	5.44	17.4
Iroko[2] (*Chlorophora excelsa*)	West Africa	1	Green	102.4	0.61	0.56	5,100	9,300	1,220	1.23	7.8
			Air Dry[1]	9.0			8,200*	11,600*	1,470*	2.63*	6.3*
Black Locust[3] (*Robinia pseudoacacia*)	United States		Green	40	0.71	0.66	8,800	13,800	1,850	2.36	15.4
			Air Dry	12			12,800	19,400	2,050	4.62	18.4

Species	Condition	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
Mora Amarilla (*Chlorophora tinctoria*)											
Guatemala	Green	6,000	8,500	1,680	2600	2670	1740	1270	2080	530	234.0
	Air Dry[1]	9,280	11,660	2,020	2890	2640*	1740	730*	2260	420*	
Venezuela	Green	5,170	7,290	1,910	1990	2180	2130	870	1840	390	203.9
	Air Dry[1]	7,660	10,490	1,980	2300	2110*	2150	570*	1720*	300*	
Honduras	Green	3,400	4,800	1,480	1630	1710	1520	960	1620	430	250.0
	Air Dry[1]	—	—	—	—	—	—	—	—	—	
Average	Green	4,860	6,860	1,690	2070	2190	1800	1030	1850	450	229.3
	Air Dry[1]	8,470	11,080	2,000	2600	2380*	1940	650*	1990	360*	
Iroko[2] (*Chlorophora excelsa*) West Africa	Green	3,770	5,260	1,500	1240	1280	880	—	1270	—	—
	Air Dry[1]	4,380*	8,220*	1,710*	1480*	1280*	1350*	—	1510*	—	
Black Locust[3] (*Robina pseudoacacia*)	Green	6,120	6,800	—	1640	1570	1430	770	1760	400	—
	Air Dry	6,800	10,180	—	1580	1700	2260	640	2480	330	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).

Heartwood is extremely resistant to water absorption, bettering Teak in this respect. It appears to be moderately well adapted to steam bending.

The potential uses for this wood as previously given are not appreciably altered as a result of the new information presented here (10).

LAUREL BLANCO *Cordia alliodora* (R. and P.) Cham.

Other common names: Pardillo, Uruá, Peterebí, Princewood, Bois Soumis, Varía, and Bojón.

Occurrence: Southern Mexico to northern Argentina and in the West Indies.

The tree and wood of Laurel Blanco were described in an earlier publication which included a discussion of the properties and uses of the wood.[1] Subsequently additional testing has been conducted on green material originating in Panama and on air-dry material from Panama as well as from other sources represented in the earlier tests. Results are reported in the accompanying table.

Laurel Blanco from Panama was found to be denser than the average shown for the species in the tests previously reported, and most strength properties are correspondingly higher. Inclusion of these data with those for Laurel Blanco from British Honduras, Honduras, and Nicaragua had only a slight effect upon average properties for the species. Average values shown in the accompanying table are slightly higher than those previously given for all green strength properties except work to maximum load, compression across the grain, and cleavage resistance.

Although air-dry strength properties of Laurel Blanco display considerable variation from source to source, most of these differences are associated with specific gravity variations, and average results shown in the accompanying table are regarded as representative of the species. On the basis of these average properties Laurel Blanco is slightly lighter in weight than the Venezuelan *Cordia Collococca* but

[1] *Tropical Woods* 95: 60-64.

nevertheless exceeds that species in toughness and in all static-bending properties except modulus of elasticity. Laurel Blanco is also slightly superior to *Cordia Collococca* in crushing strength and tension across the grain, equal in hardness, but weaker than that species in compression across the grain, shear, and cleavage.

Air-dry strength properties of Laurel Blanco are quite similar to those of Mahogany. With the exception of shock resistance which is appreciably higher for Laurel Blanco, and compression across the grain, tension across the grain, and cleavage resistance which are lower, the properties of these woods are essentially the same.

Upon air-drying, Laurel Blanco improved moderately in most strength properties but in none of these did the improvement equal that generally shown by domestic hardwoods. Greatest proportionate improvement occurred in elastic resilience, followed by compressive strength parallel to the grain, bending strength, end hardness, compression across the grain, stiffness, and shear. Side hardness remained unchanged. Both tension across the grain and cleavage resistance decreased upon drying.

The wood air seasons easily with a minimum of defect. Only slight checking and warp resulted from rapid drying. Milder drying conditions would likely further reduce such minor defects as were observed.

Shrinkage data for material from Panama somewhat alter results previously reported. Shrinkage values are considerably higher for this source as shown in the following tabulation:

Species and Source	SHRINKAGE (percent) 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	7.8
Panama	4.4	8.3	0.21	10.6
Average	3.4	7.1	0.16	9.2
Venezuela[1]	—	5.6	—	8.5

[1] Kynoch and Norton (11).

Species	Source	No. of Logs	Condition	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)*	Panama	3	Green	51.0	0.54	0.49	6,790	10,040	1,600	1.62	8.9
			Air Dry[1]	12.4			9,930	14,620	1,960	2.89	10.7
	British Honduras	3	Green	106.6	0.53	0.49	6,000	10,100	1,330	1.59	10.5
			Air Dry[1]	12.0			9,050	12,900	1,500	3.08	10.2*
	Honduras	4	Green	118.5	0.44	0.40	4,780	7,640	1,080	1.34	8.3
			Air Dry[1]	12.7			7,510	10,530	1,280	3.26	7.4*
	Nicaragua	3	Green	141.4	0.40	0.38	5,270	8,410	1,100	1.45	10.5
			Air Dry[1]	12.1			6,190	10,690	1,300	1.69	11.1
	Average	13	Green	104.4	0.48	0.44	5,710	9,050	1,280	1.50	9.6
			Air Dry[1]	12.3			8,170	12,180	1,510	2.73	9.8
	Venezuela[2]	1	Green	58.4	0.56	0.52	5,900	10,100	1,590	1.24	10.7
			Air Dry[1]	14.2			6,800*	13,300*	1,770*	1.47*	13.1*
Candelera *(Cordia Collococca)*	Venezuela	3	Green	87.4	0.54	0.47	4,600	6,970	1,350	0.78	4.7
			Air Dry[1]	13.3			6,990	11,320	1,750	1.61	9.6
Mahogany[3] *(Swietenia macrophylla)*	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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
Laurel Blanco *(Cordia alliodora)*											
Panama	Green	3,700	4,440	1,810	880	990	620	600	1290	270	157.5
	Air Dry[1]	5,960	7,410	2,140	1180	1050	850	490*	1190*	250*	
British Honduras	Green	3,740	4,530	1,440	1090	1030	920	630	1330	320	154.8
	Air Dry[1]	5,350	6,920	1,570	1330	1010*	1180	520*	1370	220*	
Honduras	Green	3,140	3,560	1,240	730	630	640	580	970	300	114.3
	Air Dry[1]	4,520	5,620	1,330	860	590*	640*	520*	1190	220*	
Nicaragua	Green	3,220	3,650	1,250	630	560	550	360	980	200	125.9
	Air Dry[1]	4,350	5,370	1,290	820	590	590	390	1130	240	
Average	Green	3,450	4,040	1,440	830	800	680	540	1140	270	138.1
	Air Dry[1]	5,040	6,330	1,580	1050	810	820	480*	1220	230*	
Venezuela[2]	Green	4,680	4,960	1,700	900	610	480	590	930	290	—
	Air Dry[1]	4,690*	6,260*	1,950*	1090*	910*	820*	—	—	—	
Candelera *(Cordia Collococca)* Venezuela	Green	2,370	3,510	1,410	630	540	380	600	730	260	85.9
	Air Dry[1]	5,110	6,100	1,830	1100	810	900	420*	1320	280	
Mahogany[3] *(Swietenia macrophylla)* Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Kynoch and Norton (11).
[3] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

Although previous data for material representing two sources showed uniformly high durability, completed decay resistance studies including material from Nicaragua and Panama show Laurel Blanco as averaging very durable but exhibiting some variation in resistance to a white-rot organism. Resistance to a brown-rot fungus remains uniformly high as reported previously.

Chemical analyses made at the Institute of Paper Chemistry show a total ash content of 0.98 percent with only weak indications of silicon obtained in spectrographic analysis of the ash (18).

The wood has good weathering qualities, particularly from the standpoint of the resistance to checking. The principal result of exposure of unpainted material was a loss of surface smoothness.

Heartwood absorbs moisture at a moderate rate, and appears to be somewhat more permeable than Mahogany. Laurel Blanco is only fair in steam-bending quality.

Recommendations with regard to prospective uses for the wood remain unchanged from those presented earlier (7).

CANDELERA *Cordia Collococca* L.

Occurrence: West Indies, Central America, and northern Venezuela.

The tree and wood of Candelera were described in a previous publication which also included a discussion of the properties and uses of the wood.[1] The mechanical properties of the wood in the air-dry condition have been subsequently determined and are presented, together with green strength data for comparison, in the accompanying table.

In its air-dry strength properties Candelera closely resembles the better known Laurel Blanco *(Cordia alliodora)*. Candelera is slightly weaker in bending, somewhat higher in stiffness, and approximately equivalent to Laurel Blanco in other properties including shock resistance (work to maximum load), hardness, compression and tension across the grain, shear, and cleavage. Candelera may also be compared with Mahogany in most of its properties. These woods are similar in bending strength, crushing strength, hardness, shear, and toughness. Candelera is somewhat stiffer than Mahogany, even exceeding Black Walnut in this respect. It is appreciably above Mahogany in work to maximum load in static bending, but is notably deficient in tension across the grain.

[1]*Tropical Woods* 97: 61-64.

Upon air drying, Candelera improved notably in most properties. Greatest proportionate improvement was shown in elastic resilience, compression across the grain, and work to maximum load in static bending, followed by shear, crushing strength, bending strength, hardness, and stiffness. In several of these properties the increase upon drying exceeded that characteristic of domestic hardwoods. Cleavage resistance was not appreciably affected by drying, and tensile strength across the grain was decreased by 30 percent.

As previously reported, Candelera proved easy to air season. The wood dried rapidly with only slight checking and slight warp. Milder drying conditions would undoubtedly eliminate such slight defects as were observed.

Heartwood of Candelera showed a wide range of variability in resistance to a white-rot fungus, but averaged durable. It was consistently very durable in resisting deterioration by a brown-rot organism. Candelera is rated poor in weathering resistance on the basis of severe surface and end checking and surface roughness observed in specimens exposed to weather without paint protection. Heartwood absorbs moisture very readily.

No changes are indicated in the potential uses for this wood as presented previously (10).

Species	Source	No. of Logs	Condition	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.
Candelera (*Cordia Collococca*)	Venezuela	3	Green	87.4	0.54	0.47	4,600	6,970	1,350	0.78	4.7
			Air Dry[1]	13.3			6,990	11,320	1,750	1.61	9.6
Laurel Blanco (*Cordia alliodora*)	Central America	13	Green	104.4	0.48	0.44	5,710	9,050	1,280	1.50	9.6
			Air Dry[1]	12.3			8,170	12,180	1,510	2.73	9.8
Black Walnut[2] (*Juglans nigra*)	United States		Green	81	0.56	0.51	5,400	9,500	1,420	1.16	14.6
			Air Dry	12			10,500	14,600	1,680	3.70	10.7
Mahogany[3] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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
Candelera (*Cordia Collococca*) Venezuela	Green	2,370	3,510	1,410	630	540	380	600	730	260	85.9
	Air Dry[1]	5,110	6,100	1,830	1100	810	900	420*	1320	280	
Laurel Blanco (*Cordia alliodora*) Central America	Green	3,450	4,040	1,440	830	800	680	540	1140	270	138.1
	Air Dry[1]	5,040	6,330	1,580	1050	810	820	480*	1220	230*	
Black Walnut[2] (*Juglans nigra*) United States	Green	3,520	4,300	—	960	900	600	570	1220	360	—
	Air Dry	5,780	7,580	—	1050	1010	1250	690	1370	320	
Mahogany[3] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

ALMENDRO *Coumarouna oleifera* (Benth.) Taub.

Other common name: Ebo.

Occurrence: Lowland forests of Nicaragua, Costa Rica, and Panama.

CUMARÚ *Coumarouna odorata* Aubl.

Other common names: Tonka Bean, Koemaroe, Tonka, Kumaru, and Sarrapio.

Occurrence: Venezuela, the Guianas, and the Amazon valley of Brazil.

Because of their similarity these woods are considered together. The trees and the woods of Almendro and Cumarú were described in an earlier publication which also included a discussion of the properties and uses of these woods.[1] Subsequent tests of air-dry material have resulted in determination of the properties shown in the acompanying table. Data on green strength properties are also given for comparison.

In the air-dry condition the Cumarú involved in these tests exceeds the slightly lower density Almendro in all properties except stiffness, end hardness, and shear strength. These differences are small, however, in all properties except work to maximum load which denotes shock resistance. On the basis of average values for Almendro and Cumarú, these species compare favorably with Greenheart *(Ocotea Rodiaei)* in most mechanical properties. Only in modulus of elasticity and tension across the grain does Greenheart show to advantage.

The outstanding air-dry strength properties of the wood of these species may be indicated by the following comparison with White Oak. Relative values are shown taking the value for White Oak in each case as 100.

These relative values emphasize the exceptionally high stiffness, hardness, bending strength, and compressive

[1] *Tropical Woods* 97: 64-69.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
144	170	175	146	183

Side hardness	Shear	Bearing strength	Cleavage resistance
250	116	182	89

strength both parallel and perpendicular to the grain of Almendro and Cumarú.

Upon air drying, these woods improved substantially in nearly all properties, but only in work to maximum load in static bending did the improvement exceed that normally shown by domestic hardwoods. In other properties greatest proportionate increase was shown in elastic resilience, followed by compression parallel to the grain, bending strength, hardness, compression across the grain, stiffness, and shear strength. Both cleavage resistance and tensile strength across the grain were lowered appreciably as a result of air drying.

Both Almendro and Cumarú are rated as easy to air season. Completed studies show a slight tendency to check on the part of both species. Moderate warping and slight casehardening were also observed in Almendro. No other defects were apparent although drying was uniformly fast. Seasoning at a more moderate rate would doubtless tend to eliminate the relatively minor defects observed in this study.

Upon completion of decay resistance studies, the heartwood of Cumarú is rated as very durable to both white-rot and brown-rot organisms. Almendro was found to be very durable to durable upon exposure to a white rot and very durable in its resistance to a brown-rot fungus. The wood displays excellent weathering characteristics from the standpoint of surface smoothness and freedom from warp and checking when exposed in the unpainted condition.

Cumarú appears to be rather difficult to glue although no more so than most other woods of comparable high density.

No change is indicated in the list of potential uses for these woods as previously published (10).

Species	Source	No. of Logs	Condition	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.
Cumarú											
(Coumarouna odorata)	Brazil	1	Green	49.2	1.04	0.91	12,530	19,290	2,690	3.27	12.3
			Air Dry[1]	12.0			19,130	27,270	3,030	6.74	26.1
Almendro											
(Coumarouna oleifera)	Panama	3	Green	44.2	0.99	0.87	11,790	16,610	2,690	3.02	10.1
			Air Dry[1]	11.3			16,950	24,400	3,220	5.51	17.0
	Average	4	Green	46.7	1.02	0.89	12,160	17,950	2,690	3.14	11.2
			Air Dry[1]	11.6			18,040	25,840	3,120	6.12	21.6
Greenheart[2]											
(Ocotea Rodiaei)	British Guiana		Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
			Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*
White Oak[3] *(Quercus alba)*	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Cumarú *(Coumarouna odorata)* Brazil	Green	7,420	9,020	2,700	2000	2200	2280	1160	1990	480	265.3
	Air Dry[1]	11,720	13,720	3,190	2490	3540	2740	710*	2100	420*	
Almendro *(Coumarouna oleifera)* Panama	Green	5,490	8,190	2,910	2390	2570	1660	1010	2140	490	244.9
	Air Dry[1]	9,160	13,610	3,330	3020	3270	2070	500*	2530	370*	
Average	Green	6,460	8,600	2,800	2200	2380	1970	1080	2060	480	255.1
	Air Dry[1]	10,440	13,660	3,260	2760	3400	2400	600*	2320	400*	
Greenheart[2] *(Ocotea Rodiaei)* British Guiana	Green	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
	Air Dry[1]	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
White Oak[3] *(Quercus alba)* United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

TAUARY *Couratari pulchra* Sandw.

Other common names: Wadara, Ingie-pipa.

Occurrence: Brazil, British Guiana, and Surinam.

Descriptions of the tree and wood of Tauary were presented together with a discussion of the properties and uses of the wood in a previous publication.[1] Air-dry strength properties of the wood have been determined in subsequent tests and are shown in the accompanying table together with green strength properties for comparison.

Based on average properties in the air-dry condition, Tauary exceeds White Oak in elastic resilience and stress at proportional limit in static bending. It is equal to White Oak in stiffness and crushing strength, but is slightly below Oak in modulus of rupture and shock resistance, and much lower in hardness, compression across the grain, shear, tension across the grain, and cleavage. Tauary is clearly inferior to Hard Maple in all properties except proportional limit stresses in bending and compression parallel to the grain, elastic resilience, and stiffness.

Upon air-drying, Tauary increased moderately in most mechanical properties but only in work to maximum load and elastic resilience were these increases greater than the average increases shown by domestic hardwoods. The greatest proportionate increase was that in elastic resilience, followed by proportional limit stress in static bending, crushing strength, compression across the grain, end hardness, bending strength, shear and side hardness. Modulus of elasticity was not appreciably affected by drying and considerable decreases occurred in cleavage resistance and tensile strength across the grain.

Tauary proved to be moderately difficult to air season. Studies now completed indicate a moderate rate of drying with moderate end checking and slight surface checking. Slight warp was also observed. End checking does not appear to be as critical as was indicated in an earlier report.

[1] *Tropical Woods* 97: 69-72.

Considerable variability is shown by the heartwood of this species in decay resistance. However, the wood averages durable in resistance to a white-rot organism and very durable in resistance to a brown rot.

Tauary offers considerable resistance to attack by marine borers on the basis of data collected subsequent to the earlier report. In tests conducted at Harbor Island, North Carolina, under conditions in which small specimens of such domestic woods as Southern Yellow Pine, Douglas Fir, Red Oak, and White Oak were heavily attacked within six months, comparable specimens of Tauary showed only light attack by teredo after 12 months of exposure. After 15 months, another series of specimens of Tauary and the related *C. oblongifolia* showed fairly heavy attack by marine borers and resistance appeared to be comparable to that of Teak (4, 5). Determinations made at the Institute of Paper Chemistry show an ash content for Tauary of 0.83 percent with strong indications of silicon in a spectrographic analysis which was later determined in quantitative analysis to be equivalent to 0.2 percent silica on the basis of total weight of the wood (18).

Weathering characteristics of Tauary are only fair. Unpainted material, exposed to the weather, remained free of warp but developed considerable surface and end checking.

Steam-bending quality appears to be poor.

No change is indicated in the proposed uses for the wood as published previously (10).

ANGÉLIQUE *Dicorynia paraensis* Benth.

Other common names: Basra Locus, Angélica do Pará, Tapaiuna, and Teck de la Guyane.

Occurrence: On moist, well-drained lowland sites in Surinam, French Guiana, and Brazil.

The tree and wood of Angélique were described in a previous publication which also included a discussion of the properties and uses of the wood.[1] The air-dry strength

[1] *Tropical Woods* 95: 65-69.

Species	Source	No. of Logs	Condition	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.
Tauary (*Couratari pulchra*)	Brazil	2	Green	60.1	0.63	0.56	6,260	10,240	1,980	1.11	8.6
			Air Dry[1]	12.8			11,180	15,690	2,090	3.36	14.1
	British Guiana	1	Green	77.4	0.50	0.45	4,520	8,230	1,480	0.78	8.0
			Air Dry[1]	13.9			8,190	11,340	1,500	2.39	10.4
	Average	3	Green	68.8	0.56	0.50	5,390	9,240	1,730	0.94	8.3
			Air Dry[1]	13.4			9,680	13,520	1,800	2.88	12.2
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	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
Tauary (*Couratari pulchra*) Brazil	Green	4,220	4,840	2,220	950	880	580	620	1100	380	145.2
	Air Dry[1]	5,550	8,220	2,210*	1440	1090	970	540*	1420	250*	
British Guiana	Green	2,560	3,690	1,790	720	590	540	690	1040	250	102.6
	Air Dry[1]	5,880	6,690	1,700*	1070	680	760	560*	1330	290	
Average	Green	3,390	4,260	2,000	840	740	560	660	1070	320	123.9
	Air Dry[1]	5,720	7,460	1,960*	1260	880	860	550*	1380	270	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]Value obtained for plank material received from the New York Naval Shipyard.

properties of the wood have been subsequently determined and are presented in the accompanying table. Green strength properties are included for comparison.

In the air-dry condition Angélique is superior to Teak in all mechanical properties except tension perpendicular to the grain. The superiority of Angélique is shown particularly in shock resistance and stiffness, but substantial differences are noted in all other static-bending properties, compression parallel to the grain, end hardness, and shear. Angélique also exceeds White Oak in static-bending strength, stiffness, compression parallel to the grain, and end hardness. These woods are comparable in shock resistance, side hardness, and compression across the grain, but Angélique falls below Oak in shear, tension across the grain, and cleavage resistance.

Upon air drying Angélique improved substantially in most strength properties, but only in work to maximum load in static bending did the increase exceed that shown generally by domestic hardwoods. Among other properties greatest proportionate increase was shown in elastic resilience, followed by maximum crushing strength, end hardness, proportional limit stress and maximum strength in static bending, proportional limit stress in compression parallel to grain, compression across the grain, shear, stiffness, side hardness, and cleavage resistance. Strength in tension across the grain was reduced as a result of air drying.

Angélique is moderately difficult to season. In air-seasoning tests conducted in the present study, drying was rapid but accompanied by moderate surface checking and variable end checking. Slight warp was also observed. Casehardening, noted in a previous report, appears to be restricted to heavy stock. Seasoning defects would probably be minimized if the wood were dried at a moderate rate.

The heartwood of Angélique appears to be variable in resistance to decay on the basis of tests now completed. The wood was found to be very durable to durable in resistance to a white rot and variable, although averaging durable, in

FIGURE 5

Logs of Angélique (*Dicorynia paraensis*) from Surinam showing excellent condition upon arrival in New Haven.

Species	Source	No. of Logs	Condition	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.
Angélique (*Dicorynia paraensis*)	Surinam	2	Green	78.7	0.69	0.60	7,650	11,410	1,840	1.78	12.0
			Air Dry[1]	11.8			11,610	17,390	2,190	3.32	15.2
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
Teak[4] (*Tectona grandis*)	Burma		Green	52.0	0.62	0.58	7,250	11,380	1,580	1.89	10.0
			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	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
Angélique (*Dicorynia paraensis*) Surinam	Green	4,810	5,590	2,180	1100	1100	1000	700	1340	340	151.2
	Air Dry[1]	6,810	8,770	2,490	1700	1290	1280	560*	1660	360	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Teak[4] (*Tectona grandis*) Burma	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] Value obtained for plank material received from the New York Naval Shipyard.
[4] A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.

resistance to a brown-rot fungus. The wood is reported from other sources as resistant to decay and insect attack.

Tests conducted at Harbor Island, North Carolina, to determine resistance to marine-borer attack, generally confirm the favorable reputation of Angélique in this regard. After 10 months of exposure, small specimens showed no evidence of marine-borer activity, and after 15 months only moderate attack by teredo and pholads was noted. This performance surpassed that of Teak. Under the same conditions comparable specimens of such domestic woods as Southern Pine, Douglas Fir, Red Oak, and White Oak were heavily attacked within six months (4, 5). In chemical analyses made at the Institute of Paper Chemistry, Angélique showed a normal ash content of 0.64 percent with a silica content of 0.46 percent expressed on the basis of total weight of the wood (18). These results are somewhat higher than those given in a previous report but confirm the unusually high proportion of silica in the ash.

Weathering quality of Angélique is fair. When exposed to the weather without paint protection, plain-sawed specimens tend to develop numerous rather fine surface checks. Heartwood is quite resistant to moisture absorption, comparable to White Oak. The wood is moderately easy to glue.

Potential uses for this wood were listed in a previous report (7).

BLACK KAKERALLI *Eschweilera Sagotiana* Miers

Occurrence: Throughout most of the climax rain forests of British Guiana but most abundantly in the western districts of that country. Closely related species include Manbarklak *(E. longipes)* of Surinam and Mata-mata *(E. odora)* of the Amazon basin.

Descriptions of the tree and wood of Black Kakeralli as well as a discussion of its properties and uses have been presented in an earlier publication.[1] The testing of air-dry

[1] *Tropical Woods* 95: 69-73.

material has now been completed, and results are shown in the accompanying table together with green strength data which are included for comparison.

In most mechanical properties in the air-dry condition Black Kakeralli exceeds all common domestic woods. Although not equivalent to Greenheart *(Ocotea Rodiaei)*, it approaches that species in many properties. The greatest superiority of Greenheart is shown in fiber stress at proportional limit in compression parallel to the grain, but in maximum crushing strength, maximum bending strength, and stiffness Greenheart exceeds Black Kakeralli by only 10-15 percent. Greenheart is also superior in compression across the grain, tension across the grain, and elastic resilience in bending, whereas Black Kakeralli is slightly superior to Greenheart in hardness, shear, and shock resistance.

Upon air drying, Black Kakeralli showed only a moderate increase in most strength properties. Improvement in bending strength properties (with the exception of work to maximum load), maximum crushing strength, side hardness, and shear is considerably less than that shown in these properties by domestic hardwoods. Work to maximum load indicative of shock resistance, on the other hand, showed an outstanding improvement upon drying. Values for fiber stress at proportional limit in compression parallel to grain and in compression perpendicular to grain were not changed appreciably upon drying, and cleavage resistance was considerably less than that in the green condition.

A comparison of some of the air-dry properties of Black Kakeralli with those of White Oak *(Quercus alba)*, taking values for the latter wood as 100, follows:

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
138	154	182	165	151

Side hardness	Shear	Bearing strength	Cleavage resistance
204	113	116	67

Weight for weight, Black Kakeralli is stronger than White Oak in all of these properties except shear, bearing strength

Species	Source	No. of Logs	Condition	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.
Black Kakeralli (*Eschweilera Sagotiana*)	British Guiana	2	Green	50.7	0.98	0.82	10,680	17,780	2,910	2.28	13.4
			Air Dry[1]	14.2			12,860	23,420	3,250	2.84	24.4
Greenheart[2] (*Ocotea Rodiaei*)	British Guiana		Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
			Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	2,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Black Kakeralli (*Eschweilera Sagotiana*) British Guiana	Green	6,170	7,780	2,880	2000	2480	1580	560	1790	390	264.5
	Air Dry[1]	5,930*	11,210	3,750	2760	2780	1530*	860	2250	300*	
Greenheart[2] (*Ocotea Rodiaei*) British Guiana	Green	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
	Air Dry[1]	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

in compression across the grain, and cleavage resistance. Comparison of these ratios with those presented previously[2] for green wood, however, reveals a ratio for dry wood less favorable to Black Kakeralli than in the case of unseasoned wood for all properties except shock resistance.

When air seasoned at a moderate rate, Black Kakeralli displayed only a minimum of warp and a slight amount of end checking. A general rating of moderately difficult to air season on the basis of these tests would seem to dispute a local reputation in the tropics for considerable checking by this species.

Black Kakeralli showed only light attack by teredo after 12 months' exposure of small specimens to marine organisms at Harbor Island, North Carolina. These results substantiate the preliminary conclusions reported earlier. The closely related *Eschweilera blanchetiana* displayed similar resistance after nearly 2 years of comparable exposure. Under the same conditions such domestic woods as Southern Pine, Douglas Fir, Red Oak, and White Oak were heavily attacked within six months (4, 5). Black Kakeralli was found to have a normal ash content of 0.63 percent in tests conducted at the Institute of Paper Chemistry. Spectrographic analysis indicated a high silicon content in the ash (18).

The wood is poor in its resistance to weathering. Unpainted wood quickly develops a rough surface and checks badly upon exposure. Its steam-bending quality is only fair.

No change is indicated in the recommended potential uses for this wood as listed previously (7).

POSSUMWOOD *Hura crepitans* L.

Other common names: Hura Wood, Rakuda, Possentrie, Jabillo, and Assacú.

Occurrence: West Indies throughout Central America and northern South America.

A previous publication contains descriptions of the tree and wood of *Hura crepitans* and includes a discussion of the

[2]*Tropical Woods* 95: 72.

Species	Source	No. of Logs	Condition	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.
Possumwood *(Hura crepitans)*	Panama	3	Green	64.7	0.42	0.38	3,630	6,320	1,030	0.70	7.1
			Air Dry[1]	12.3			5,790	8,940	1,220	1.52	7.2
	Venezuela	3	Green	60.9	0.42	0.38	3,650	5,670	950	0.88	5.0
			Air Dry[1]	11.4			4,680	8,130	1,180	1.05	6.7
	Surinam	1	Green	76.0	0.40	0.37	4,500	6,940	1,140	1.08	5.7
			Air Dry[1]	12.0			5,660	9,050	1,120*	1.46	6.3
	Average	7	Green	67.2	0.41	0.38	3,930	6,310	1,040	0.89	5.9
			Air Dry[1]	11.9			5,380	8,710	1,170	1.34	6.7
Yellow Poplar[2] *(Liriodendron tulipifera)*	United States		Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
			Air Dry	12			6,100	9,200	1,500	1.43	6.8

Species	Condition	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
Possumwood *(Hura crepitans)*											
Panama	Green	1,410	2,430	1,090	510	440	410	330	870	210	78.6
	Air Dry[1]	3,450	4,650	1,290	730	540	570	440	990	210	
Venezuela	Green	1,900	2,670	1,170	460	390	400	440	730	210	75.4
	Air Dry[1]	2,710	4,610	1,320	730	500	580	360*	970	180*	
Surinam	Green	2,580	3,270	1,240	590	500	460	520	880	250	57.0
	Air Dry[1]	3,750	5,130	1,270	920	600	750	260*	1270	280	
Average	Green	1,960	2,790	1,170	520	440	420	430	830	220	70.3
	Air Dry[1]	3,300	4,800	1,290	790	550	630	350*	1080	220	
Yellow Poplar[2] *(Liriodendron tulipifera)*	Green	1,930	2,420	—	390	340	330	450	740	220	—
United States	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).

properties and uses of the wood.[1] Subsequent testing of air-dry material has resulted in the data on mechanical properties which are presented in the accompanying table. Strength properties in the unseasoned condition are included for comparison.

On the basis of average air-dry properties, Possumwood compares closely with Yellow Poplar. With the exception of modulus of elasticity which is considerably lower for Possumwood, these two woods are virtually equal in static-bending properties and shock resistance, crushing strength, compression across the grain, and shear. Possumwood exceeds Yellow Poplar by a substantial amount in hardness, but lies below that wood in tension across the grain and cleavage.

Upon air drying, Possumwood increased by a moderate amount in all properties except cleavage and tension across the grain, but improvement was generally below that normally found for domestic hardwoods. Greatest proportional increase occurred in compression parallel to the grain, followed by end hardness, compression across the grain, elastic resilience, shear, side hardness, and stiffness. A strength loss of 20 percent was noted in tension across the grain.

The wood is considered moderately difficult to air season on the basis of completed studies. Rapid drying was accompanied by variable warp, which was severe in some cases. Slight checking was also observed. Milder drying conditions would doubtless reduce defects encountered in rapid drying.

Upon the completion of durability studies, Possumwood is shown to exhibit extreme variation in resistance to decay. However, the species was found generally to be durable to moderately durable in its resistance to a white-rot fungus and to average durable, although exhibiting wide variability, in its resistance to a brown rot. Possumwood has excellent weathering characteristics. Freedom from surface checks and warp with only slight loss of surface smoothness upon exposure to weather in the unpainted condition confirms

[1]*Tropical Woods* 97: 73-76.

earlier observations in which this species was rated comparable to Central American Mahogany.

Potential uses for the wood were suggested in a previous report (10).

COURBARIL

Hymenaea courbaril L.
Hymenaea Davisii Sandw.

Other common names: Algarrobo, Guapinol, Jatobá, Jutaiacu, West Indian Locust, and South American Locust.

Occurrence: A common tree throughout many parts of its range extending from Mexico throughout Central America, and the West Indies, through northern South America to Bolivia.

The tree and wood of these species of Courbaril were described in an earlier publication which included a discussion of the properties and uses of the wood.[1] Since that time data have been secured on the properties of Courbaril from Panama and are included in the accompanying tabulation of mechanical properties of the wood. In the green condition *Hymenaea courbaril* from Panama, although nearly average in density for the species, is considerably superior to the wood from other sources in most static-bending and compression parallel to grain properties and in toughness, but is generally lower in other respects than the material of this species tested previously. Inclusion of the Panama wood in species tested previously. Inclusion of the Panama wood in recomputing average values for the species resulted in relatively minor changes, however.

Subsequent to the earlier publication, mechanical tests have also been completed on seasoned wood. In the air-dry condition Courbaril is approximately equivalent to Black Locust in static-bending properties and shear strength, superior to Black Locust in hardness, tension across the grain, and shear, and somewhat below that species in compression parallel and perpendicular to the grain. It is also generally comparable to Shagbark Hickory in bending

[1]*Tropical Woods* 95: 74-81.

properties (other than work to maximum load in which Hickory is outstanding), in crushing strength and shear, but is exceeded by Hickory in compression across the grain.

Hymenaea Davisii from British Guiana is also comparable to Black Locust and Hickory in air-dry bending strength, surpasses both in stiffness, and is equivalent to Black Locust in shock resistance and side hardness. In compression across the grain it is decidedly inferior to Black Locust and Hickory. *Hymenaea Davisii* is clearly superior to White Oak in all properties except compression and tension across the grain, shear, and cleavage resistance in which these two woods are approximately equal.

Upon air-drying, both species of Courbaril improved considerably in most strength properties. Greatest proportionate increase was shown by British Guiana Courbaril in work to maximum load whereas *Hymenaea courbaril* increased only moderately in this respect. In other properties greatest relative increase was shown by these species in elastic resilience, followed by compressive strength parallel to the grain, static-bending strength, end hardness, shear, stiffness, side hardness, and compression perpendicular to the grain. Decreases occurred in tensile strength across the grain and cleavage resistance.

Courbaril was found to be moderately difficult to air season in tests now completed as a part of the present study. Drying of *Hymenaea courbaril* was fast to moderate with only slight checking, warp, and casehardening. *H. Davisii* exhibited a moderate rate of drying. Moderate surface checking was observed for this species, together with slight end checking and warp. Completed tests indicate that checking exhibited by *H. Davisii* is not so critical as that reported in an earlier phase of the present study.

Shrinkage data presented earlier are changed but little with the addition of results for material of *H. courbaril* received from Panama. These data are shown in the accompanying table.

Species and Source	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Courbaril				
(Hymenaea courbaril)				
Panama	4.6	8.3	0.19	13.2
Species Average (Panama, Puerto Rico, Honduras, Surinam)	4.5	8.5	0.27	12.7
British Guiana Courbaril				
(Hymenaea Davisii)				
British Guiana	4.1	7.6	0.51	14.8

Durability tests for *Hymenaea courbaril* were recently completed on material from Surinam and Panama and indicate slight changes in the results previously reported. The heartwood appears to be very durable in resistance to a white-rot fungus and very durable to durable in resistance to a brown rot. *H. Davisii* appears to be variable with an average rating of durable in resistance to both a white-rot fungus and a brown-rot organism.

Marine-borer resistance of Courbaril is not high. In tests of small specimens conducted at Harbor Island, North Carolina, both *Hymenaea courbaril* and *H. Davisii* showed very heavy attack within 12 to 15 months. Performance in this respect was generally comparable to that of Mahogany *(Swietenia macrophylla)* (4, 5). A number of domestic woods including Red Oak and White Oak were heavily attacked within six months. Determinations made at the Institute of Paper Chemistry show an ash content of 0.85 percent with only weak indications of silicon in a spectrographic analysis (18).

Courbaril checks badly upon exposure to the weather without protection of paint. The heartwood is relatively permeable and absorbs moisture readily. Largely on the basis of these characteristics it now appears that boat decking should be deleted from the list of potential uses previously presented for this wood (7).

Species	Source	No. of Logs	Condition	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.
Courbaril (*Hymenaea courbaril*)	Honduras	2	Green	49.6	0.84	0.74	7,250	12,910	1,740	1.76	12.8
			Air Dry[1]	13.6			12,350	19,820	1,920	4.38	12.8*
	Panama	3	Green	63.8	0.84	0.73	10,760	15,240	2,420	2.63	16.2
			Air Dry[1]	12.0			14,930	22,950	2,920	4.47	22.0
	Puerto Rico	3	Green	52.7	0.84	0.72	5,420	10,700	1,250	1.19	18.7
			Air Dry[1]	11.8			8,440	15,660	1,540	2.60	15.8*
	Surinam	1	Green	77.0	0.73	0.65	8,190	12,930	1,930	1.91	10.7
			Air Dry[1]	13.0			11,890	19,150	2,270	3.42	19.8
	Average	9	Green	60.8	0.81	0.71	7,910	12,940	1,840	1.87	14.6
			Air Dry[1]	12.6			11,900	19,400	2,160	3.72	17.6
British Guiana Courbaril (*Hymenaea Davisii*)	British Guiana	3	Green	64.8	0.79	0.67	8,230	12,440	2,080	1.62	8.5
			Air Dry[1]	12.1			10,720	19,290	2,950	2.30	19.3
Black Locust[2] (*Robinia pseudoacacia*)	United States		Green	40	0.71	0.66	8,800	13,800	1,850	2.36	15.4
			Air Dry	12			12,800	19,400	2,050	4.62	18.4
Shagbark Hickory[2] (*Carya ovata*)	United States		Green	60	—	0.64	5,900	11,000	1,570	1.28	23.7
			Air Dry	12			10,700	20,200	2,160	3.01	25.8
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	Compression Parallel to Grain: Fiber Stress at Proportional Limit	Maximum Crushing Strength	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	Green	3,840	5,620	1,910	1940	2140	1860	1180	1700	520	187.4
	Air Dry[1]	6,080	9,200	2,060	2590	2380	2140	790*	2290	480*	
Panama	Green	5,570	7,160	2,540	1770	1970	1100	1010	1680	460	278.2
	Air Dry[1]	8,790	11,630	2,990	2560	2400	1890	1030	2190	460	
Puerto Rico	Green	2,840	4,530	1,320	1840	2140	1690	1320	1910	600	267.2
	Air Dry[1]	4,460	8,290	1,650	2760	2680	1960	1180*	2860	500*	
Surinam	Green	4,780	5,870	2,080	1570	1630	1890	1380	1800	590	189.2
	Air Dry[1]	6,680	8,920	2,270	2170	1950	1550*	860*	2540	450*	
Average	Green	4,260	5,800	1,960	1780	1970	1640	1220	1770	540	230.5
	Air Dry[1]	6,500	9,510	2,240	2520	2350	1880	960*	2470	470*	
British Guiana Courbaril (*Hymenaea Davisii*) British Guiana	Green	4,260	5,540	2,450	1480	1610	1120	890	1680	410	187.8
	Air Dry[1]	6,430	9,400	3,170	2070	1760	1230	860*	2130	390*	
Black Locust[2] (*Robinia pseudoacacia*) United States	Green	6,120	6,800	—	1640	1570	1430	770	1760	400	—
	Air Dry	6,800	10,180	—	1580	1700	2260	640	2480	330	
Shagbark Hickory[2] (*Carya ovata*) United States	Green	3,430	4,580	—	—	—	1040	—	1520	—	—
	Air Dry	—	9,210	—	—	—	2170	—	2430	—	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] Value obtained for plank material received from the New York Naval Shipyard.

HUBUBALLI *Loxopterygium Sagotii* Hook.f.

Other common names: Hoobooballi, Kooel Pialli, Hoeboeballi, Slangenhout.

Occurrence: British Guiana, French Guiana, and Surinam.

Descriptions of the tree and wood of Hububalli appeared in a previous publication which also included a discussion of the properties and uses of the wood.[1] Air-dry strength properties have been determined subsequently and are shown together with green strength data for comparison in the accompanying table.

In contrast to the favorable comparison of Hububalli with Yellow Birch which is permitted on the basis of strength properties of the unseasoned wood, Hububalli is surpassed by Birch in every air-dry property except elastic resilience. The shock resistance of Hububalli is only about half that of Yellow Birch, and bending strength and stiffness are about 15-20 percent less than those of Yellow Birch. The air-dry mechanical properties of Hububalli compare closely with those of Teak in bending strength, crushing strength, stiffness, shock resistance, hardness, shear, and cleavage, and are somewhat below those of Teak in compression and tension across the grain.

Upon air drying, *Loxopterygium Sagotii* increased moderately in most properties but only in elastic resilience and shock resistance did the improvement exceed that anticipated on the basis of domestic hardwood behavior. The greatest proportional increase occurred in elastic resilience followed by proportional limit stress in static bending, crushing strength, bending strength, shear, and stiffness. Hardness and compression across the grain were virtually unaffected, and slight losses were found in tension across the grain and cleavage resistance.

As previously reported Hububalli displays variable air-seasoning characteristics. Material from British Guiana developed severe checking and slight warp while drying at

[1] *Tropical Woods* 95: 81-85.

a moderate rate. On the other hand, material from a single Surinam log dried rapidly with a minimum of checking and only slight warp. On the basis of these results the species is classed with those woods moderately difficult to season.

Decay resistance tests, supplemented by additional results obtained since the earlier report, show the heartwood of Hububalli to be very durable to durable upon exposure to a white-rot fungus and very durable in resistance to a brown rot.

The wood is only fair in weathering quality. Although remaining free from warp, unpainted material exposed to the weather lost its original surface smoothness and checked severely. Hububalli has been reported as easy to glue, but results obtained in connection with the present study indicate that special care is required in the gluing operation if the full strength of the wood is to be developed.

Potential uses of the wood were given previously (7).

VACO *Magnolia sororum* Seibert

Occurrence: In the highlands of Panama, probably extending into the mountains of Costa Rica.

The tree and wood of Vaco were described in an earlier report which also included a discussion of the properties and uses of the wood.[1] In subsequent tests, the strength properties of air-dry wood have been determined as shown in the accompanying table. Green strength properties are shown for comparison.

In the air-dry condition Vaco is surpassed by Yellow Birch in nearly all properties. Although most static-bending and compression parallel to grain properties of Vaco are only slightly below comparable values for Yellow Birch, the differences between these woods are noticeable in compression across the grain, tension across the grain, shear, cleavage, and work to maximum load. In the latter, Vaco has only half the capacity of Yellow Birch to absorb work. Vaco

[1] *Tropical Woods* 95: 85-88.

Species	Source	No. of Logs	Condition	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)*	Surinam	1	Green	99.4	0.64	0.58	5,530	9,760	1,750	1.03	8.3
			Air Dry[1]	12.2			11,210	14,630	1,680*	4.07	12.2
	British Guiana	3	Green	96.5	0.61	0.54	5,960	9,000	1,600	1.35	6.9
			Air Dry[1]	12.7			8,600	12,700	1,820	2.30	8.9
	Average	4	Green	98.0	0.62	0.56	5,740	9,380	1,680	1.19	7.6
			Air Dry[1]	12.4			9,900	13,660	1,750	3.18	10.6
Yellow Birch[2] *(Betula lutea)*	United States		Green	67	0.66	0.55	4,200	8,300	1,500	0.70	16.1
			Air Dry	12			10,100	16,600	2,010	2.89	20.8
Teak[3] *(Tectona grandis)*	Burma		Green	52	0.62	0.58	7,250	11,380	1,580	1.89	10.0
			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	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
Hububalli *(Loxopterygium Sagotii)*											
Surinam	Green	4,670	5,280	2,090	1080	1140	1020	730	1220	340	107.3
	Air Dry[1]	6,710	8,450	2,060*	1100	1160	920*	680*	1380	370	
British Guiana	Green	2,910	4,110	1,760	840	930	750	580	1180	400	114.4
	Air Dry[1]	4,380	6,390	2,110	930	910*	870	590	1480	310*	
Average	Green	3,790	4,700	1,920	960	1040	880	660	1200	370	110.8
	Air Dry[1]	5,540	7,420	2,080	1020	1040	900	640	1430	340	
Yellow Birch[2] *(Betula lutea)* United States	Green	2,620	3,380	—	810	780	530	430	1110	270	—
	Air Dry	6,130	8,170	—	1480	1260	1190	920	1880	520	
Teak[3] *(Tectona grandis)* Burma	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).
[3] A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.

is only slightly less shock resistant than Evergreen Magnolia and is superior to that wood in all other properties in static bending, compression parallel to the grain, and hardness. Vaco is somewhat below Evergreen Magnolia in compression and tension across the grain, cleavage resistance, and shear.

Upon air drying, Vaco improved markedly in a number of strength properties. Increases in shock resistance, elastic resilience, bending strength, compression parallel to grain properties, and end hardness all exceeded those generally shown by domestic hardwoods. Shear strength, side hardness, compression across the grain, and modulus of elasticity also increased in the order named, but tensile strength across the grain and cleavage resistance decreased considerably.

Completed air-seasoning studies substantiate an earlier report based on results for limited material. The wood is easily air seasoned. Drying was rapid and accompanied only by slight surface checking and slight warp.

Upon completion of decay-resistance studies, Vaco is rated very durable with respect to deterioration by both white-rot and brown-rot organisms. The weathering characteristics of Vaco are poor. Exposure of unpainted material resulted in severe surface and end checking.

Heartwood is resistant to moisture absorption, occupying a position intermediate to White Oak and Mahogany. The wood is easy to glue. The wood appears to be fair to good in steam-bending quality.

No changes are indicated in the potential uses for this species as previously given (7).

BULLETWOOD *Manilkara bidentata* (A.DC.) Chev.

Other common names: Beefwood, Horseflesh, Bolletrie, Balata, Maparajuba, Massaranduba, Ausubo, and Nispero.

Occurrence: Common in northern South America, Panama, and parts of the West Indies.

Descriptions of the tree and wood of Bulletwood together with a discussion of its properties and uses have been pre-

Species	Source	No. of Logs	Condition	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.
Vaco (*Magnolia sororum*)	Panama	3	Green	84.8	0.56	0.50	4,950	8,560	1,690	0.84	6.5
			Air Dry[1]	10.8			9,600	14,250	1,970	2.54	10.8
Yellow Birch[2] (*Betula lutea*)	United States		Green	67	0.66	0.55	4,200	8,300	1,500	0.70	16.1
			Air Dry	12			10,100	16,600	2,010	2.89	20.8
Evergreen Magnolia[2] (*Magnolia grandiflora*)	United States		Green	105	0.53	0.46	3,600	6,800	1,100	0.67	15.4
			Air Dry	12			6,800	11,200	1,400	1.90	12.8

Species	Condition	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	Green	2,610	3,590	2,060	880	860	740	860	1120	410	118.3
	Air Dry[1]	5,660	7,850	2,140	1580	1090	890	630*	1490	280*	
Yellow Birch[2] (*Betula lutea*) United States	Green	2,620	3,380	—	810	780	530	430	1110	270	—
	Air Dry	6,130	8,170	—	1480	1260	1190	920	1880	520	
Evergreen Magnolia[2] (*Magnolia grandiflora*) United States	Green	2,160	2,700	—	780	740	570	610	1040	340	—
	Air Dry	3,420	5,460	—	1280	1020	1060	740	1530	430	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).

sented previously.[1] Subsequent testing of air-dry material has now been completed with the results shown in the accompanying table. Green strength data are also included for comparison.

As in the case of strength properties in the green condition, considerable differences are shown in the air-dry properties of material from the three sources, but these are of doubtful significance and the average values presented in the table are believed to represent the species. On the basis of these average air-dry properties, Bulletwood is equal or superior to Greenheart *(Ocotea Rodiaei)* in bending strength, shock resistance, hardness, shear, and in across-the-grain properties in compression and tension. Bulletwood is slightly weaker than Greenheart in compression parallel to the grain and elastic resilience in bending, and is notably less stiff than Greenheart.

Upon air drying, Bulletwood increased substantially in all strength properties except compression perpendicular to the grain and cleavage. Greatest increases were shown in modulus of rupture, work to proportional limit, and work to maximum load in static bending, followed in order of increase by side hardness, maximum crushing strength, fiber stress at proportional limit in static bending, and shear. Increases upon drying in modulus of rupture, modulus of elasticity, hardness, and shear are generally comparable to those shown by domestic hardwoods. Notable exceptions in this respect are the large increase in work to maximum load and the relatively slight improvement in compression parallel to grain properties and fiber stress at proportional limit in static bending. Decreased strength in compression perpendicular to the grain upon drying represents a particularly outstanding difference between the behavior of Bulletwood and that of most domestic hardwoods, but it should be noted that a similar effect is shown by Greenheart.

The outstanding air-dry strength properties of Bulletwood are indicated by the following comparison with White Oak

[1] *Tropical Woods* 95: 89-93.

(Quercus alba) in which the value for the latter wood is taken as 100.

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
145	180	194	193	157

Side hardness	Shear	Bearing strength	Cleavage resistance
234	125	176	73

Comparison of the above ratios and those given previously[2] for unseasoned wood shows an increase upon drying in the ratio for shock resistance and decreases in cleavage resistance, crushing strength, and bearing strength ratios, thus illustrating the chief difference between the effect of drying upon Bulletwood and most domestic hardwoods.

As reported in an earlier phase of this study, Bulletwood is prone to check badly and to caseharden moderately in air seasoning. Warp was only slight in the material seasoned for this study. Bulletwood is a difficult wood to season and must be dried slowly in order to minimize these defects.

Heartwood of Bulletwood was found in decay-resistance tests conducted as a part of this study to be very durable with respect to deterioration by both white-rot and brown-rot fungi. Lack of appreciable resistance to marine-borer attack may be accounted for on the basis of the low silica content of the wood. Chemical analyses conducted at the Institute of Paper Chemistry show a normal ash content of 0.37 to 0.70 percent with only a slight amount of silicon as indicated by spectrographic methods (18).

The wood weathers poorly, developing severe surface checks upon exposure to the weather without protection. Results of steam-bending tests have been variable, ratings for Bulletwood ranging from fair to excellent.

No changes are indicated in the uses for which Bulletwood appears to be adapted as reported previously (7).

[2] *Tropical Woods* 95: 91.

Species	Source	No. of Logs	Condition	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.
Bulletwood											
(Manilkara bidentata)	Surinam	1	Green	44.4	1.06	0.87	12,910	18,420	2,860	2.96	14.1
			Air Dry[1]	12.3			17,600	29,000	3,840	4.50	29.2
	British Guiana	3	Green	45.5	1.04	0.88	12,740	18,430	2,890	3.12	12.6
			Air Dry[1]	14.8			14,610	28,320	3,630	3.61	34.7
	Puerto Rico	3	Green	52.9	0.98	0.80	7,700	15,080	2,340	1.45	14.0
			Air Dry[1]	12.4			12,880	24,530	2,890	3.16	21.6
	Average	7	Green	47.6	1.03	0.85	11,120	17,310	2,700	2.51	13.6
			Air Dry[1]	13.2			15,030	27,280	3,450	3.76	28.5
Greenheart[2] *(Ocotea Rodiaei)*	British Guiana		Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
			Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*
White Oak[3] *(Quercus alba)*	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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
Bulletwood *(Manilkara bidentata)* Surinam	Green	9,390	10,060	3,550	2240	2230	2940	970	1880	500	266.8
	Air Dry[1]	8,300*	11,280	3,370*	2540	3520	2940	—	2580	270*	
British Guiana	Green	7,820	9,570	2,940	2280	2430	2500	700	1980	370	274.3
	Air Dry[1]	8,900	12,510	3,640	2720	3180	2190*	1380	2430	320*	
Puerto Rico	Green	3,870	6,430	2,680	1950	2040	2010	1310	1840	580	253.2
	Air Dry[1]	6,960	11,120	3,060	2690	2860	1840*	820*	2500	400*	
Average	Green	7,030	8,690	3,060	2160	2230	2480	990	1900	480	264.8
	Air Dry[1]	8,050	11,640	3,360	2650	3190	2320*	1100	2500	330*	
Greenheart[2] *(Ocotea Rodiaei)* British Guiana	Green	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
	Air Dry[1]	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
White Oak[3] *(Quercus alba)* United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

ANGELINO ACEITUNO *Nectandra concinna* Nees

Other common names: Laurel, Aji de Monte.

Occurrence: Costa Rica, Venezuela, and Colombia.

The tree and wood of Angelino Aceituno were described in a previous publication which included a discussion of the properties and uses of the wood.[1] In the accompanying table are the results of subsequent tests conducted to determine the air-dry strength properties of the wood. Green strength values are also included for comparison.

In the air-dry condition the wood of Angelino Aceituno tested here is stronger than the wood of this species as shown in previous tests in static-bending strength, elastic resilience, shock resistance, compression parallel to the grain, and shear. Stiffness is lower than that previously reported. Angelino Aceituno compares closely with Teak in most mechanical properties including bending strength, stiffness, elastic resilience, crushing strength, hardness, compression perpendicular to the grain, shear, tension across the grain, and cleavage. It surpasses Teak in work to maximum load indicative of shock resistance. Angelino Aceituno also compares closely with Black Walnut, showing a slight advantage over Walnut in shock resistance and an appreciably greater resistance than Walnut to tension across the grain.

Upon air drying, *Nectandra concinna* showed a moderate increase in most strength properties but only work to maximum load improved to a greater extent than in most domestic hardwoods. Other properties increased in the following order: elastic resilience, proportional limit stress in static bending, compression across the grain, crushing strength, modulus of rupture, hardness, stiffness, tension across the grain, and cleavage. Shear strength remained unchanged by air drying.

On the basis of completed air-seasoning tests, Angelino Aceituno is considered easy to season. The rate of drying ranged from fast to moderate. Only slight checking was

[1] *Tropical Woods* 97: 76-80.

observed for material that dried at a moderate rate. Observations made since an earlier phase of the study indicate that the occurrence of a moderate amount of warp was restricted to material which dried very rapidly.

The wood displays good weathering characteristics, showing little change in surface smoothness or planeness and very little surface checking although end checking was noticeable in panels exposed to the weather without the protection of paint.

Potential uses for this wood remain unchanged from those previously reported (10).

DETERMA *Ocotea rubra* Mez

Other common names: Wane, Grignon Rouge, and Louro Vermelho.

Occurrence: The Guianas and lower Amazon region of Brazil.

The tree and wood of Determa were described in an earlier publication which included a discussion of the properties and uses of the wood.[1] The properties reported previously from this study were based upon tests of material from Surinam to which are now added data on the green strength properties of this species originating in British Guiana.

The wood received from British Guiana was considerably lighter and weaker than that tested earlier and consequently its inclusion lowers the species average considerably as shown in the accompanying tabulation. The average green strength of Determa is below that of Mahogany in all properties except modulus of elasticity and elastic resilience, even though Mahogany is appreciably lower in density. Differences are particularly marked in shear, hardness, compression across the grain, and work to maximum load in static bending.

Subsequent to the previous report tests have also been completed to determine the air-dry strength properties of

[1] *Tropical Woods* 95: 93-97.

Species	Source	No. of Logs	Condition	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.
Angelino Aceituno (*Nectandra concinna*)	Venezuela	2	Green	88.0	0.63	0.56	5,830	10,440	1,540	1.26	10.4
			Air Dry[1]	12.9			9,580	14,230	1,650	3.12	12.4
	Venezuela[2]	1	Green	52.0	0.60	0.49	4,200	8,200	1,550	0.73	9.3
			Air Dry[1]	14.8			7,100*	13,400*	1,910*	1.46*	10.8*
Teak[3] (*Tectona grandis*)	Burma		Green	52.0	0.62	0.58	7,250	11,380	1,580	1.89	10.0
			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*
Black Walnut[4] (*Juglans nigra*)	United States		Green	81	0.56	0.51	5,400	9,500	1,420	1.16	14.6
			Air Dry	12			10,500	14,600	1,680	3.70	10.7

Species	Condition	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
Angelino Aceituno (*Nectandra concinna*) Venezuela	Green	3,660	5,020	1,680	1020	930	710	1020	1460	430	122.6
	Air Dry[1]	4,720	7,260	1,880	1170	1060	1140	1070	1460	440	
Venezuela[2]	Green	3,990	4,990	1,550	830	620	660	1050	1070	400	—
	Air Dry[1]	4,160*	5,800*	2,270*	1210*	1010*	1030*	—	850*	—	
Teak[3] (*Tectona grandis*) Burma	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	
Black Walnut[4] (*Juglans nigra*) United States	Green	3,520	4,300	—	960	900	600	570	1220	360	—
	Air Dry	5,780	7,580	—	1050	1010	1250	690	1370	320	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.

[2]Kynoch and Norton (11).

[3]A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.

[4]U. S. Dept. Agr. Tech. Bul. 479 (12).

Determa shown in the accompanying table. Based on average air-dry values, Determa is exceeded by Mahogany in every property except stiffness. Greatest differences between these woods are indicated in shear, tension and compression across the grain, and hardness.

Upon air drying, Determa improved moderately in most properties. Only in work to maximum load did this improvement exceed that normally shown by domestic hardwoods. Other properties improved in the following order: elastic resilience, compression parallel to the grain, static-bending strength, hardness, stiffness, compression across the grain, and shear. Air drying resulted in considerable reduction in tension across the grain and cleavage resistance.

Determa is moderately difficult to air season, drying at a moderate rate with slight checking and casehardening. Moderate warp was also observed in this study. As previously reported, thick stock tends to remain moist in the center for considerable time, resulting in slight casehardening. Determa has been successfully kiln dried using a mild schedule (6).

Minor changes in shrinkage values result from completed studies of material from British Guiana. Results are shown in the accompanying tabulation:

Species and Source	SHRINKAGE (percent) Radial	Tangential	Longitudinal	Volumetric
Determa (*Ocotea rubra*) British Guiana	3.4	7.6	0.23	9.2
Species Average (British Guiana, Surinam)	3.7	7.6	0.26	10.4

Completed durability studies have resulted in minor changes from preliminary ratings. The heartwood of the species is rated very durable to durable upon exposure to a white-rot fungus. Resistance to a brown-rot fungus was variable but averaged durable. Determa is included among the woods that exhibit considerable natural resistance to marine-borer attack. In tests of small specimens exposed to

Species	Source	No. of Logs	Condition	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.
Determa (*Ocotea rubra*)	Surinam	2	Green	75.2	0.62	0.56	6,360	8,810	1,650	1.42	5.2
			Air Dry[1]	12.6			8,960	11,770	1,960	2.30	6.3
	British Guiana	3	Green	91.3	0.53	0.47	4,490	6,830	1,270	0.94	4.5
			Air Dry[1]	12.9			6,320	9,170	1,680	1.71	6.5
	Average	5	Green	83.2	0.58	0.52	5,420	7,820	1,460	1.18	4.8
			Air Dry[1]	12.8			7,640	10,470	1,820	2.00	6.4
Mahogany[2] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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
Determa (*Ocotea rubra*) Surinam	Green	3,620	4,380	2,070	540	600	700	640	910	320	74.9
	Air Dry[1]	5,240	6,690	2,130	670	740	730	400*	1100	240*	
British Guiana	Green	2,470	3,130	1,410	360	430	400	590	800	240	75.0
	Air Dry[1]	3,590	4,900	1,490	510	580	550	470*	870	210*	
Average	Green	3,040	3,760	1,740	450	520	550	620	860	280	75.0
	Air Dry[1]	4,420	5,800	1,810	590	660	640	440*	980	220*	
Mahogany[2] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

marine organisms at Harbor Island, North Carolina, heartwood showed very slight indications of attack after 10 months and moderate attack by teredo and pholads after 15 months. On the basis of these results Determa is superior to Teak. Domestic woods including Southern Pine, Douglas Fir, Red Oak, and White Oak were heavily attacked within six months in these tests (4, 5). The ash content of Determa was found to be only 0.19 percent in tests conducted at the Institute of Paper Chemsitry, and spectrographic analysis of the ash revealed only a small amount of silicon present (18).

Determa shows excellent weathering characteristics. Upon exposure of unpainted material there occurred little or no checking, no warp, and only a moderate loss of original surface smoothness. Heartwood is highly resistant to moisture absorption, surpassing Teak in this respect. The wood glues readily.

No change is indicated in potential uses for Determa as presented in an earlier report (7).

OCOTE PINE *Pinus oocarpa* Schiede

Occurrence: On upper mountain slopes and flat highlands from northwestern Mexico to central Nicaragua.

Descriptions of the tree and wood of Ocote Pine were presented in an earlier publication which also included a discussion of the properties and uses of the wood.[1] Subsequent tests of material in the air-dry condition have yielded the results shown in the accompanying table. Strength properties in the green condition are included for comparison.

Ocote Pine when air dry compares closely with Longleaf Pine in its mechanical properties. Among static-bending properties the greater stiffness of Ocote Pine is the only difference that is clearly apparent. As in the green condition, the crushing strength of Ocote Pine is intermediate to that of Longleaf and Shortleaf Pines. In compression across the grain it is exceeded by both of these southern pines, but in

[1]*Tropical Woods* 97: 80-83.

Species	Source	No. of Logs	Condition	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.
Ocote Pine (*Pinus oocarpa*)	Honduras	3	Green	40.5	0.61	0.55	5,060	7,970	1,740	0.84	6.9
			Air Dry[1]	13.5			10,010	14,870	2,250	2.47	10.9
Longleaf Pine[2] (*Pinus palustris*)[3]	United States		Green	63	0.62	0.54	5,200	8,700	1,600	0.95	8.9
			Air Dry	12			9,300	14,700	1,990	2.44	11.8
Shortleaf Pine[2] (*Pinus echinata*)	United States		Green	81	0.54	0.46	3,900	7,300	1,390	0.63	8.2
			Air Dry	12			7,700	12,800	1,760	1.93	11.0

Species	Condition	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
Ocote Pine (*Pinus oocarpa*) Honduras	Green	2,580	3,690	1,920	530	580	530	380	1040	220	119.9
	Air Dry[1]	5,590	7,680	2,210	1050	910	970	630	1720	340	
Longleaf Pine[2] (*Pinus palustris*)[3] United States	Green	3,430	4,300	—	550	590	590	330	1040	210	—
	Air Dry	6,150	8,440	—	920	870	1190	470	1500	270	
Shortleaf Pine[2] (*Pinus echinata*) United States	Green	2,500	3,430	—	410	440	440	320	850	200	—
	Air Dry	5,090	7,070	—	750	690	1000	470	1310	270	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]= *Pinus australis* Michx.

all other properties, including hardness, shear, tension across the grain, and cleavage, Ocote Pine is somewhat superior to Longleaf Pine.

Upon air drying, Ocote Pine increased substantially in all properties. With the single exception of compression across the grain, these increases were greater than the average increases shown by domestic softwoods. The greatest proportionate increase in strength occurred in elastic resilience, followed by crushing strength, fiber stress at proportional limit in static bending, modulus of rupture, compression across the grain, hardness, tension across the grain and cleavage, shear, shock resistance, and stiffness.

A previous rating of easy to air season is not altered by the completion of seasoning studies on Ocote Pine. The rate of drying is fast to moderate with a minimum of checking and only slight warp.

Completion of decay resistance tests involves a minor revision of the durability ratings for Ocote Pine. As previously reported this species is very durable in resistance to attack by a white-rot fungus, but its rating with respect to a brown rot is now shown as moderately durable. The wood does not weather well without the protection of paint or other coating due to the development of raised grain and severe surface checking.

A list of uses for which this species appears to be suitable was presented in a previous report (10).

CHUPÓN *Pouteria carabobensis* Pittier

Other common names: Chupón Torito, Taco.

Occurrence: In Venezuela from the coastal mountains of Carabobo and Yaracuy south to the Rio Apure.

The tree and wood of Chupón were described in an earlier publication which included a discussion of the properties and potential uses of the wood.[1] Tests to determine the air-dry mechanical properties of the wood have since been completed with the results shown in the accompanying table. Strength properties of the unseasoned wood are included for comparison.

[1] *Tropical Woods* 97: 84-87.

In the air-dry condition Chupón surpasses Persimmon in shock resistance (as measured by work to maximum load in static bending) and stiffness. These woods are comparable in modulus of rupture, but Persimmon is slightly superior to Chupón in shear strength and in tension across the grain, and distinctly above Chupón in compressive strength parallel and perpendicular to the grain, hardness, cleavage, and elastic resilience.

Upon air drying, Chupón increased substantially in all properties except tension across the grain and cleavage resistance. Work to maximum load and modulus of elasticity increased to a greater degree than is generally shown by domestic hardwoods. Among other properties greatest improvement was shown in compression parallel to grain, elastic resilence, static-bending strength, modulus of elasticity, shear, hardness, and compression across the grain. Substantial decreases in tension across the grain and cleavage resistance accompanied air drying.

Final observations of material undergoing air seasoning have shown a wide variance in seasoning characteristics not noted in the earlier report. Drying was fast, but was accompanied by end checking ranging from none to severe and surface checking which at times reached moderate proportions. A rating of moderately difficult to season also takes into consideration a moderate amount of warp which occurred occasionally. It is probable that more moderate drying conditions would eliminate most of these defects.

Heartwood of Chupón is durable in resisting attack by a white-rot organism and very durable with respect to a brown rot. Chupón weathers poorly, its low rating arising chiefly from the conspicuous severe surface and end checking that develops upon exposure to the weather without paint protection.

The wood is of excellent steam-bending quality on the basis of high retention of original strength and appearance.

Species	Source	No. of Logs	Condition	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.
Chupón (*Pouteria carabobensis*)	Venezuela	3	Green	63.8	0.81	0.68	5,490	11,420	1,740	1.02	12.9
			Air Dry[1]	11.1			8,400	17,770	2,320	1.74	22.1
Persimmon[2] (*Diospyros virginiana*)	United States		Green	58	0.78	0.64	5,600	10,000	1,370	1.35	13.0
			Air Dry	12			10,900	17,700	2,010	3.49	15.4

Species	Condition	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
Chupón (*Pouteria carabobensis*) Venezuela	Green	2,900	4,360	1,820	1470	1440	1200	1250	1480	580	230.4
	Air Dry[1]	4,890	7,660	2,230	1850	1800	1500	1000*	1880	430*	
Persimmon[2] (*Diospyros virginiana*) United States	Green	3,160	4,170	—	1240	1280	1110	770	1470	410	—
	Air Dry	6,390	9,170	—	2520	2300	2460	1200	2160	590	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

The potential uses previously indicated for Chupón (10) are altered by the inclusion of steam-bent applications and, on the basis of the relatively slight increase in hardness upon drying, by the exclusion of uses involving exceptional hardness.

CATIVO *Prioria Copaifera* Gris.

Other common names: Cautivo, Tremontino, Floresa, and Tabasaro.

Occurrence: Lowland areas from Nicaragua to Colombia, often in nearly pure stands.

The tree and wood of Cativo were described in an earlier publication which included a discussion of the properties and uses of the wood.[1] The air-dry strength properties of Cativo have been determined in recent tests and are presented, together with data on the green strength properties of the wood, in the accompanying table.

The air-dry properties of Cativo as determined in these tests substantiate, in general, the results of previous work by Kynoch and Norton (11). In comparison with Yellow Poplar, Cativo is slightly weaker in all properties except elastic resilience, shock resistance, and hardness. Principal differences are in stiffness (about one-third less for Cativo) and crushing strength in which Cativo is about 20 percent below Yellow Poplar. Cativo compares closely with Butternut in all air-dry mechanical properties except compressive strength parallel to the grain, which is slightly below that of Butternut, and hardness which is considerably greater in the case of Cativo.

Cativo showed a marked improvement in most properties upon air drying. Stress at proportional limit in static bending and compression parallel to the grain, elastic resilience, shock resistance, and hardness all improved to a greater extent than is generally shown by domestic hardwoods. Among other properties, greatest proportionate improvement was shown in crushing strength, followed by bending strength, shear,

[1] *Tropical Woods* 97: 87-92.

Species	Source	No. of Logs	Condition	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.
Cativo *(Prioria Copaifera)*	Panama	3	Green	81.2	0.44	0.40	3,240	5,920	940	0.57	5.4
			Air Dry[1]	10.9			6,070	8,560	1,110	1.85	7.2
	Panama[2]	1	Green	164.4	0.42	0.40	3,500	5,940	980	0.69	5.5
			Air Dry[1]	10.2			5,670	9,230	1,270	1.45	7.3
Yellow Poplar[3] *(Liriodendron tulipifera)*	United States		Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
			Air Dry	12			6,100	9,200	1,500	1.43	6.8
Butternut[3] *(Juglans cinerea)*	United States		Green	104	0.40	0.36	2,900	5,400	970	0.52	8.2
			Air Dry	12			5,700	8,100	1,180	1.59	8.2

Species	Condition	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
Cativo *(Prioria Copaifera)* Panama	Green	1,610	2,460	1,030	460	440	450	460	860	210	88.4
	Air Dry[1]	2,930	4,290	1,070	830	630	520	420*	1060	220	
Panama[2]	Green	—	2,980	—	500	490	440	470	860	240	—
	Air Dry[1]	—	5,100	—	740	550	570	480	970	260	
Yellow Poplar[3] *(Liriodendron tulipifera)* United States	Green	1,930	2,420	—	390	340	330	450	740	220	—
	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	
Butternut[3] *(Juglans cinerea)* United States	Green	2,020	2,420	—	410	390	270	430	760	220	—
	Air Dry	4,200	5,110	—	570	490	570	440	1170	220	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Kynoch and Norton (11).
[3] U. S. Dept. Agr. Tech. Bul. 479 (12).

stiffness, compression perpendicular to the grain, and cleavage resistance. A slight decrease occurred in tensile strength across the grain.

As reported previously Cativo was found to dry readily in air-seasoning tests completed as a part of the present study. Drying was rapid with only slight warp and without checking. Collapse is reported to occur sometimes in the darker streaks in the heartwood particularly during kiln drying. As noted previously, a characteristic heavy exudation of gum is an unusual difficulty encountered in drying the species.

Completion of decay resistance studies results in a rating for Cativo of moderately durable to non-durable in resistance to a white rot and an average rating of durable, although exhibiting considerable variability, with respect to a brown-rot fungus. Cativo weathers moderately well with only minor checking and no appreciable warping, although considerable loss of surface smoothness occurred upon exposure of unpainted material.

The wood is rated fair to good in steam-bending quality.

Potential uses for Cativo were pointed out in an earlier publication (10).

FRIJOLILLO *Pseudosamanea guachapele* (H.B.K.) Harms

Other common names: Cadeno, Tabaca, Guamarillo, Samanigua, and Guachapele.

Occurrence: Guatemala and Honduras to Venezuela and Ecuador.

The tree and wood of Frijolillo were described in a previous publication which included a discussion of the properties and uses of the wood.[1] Subsequent testing of air-dry material has yielded the strength data shown in the accompanying table. Strength properties in the green condition are included for comparison.

In contrast to their similarity in the green condition, Frijolillo is exceeded by White Oak in every air-dry strength

[1] *Tropical Woods* 95: 97-101.

property except stress at proportional limit in compression parallel to the grain and work to proportional limit in static bending. These two woods are also quite similar in crushing strength and proportional limit stress in static bending, but Frijolillo has only about two-thirds of the bending strength, stiffness, end hardness, compressive strength across the grain, shear, and cleavage resistance of White Oak. Shock resistance as measured by work to maximum load is less than half that of Oak.

Upon air drying, Frijolillo increased considerably in compressive strength parallel to the grain, elastic resilience, and in proportional limit stress in static bending. Only in stress at proportional limit in compression along the grain and elastic resilience did these increases exceed those shown generally by domestic hardwoods. Modulus of elasticity was not affected consistently nor were hardness and compression across the grain. Tension across the grain and cleavage resistance decreased slightly and shock resistance decreased by approximately one third upon air drying.

One of the unusual effects of drying is illustrated by the comparison of air-dry values for hardness and compression across the grain with those of Hard Maple. Whereas Frijolillo equalled or surpassed Maple in these properties while green, it shows only about two-thirds of the hardness and half the resistance to compression across the grain shown by Hard Maple when air dry.

Upon completion of air-seasoning studies Frijolillo is classed as moderately difficult to season. A moderate rate of drying resulted in variable warp and slight checking.

In durability tests completed since an earlier report, the heartwood of Frijolillo was found to be very durable to durable upon exposure to both white-rot and brown-rot fungi. Weathering resistance of Frijolillo is excellent on the basis of retention of surface smoothness and freedom from warping or checking upon exposure of unpainted material.

Frijolillo was included among a limited number of species which were subjected to chemical analysis at the Institute of

Species	Source	No. of Logs	Condition	Moisture Content (percent)	Specific Gravity: Oven-dry vol.	Specific Gravity: Green vol.	Static Bending: Fiber Stress at Proportional Limit (lb. per sq. in.)	Static Bending: Modulus of Rupture (lb. per sq. in.)	Static Bending: Modulus of Elasticity (1000 lb. per sq. in.)	Static Bending: Work to Proportional Limit (in.-lb. per cu. in.)	Static Bending: Work to Maximum Load (in.-lb. per cu. in.)
Frijolillo (*Pseudosamanea guachapele*)	Honduras	3	Green	60.4	.062	0.56	4,920	8,190	1,200	1.11	9.2
			Air Dry[1]	13.3			8,150	10,750	1,150*	2.98	6.0*
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	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)
Frijolillo (*Pseudosamanea guachapele*) Honduras	Green	2,790	3,930	1,410	1060	1030	960	710	1270	310	130.3
	Air Dry[1]	4,880	6,570	1,790	1070	1040	970	660*	1430	290*	
White Oak[2] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1960	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	—

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]Value obtained for plank material received from the New York Naval Shipyard.

Paper Chemistry. Ash content was found to be a normal 0.58 percent with only weak indications of silicon as shown by spectrographic analysis (18).

Heartwood is highly resistant to moisture absorption, and the species is rated intermediate to Teak and White Oak in this respect.

Potential uses for the species were suggested in an earlier report (7).

SANGRE *Pterocarpus vernalis* Pittier

Other common names: Sangre de Drago, Lagunero, Mucunana.

Occurrence: Common on abandoned agricultural lands and cut-over forest areas in Venezuela.

The tree and wood of Sangre were described in a previous publication which included a discussion of the properties and potential uses of the wood.[1] The properties of the air-dry wood have been determined in subsequent tests and are reported in the accompanying table. Green strength properties are included for comparison.

In its air-dry strength properties Sangre compares favorably with White Ash in bending strength, stiffness, elastic resilience, shock resistance, compressive strength parallel to the grain, and side hardness. It is below White Ash, however, in compression and tension across the grain and resistance to cleavage.

Upon air drying, Sangre improved substantially in most strength properties showing increases equal to or greater than those shown by most domestic hardwoods in work to maximum load, modulus of rupture, and hardness. Among other properties, greatest proportionate increase was shown in elastic resilience, followed by compressive strength parallel to the grain, proportional limit stress in static bending, stiffness, and compresssion across the grain. Tensile strength

[1]*Tropical Woods* 97: 92-95.

Species	Source	No. of Logs	Condition	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.
Sangre *(Pterocarpus vernalis)*	Venezuela	3	Green	62.0	0.65	0.57	5,600	9,580	1,580	1.13	8.9
			Air Dry[1]	11.4			9,060	16,020	2,000	2.41	19.9
White Ash[2] *(Fraxinus americana)*	United States		Green	42	0.64	0.55	5,100	9,600	1,460	1.04	16.6
			Air Dry	12			8,900	15,400	1,770	2.60	17.6

Species	Condition	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
Sangre *(Pterocarpus vernalis)* Venezuela	Green	3,040	4,140	1,820	1020	980	920	900	1220	460	220.5
	Air Dry[1]	5,140	7,390	1,890	1570	1330	1120	400*	1710	260*	
White Ash[2] *(Fraxinus americana)* United States	Green	3,190	3,990	—	1010	960	810	590	1380	330	—
	Air Dry	5,790	7,410	—	1720	1320	1410	940	1950	480	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).

across the grain and cleavage resistance showed marked decreases upon air drying.

On the basis of completed seasoning studies, Sangre is relatively easy to air season. Rapid drying was associated with moderate warp and by slight checking and casehardening.

Sangre is only fair in its resistance to weathering. Severe surface checking developed rather quickly upon exposure of unpainted material. The wood has excellent steam-bending characteristics.

The potential uses for the wood proposed in an earlier report are substantiated by the data presented here (10).

GRONFOELOE *Qualea albiflora* Warm

Other common names: Wiswiskwalie, Meniridan, Jakopie, Mandioqueira, Cèdre Gris, Grignon Fou, and Florecillo.

Occurrence: The Guianas and the Amazon valley.

The tree and wood of Gronfoeloe were described in a previous publication which included a discussion of the properties and uses of the wood.[1] Subsequent testing of the wood in the air-dry condition has resulted in the strength values shown in the accompanying table. Green strength values are included for comparison.

Both *Qualea albiflora* and Wiswiskwalie *(Qualea* sp.) were included in the air-dry testing with generally similar results. Average values are considered as representative of these species. With the exception of work to maximum load, the static-bending properties of air-dry Gronfoeloe are similar to those of Yellow Birch which is a considerably denser wood. Gronfoeloe is characterized by only one-half the shock-resisting ability shown by Yellow Birch. Gronfoeloe surpasses Birch in compressive strength parallel to the grain and is essentially equal to Birch in end hardness, but is exceeded by Birch in shear, side hardness, compression perpendicular to the grain, and particularly in tension perpendicular to the grain and cleavage resistance.

[1]*Tropical Woods* 97: 96-100.

Species	Source	No. of Logs	Condition	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.
Simaruba (*Simaruba amara*)	Surinam	2	Green	69.2	0.40	0.38	3,900	6,310	1,140	0.76	4.5
			Air Dry[1]	12.2			6,280	8,930	1,240	1.78	5.8
Yellow Poplar[2] (*Liriodendron tulipifera*)	United States		Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
			Air Dry	12			6,100	9,200	1,500	1.43	6.8

Species	Condition	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
Simaruba (*Simaruba amara*) Surinam	Green	2,340	2,970	1,240	510	390	380	560	790	230	65.8
	Air Dry[1]	3,690	4,840	1,360	690	440	600	390*	1160	250	
Yellow Poplar[2] (*Liriodendron tulipifera*) United States	Green	1,930	2,420	—	390	340	330	450	740	220	—
	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

to Yellow Poplar in bending strength, stiffness, shock resistance, crushing strength, and in tension and cleavage resistance across the grain. Simaruba slightly exceeds Yellow Poplar, however, in proportional limit stresses in static bending and comparison parallel to the grain, end hardness, and shear. These woods are comparable in side hardness and compression across the grain.

Upon air drying, Simaruba showed a substantial improvement in most of its strength properties but only in work to maximum load and shear strength did this improvement exceed that shown by most domestic hardwoods. Greatest improvement was shown in elastic resilience followed by crushing strength, proportional limit stresses in bending and in compression along the grain, compression across the grain, shear, modulus of rupture, hardness, modulus of elasticity, and cleavage. Strength in tension across the grain was substantially reduced as a result of air drying.

Results of the present study, supplemented by additional material since an earlier report, show the wood to be easy to air season. Rapid drying was accompanied by only slight end checking. This is in contrast to the reputed tendency to split which has been reported in the case of wide boards. Precautions should be taken to avoid staining of the sapwood during air seasoning.

Completed durability studies show decay resistance of Simaruba to be extremely variable, but averaging moderately durable with respect to a white-rot fungus and durable in resistance to a brown-rot organism. The wood is rated fair in weathering resistance. Although remaining free of warp and retaining surface smoothness, severe surface and end checking occurred upon exposure of unpainted material.

The potential uses for Simaruba suggested in an earlier report remain unaltered (10).

MAHOGANY *Swietenia macrophylla* King

The Mahogany logs used in this study came from young plantation-grown trees in Honduras. The properties and potential uses for such material were discussed in an earlier publication.[1] The mechanical properties of the air-dry wood have subsequently been determined and are presented, together with green strength data for comparison, in the accompanying table.

In most air-dry properties young plantation-grown Mahogany is surpassed by the slightly heavier wood typical of forest-grown Mahogany. Static-bending strength and crushing strength are lower for plantation-grown material approximately in proportion to its lower density. Modulus of elasticity is, however, very much lower in the case of plantation-grown material than for representative forest-grown timber. The two types of Mahogany are equivalent in shock resistance, and the plantation-grown wood shows greater values for side hardness, compression across the grain, and shear than does forest-grown material. Plantation-grown wood is apparently deficient in tension across the grain and cleavage resistance.

Upon air drying, young plantation-grown Mahogany increased moderately in a number of properties but in no respect did the improvement equal that shown generally by domestic hardwoods. Greatest proportionate increase occurred in elastic resilience, followed by compression parallel to the grain, proportional limit stress in static bending, modulus of rupture, and compression across the grain. Modulus of elasticity, shock resistance, shear strength, and cleavage resistance were virtually unaffected by air drying, but decreases occurred in hardness and tensile strength across the grain. Except for the comparatively slight improvement in compression across the grain observed in these tests, the effects of air drying are generally about the same for plantation-grown and typical forest-grown timber.

[1] *Tropical Woods* 95: 101-104.

Air seasoning of the plantation-grown material was rapid with a minimum of defect. Only slight crook or bow was observed.

In decay resistance tests conducted as part of this study, plantation-grown Mahogany is rated very durable to durable in resistance to a white rot. As previously reported, it was consistently very durable with respect to a brown-rot organism.

Plantation-grown Mahogany heartwood is moderate in moisture absorption and appears to be comparable to forest-grown Mahogany in this respect. It is moderately easy to glue.

The potential uses for this type of Mahogany as listed in an earlier publication remain unchanged (7).

PRIMAVERA *Tabebuia Donnell-Smithii* Rose

Other common names: Palo Blanco, San Juan.

Occurrence: Southern Mexico, Guatemala, Salvador, and Honduras.

The tree and wood of Primavera were described in a previous publication which included a discussion of the properties and uses of the wood.[1] The properties of the air-dry wood have been determined as a result of subsequent testing and are presented, together with the green strength properties for comparison, in the accompanying table.

As previously noted in the discussion of the properties of the unseasoned wood, the material studied, although of comparable density, is considerably weaker than Primavera wood from Honduras as reported by Heck (9). This is equally true of the air-dry strength properties. Comparing Yale results for Primavera with data on Mahogany, it is evident that Primavera is surpassed by Mahogany in nearly all properties. Only in elastic resilience and shearing strength does Primavera exceed Mahogany. These woods are similar in shock resistance. Differences in crushing strength, bending

[1] *Tropical Woods* 95: 104-108.

Species	Source	No. of Logs	Condition	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	Green	50.7	0.46	0.42	5,080	8,350	1,140	1.14	7.3
			Air Dry[1]	13.4			7,620	10,310	1,150	2.52	7.5
Mahogany (*Swietenia macrophylla*)	Central America[2]	1+	Green	—	0.52	0.46	5,270	8,830	1,280	1.24	8.8
			Air Dry[1]	11.6			7,300	11,400	1,520	2.03	6.6*
	Central America[3]		Green	58	0.50	0.45	6,120	9,240	1,290	—	10.2
			Air Dry	12			8,810	11,140	1,430	—	6.8
	Mexico, Nicaragua[4]		Green	101.2	0.50	0.45	5,100	8,800	1,460	1.02	8.4
			Air Dry[1]	10.6			7,760	11,840	1,540	2.12	9.2
	Average		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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	Green	2,730	3,500	1,040	1160	1090	1090	750	1500	280	84.3
	Air Dry[1]	4,210	5,680	1,200	1000*	980*	1250	620*	1510	280	
Mahogany (*Swietenia macrophylla*) Central America[2]	Green	2,900	3,940	1,470	890	750	630	700	1330	320	88.2
	Air Dry[1]	5,340	7,010	1,470*	940	840	1160	780	1380	330	
Central America[3]	Green	—	4,540	—	750	650	710	—	1310	—	—
	Air Dry	—	6,430	—	880	760	1210	—	1050	—	
Mexico, Nicaragua[4]	Green	3,250	4,530	1,570	810	820	700	770	1080	340	—
	Air Dry[1]	4,830	6,910	1,530*	1080	790*	910	710*	1260	360	
Average	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Based on a shipment of plank material representing an unknown number of trees.
[3] Heck (9).
[4] Kynoch and Norton (11).

Species	Source	No. of Logs	Condition	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.
Primavera (*Tabebuia Donnell-Smithii*)	Honduras	3	Green	57.7	0.44	0.40	4,170	7,180	990	0.99	7.2
			Air Dry[1]	14.0			7,310	9,530	1,040	2.90	6.4*
	Honduras[2]		Green	66	0.44	0.40	6,220	9,940	1,200	—	13.0
			Air Dry	12			7,840	11,100	1,280	—	9.2
Holly[3] (*Ilex opaca*)	United States		Green	82	0.61	0.50	3,400	6,500	900	0.72	10.8
			Air Dry	12			6,100	10,300	1,110	1.88	10.7
Mahogany[4] (*Swietenia macrophylla*)	Central America		Green	79.6	0.51	0.45	5,500	8,960	1,340	1.13	9.1
			Air Dry[1]	11.4			7,960	11,460	1,500	2.08	7.5

Species	Condition	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
Primavera (*Tabebuia Donnell-Smithii*) Honduras	Green	2,850	3,510	1,050	810	700	800	720	1030	320	74.8
	Air Dry[1]	4,530	5,600	1,270	910	660*	880	440*	1390	240*	
Honduras[2]	Green	—	4,280	—	720	590	690	—	—	—	—
	Air Dry	—	6,460	—	1060	730	1140	—	—	—	
Holly[3] (*Ilex opaca*) United States	Green	2,050	2,640	—	860	790	610	610	1130	360	—
	Air Dry	3,380	5,540	—	1400	1020	1130	680	1710	—	
Mahogany[4] (*Swietenia macrophylla*) Central America	Green	3,080	4,340	1,520	820	740	680	740	1240	330	88.2
	Air Dry[1]	5,080	6,780	1,500*	970	800	1090	740	1230	340	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Heck (9).
[3] U. S. Dept. Agr. Tech. Bul. 479 (12).
[4] Heck (9); Kynoch and Norton (11); unpublished Yale results for plank material received from the New York Naval Shipyard.

strength, compression across the grain, and hardness are not great, but Mahogany is 50 percent higher than Primavera in stiffness. Although quite comparable to Holly in bending strength, stiffness, and crushing strength, Primavera is considerably below Holly in air-dry hardness and compression across the grain.

Upon air drying, Primavera increased moderately in a number of properties, but only in elastic resilience did this increase exceed that commonly shown by domestic hardwoods. Among other properties greatest relative improvement was shown in proportional limit stress in static bending, crushing strength, shear, bending strength, compression across the grain, and stiffness. Hardness was not appreciably affected, and shock resistance, cleavage, and tension across the grain all declined upon air drying.

The wood was found to be easy to air season, drying rapidly with no checking and only slight crook or bow and twist.

The heartwood of Primavera proved to be very durable to durable upon exposure to both white-rot and brown-rot fungi. Primavera shows good weathering characteristics. Exposure of unpainted material resulted in moderate loss of surface smoothness and a moderate amount of checking.

Heartwood is resistant to moisture absorption, occupying a position intermediate to White Oak and Mahogany. The wood is easy to glue.

No change is indicated in the uses proposed earlier for this species (7).

GUAYACÁN

Tabebuia guayacan (Seem.) Hemsl.
Tabebuia heterotricha (DC.) Hemsl.

Other common names: Cortez, Amapa Prieta, Verdecillo, and Mayflower.

Occurrence: Southern Mexico through Central America to Colombia and Venezuela. Other similar species of *Tabebuia* occur as far south as Argentina.

The tree and wood of these species were described in earlier publications which included discussion of the properties and uses of the wood.[1] In subsequent tests the mechanical properties of air-dry wood were determined and are presented in the accompanying table. Included for comparison are the properties of the green wood.

In the air-dry condition the average properties of Guayacán are slightly below those of Greenheart *(Ocotea Rodiaei)* in static-bending strength, elastic resilience, and maximum crushing strength. Guayacán is considerably lower than Greenheart in stiffness and tension across the grain, but exceeds Greenheart in shock resistance, hardness, compression across the grain, and shear strength.

Guayacán surpasses White Oak by a considerable margin in most air-dry properties. The following tabulation, based upon a scale of 100 for White Oak, permits a comparison of more important properties:

Specific gravity	Bending strength	Stiffness	Shock resistance	Crushing strength
137	164	148	165	157

Side hardness	Shear	Bearing strength	Cleavage resistance
238	124	173	87

The greater weight for weight strength of Guayacán in all properties except shear and cleavage resistance is evident. This is especially true of hardness.

Upon air drying, Guayacán improved only slightly in most properties. Only in work to maximum load did the

[1] *Tropical Woods* 95: 108-112; 97: 104-108.

Species	Source	No. of Logs	Condition	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	Green	35.4	1.00	0.85	11,060	18,480	2,580	2.71	18.7
			Air Dry[1]	13.6			15,820	27,150	2,970	3.74	22.9
(Tabebuia heterotricha)	Panama	3	Green	40.5	0.91	0.80	10,880	20,080	2,120	3.31	27.3
			Air Dry[1]	12.4			12,650	22,630	2,320	3.86	26.0*
	Average	6	Green	38.0	0.96	0.82	10,970	19,280	2,350	3.01	23.0
			Air Dry[1]	13.0			14,240	24,890	2,640	3.80	24.4
Greenheart[2] *(Ocotea Rodiaei)*	British Guiana		Green	42.7	1.06	0.88	13,250	19,550	2,970	3.31	13.4
			Air Dry[1]	14.8			16,200*	25,500*	3,700*	4.02*	22.0*
White Oak[3] *(Quercus alba)*	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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)	Green	7,730	9,740	2,910	2820	3140	2390	990	2230	510	286.3
Honduras	Air Dry[1]	7,570*	12,470	3,010	3240	3480	2200*	820*	2710	480*	
(Tabebuia heterotricha)	Green	6,600	7,680	2,540	2270	2530	1430	1170	2140	490	343.0
Panama	Air Dry[1]	7,000	10,930	2,460*	3160	3010	2360	540*	2280	300*	
Average	Green	7,160	8,710	2,720	2540	2840	1910	1080	2180	500	314.6
	Air Dry[1]	7,290	11,700	2,740	3200	3240	2280	680*	2490	390*	
Greenheart[2]											
(Ocotea Rodiaei)	Green	7,580	10,160	3,580	2260	2320	2040	1070	1730	610	—
British Guiana	Air Dry[1]	10,000*	12,920*	4,160*	2140*	2630*	1970*	1020*	1830*	—	
White Oak[3]											
(Quercus alba)	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
United States	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Kynoch and Norton (11).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

increase equal that shown by most domestic hardwoods. Greatest proportionate increase occurred in maximum crushing strength, followed by static-bending strength, elastic resilience and end hardness, compression across the grain, side hardness, shear, and stiffness. Tensile strength across the grain and cleavage resistance decreased markedly upon air drying.

The two species of Guayacán show somewhat different air-seasoning characteristics. Only slight checking, warp, and casehardening were observed in *Tabebuia heterotricha* despite its rapid rate of drying and resulted in the rating of this species as easy to season. Slight warp, accompanied by severe surface checking and moderate end checking, was observed for *T. guayacan*. This species varied from fast to moderate in rate of drying. Severe casehardening was also noted in some of the material seasoned as a part of this study. A rating of moderately difficult to season was consequently assigned to *T. guayacan*.

Ash content of Guayacán was found to be only 0.33 percent in analysis made at the Institute of Paper Chemistry. Spectrographic analysis for mineral components of the ash showed only small amounts of silicon (18).

Some variability has been noted in the weathering characteristics of Guayacán. Unpainted specimens exposed to the weather remained free from warp and retained a generally smooth surface, but varied in resistance to checking from fair to excellent.

Both *T. guayacan* and *T. heterotricha* are extremely resistant to moisture absorption and surpass Teak in this respect. Guayacán does not appear to be well adapted to steam bending on the basis of tests in which ratings of poor to fair were assigned on the basis of proportion of original strength retained by the bent material. The latter characteristic does not appear to be consistent with the reported use of Guayacán for bent boat ribs in the tropics.

Uses for which Guayacán appears to be adapted on the basis of its properties remain unchanged from those listed previously (7, 10).

ROBLE BLANCO *Tabebuia pentaphylla* (L.) Hemsl.

Other common names: Roble, Amapa, Rosa Morado, Mayflower, Maqueliz, Roble Morado, and Apamate.

Occurrence: Mexico, Central America, Ecuador, Colombia, Venezuela, and the West Indies.

Descriptions of the tree and wood of Roble Blanco were published in an earlier report which included a discussion of the properties and uses of the wood.[1] Later tests of green wood have included material from Panama, results of which are shown in the accompanying table and have been included in computing the average values for the species. Inclusion of the data for this additional source brought about only a slight increase in most parallel-to-grain properties and a slight reduction in the across-the-grain properties in the green condition.

Air-dry mechanical tests have also been conducted since the previous report and results are presented in the accompanying table together with green strength properties for comparison. In the air-dry condition the Roble Blanco tested here was slightly less stiff but stronger in all properties except compression across the grain than Venezuelan material previously tested (11). In comparison with the heavier woods, White Ash and White Oak, air-dry Roble Blanco is deficient in all properties except those indicative of compressive strength along the grain (including proportional limit stress in static bending) and elastic resilience. Roble Blanco is only slightly below both of these woods in modulus of elasticity and is nearly comparable to White Oak in shock resistance. The most notable differences between Roble Blanco and Oak and Ash occur in side hardness, compression perpendicular to the grain, tension perpendicular to the grain, cleavage, and shear. Roble Blanco is similar to Black Walnut in many of its mechanical properties. These woods are comparable in density, bending strength, stiffness, crushing strength, side hardness, and shear. Roble Blanco is slightly favored in shock resistance and Walnut is somewhat

[1] *Tropical Woods* 95: 112-116.

Species	Source	No. of Logs	Condition	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.
Roble Blanco (*Tabebuia pentaphylla*)	British Honduras	3	Green	67.4	0.59	0.54	6,060	9,720	1,270	1.62	10.6
			Air Dry[1]	13.5			8,870	14,050	1,500	2.93	16.6
	Honduras	3	Green	65.8	0.56	0.51	6,230	11,190	1,470	1.47	11.9
			Air Dry[1]	13.7			9,970	13,500	1,520	3.69	11.1*
	Panama	3	Green	71.4	0.55	0.50	7,520	11,400	1,610	1.98	12.5
			Air Dry[1]	13.3			9,600	13,800	1,770	2.93	9.9*
	Average	9	Green	68.2	0.57	0.52	6,600	10,770	1,450	1.66	11.7
			Air Dry[1]	13.5			9,480	13,780	1,600	3.18	12.5
	Venezuela[2]	1	Green	107.8	0.50	0.45	6,000	9,600	1,620	1.24	7.2
			Air Dry[1]	14.6			7,300*	12,500*	1,750*	1.70*	9.4*
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
White Ash[3] (*Fraxinus americana*)	United States		Green	42	0.64	0.55	5,100	9,600	1,460	1.04	16.6
			Air Dry	12			8,900	15,400	1,770	2.60	17.6

Species	Condition	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
Roble Blanco (*Tabebuia pentaphylla*)											
British Honduras	Green	3,490	4,650	1,470	1070	950	980	900	1340	390	171.1
	Air Dry[1]	5,210	7,260	1,580	1560	1140	950*	530*	1650	260*	
Honduras	Green	4,240	4,780	1,580	1120	970	750	710	1240	430	129.2
	Air Dry[1]	5,900	7,190	1,650	1270	920*	1070	510*	1480	220*	
Panama	Green	4,400	5,310	1,480	900	820	640	760	1180	310	140.8
	Air Dry[1]	6,550	7,580	2,000	1100	810*	790	630*	1210	330	
Average	Green	4,040	4,910	1,510	1030	910	790	790	1250	380	147.0
	Air Dry[1]	5,890	7,340	1,740	1310	960*	940	560*	1450	270*	
Venezuela[2]	Green	4,410	5,030	1,650	910	670	610	670	1100	320	—
	Air Dry[1]	4,630*	6,010*	2,230*	1040*	700*	1000*	—	810*	—	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
White Ash[3] (*Fraxinus americana*) United States	Green	3,190	3,990	—	1010	960	810	590	1380	330	—
	Air Dry	5,790	7,410	—	1720	1320	1410	940	1950	480	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] Kynoch and Norton (11).
[3] U. S. Dept. Agr. Tech. Bul. 479 (12).
[4] Value obtained for plank material received from the New York Naval Shipyard.

superior in tension and compression across the grain and cleavage resistance.

Upon air drying, Roble Blanco increased moderately in most strength properties, but in no instance was the improvement equal to that shown by most domestic hardwoods. Greatest proportionate increase was shown in elastic resilience, followed by compression parallel to grain, proportional limit stress in bending, modulus of rupture, end hardness, compression perpendicular to the grain, shear, stiffness, shock resistance, and side hardness. Cleavage resistance and tension across the grain were reduced about 30 percent as a result of air drying.

Completed results of air-seasoning studies do not alter a previous rating of easy to season. Drying was rapid with only slight checking and warp. Such defects could doubtless be further minimized through slower drying.

Shrinkage data previously reported are little changed by the addition of results for material from Panama. Results are outlined in a table presented below:

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Roble Blanco (*Tabebuia pentaphylla*)				
Panama	3.6	6.2	0.09	10.4
Species Average (Panama, Honduras, British Honduras)	3.6	6.1	0.14	9.5
Venezuela[1]	2.6	5.9	—	9.3

[1]Kynoch and Norton (11).

Earlier decay-resistance data are now supplemented on the basis of additional material. Heartwood was found to be variable in resistance to a white-rot fungus but is given an average rating of moderately durable. The wood was shown to be very durable in its resistance to a brown rot. Roble Blanco is rated only fair in its weathering characteristics. Unpainted material remained free from warp but lost surface smoothness and developed considerable checking upon exposure to the weather.

Heartwood absorbs moisture readily. Variability in steam-bending quality is apparent, and the wood has been variously rated as poor to good in this respect.

Some modifications of potential uses for this species as previously listed, eliminating uses involving outstanding weathering characteristics and exceptional shock resistance, are indicated (7).

TEAK *Tectona grandis* L.f.

The Teak referred to in this study is young plantation-grown material from Honduras. The wood was described in an earlier publication which included a discussion of its properties and potential uses.[1] Mechanical tests have now been completed on air-dry wood with the results shown in the accompanying table. Green strength values are included for comparison.

The air-dry strength values of plantation-grown Teak compare closely with those of forest-grown Burma Teak. Test material from Honduras was slightly stronger than Burma Teak in compression across the grain, shear, cleavage, and toughness; slightly lower in stiffness, crushing strength, and tension across the grain. In other properties both woods are similar.

Plantation-grown Teak showed only relatively slight improvement in most of its properties upon air drying. In no respect did this improvement equal that shown generally by domestic hardwoods. Greatest proportionate increase occurred in elastic resilience, followed by crushing strength, bending strength, cleavage resistance, compression across the grain, and stiffness. End hardness was unchanged by air drying, but side hardness showed a decrease as did shock resistance, tension across the grain, and shear strength.

As reported previously plantation-grown Teak air seasons at a rapid rate without defect.

The plantation-grown wood displays excellent weathering characteristics from the standpoint of surface smooth-

[1]*Tropical Woods* 95: 116-119.

Species	Source	No. of Logs	Condition	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	Green	72.3	0.59	0.56	6,160	9,940	1,350	1.59	10.9
			Air Dry[1]	12.6			8,430	13,310	1,390	2.92	10.3*
Teak (*Tectona grandis*)	Burma[2]	1+	Green	—	0.61	0.57	7,410	11,330	1,480	2.08	10.7
			Air Dry[1]	10.4			8,160	13,240	1,490	2.51	9.3*
	Burma[3]		Green	52	0.64	0.60	7,090	11,440	1,670	1.7	9.3
			Air Dry[1]	12			—	14,300	1,850	—	—
	Average		Green	52	0.62	0.58	7,250	11,380	1,580	1.89	10.0
			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	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	Green	3,960	4,780	1,350	1140	1290	1290	940	1730	390	116.2
	Air Dry[1]	5,300	6,770	1,510	1140	1110*	1340	770*	1600*	470	
Teak (*Tectona grandis*) Burma[2]	Green	4,160	5,110	1,580	890	920	1030	960	1490	420	84.4
	Air Dry[1]	5,180	6,710	1,500*	950	1080	1190	980	1380*	340*	
Burma[3]	Green	4,080	5,870	1,940	920	1040	1060	—	1110	—	—
	Air Dry[1]	—	8,320	—	1070	1130	—	—	1350	—	—
Average	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Based on a shipment of plank material representing an unknown number of trees.
[3]A. V. Thomas (15); Handbook of Empire Timbers (8).

ness, and freedom from warp and checking when exposed to the weather without paint protection.

The heartwood of plantation-grown stock is comparable to forest-grown Teak in its high degree of resistance to moisture absorption. The wood is moderately easy to glue.

No change in potential uses is indicated from those listed previously (7).

NARGUSTA *Terminalia amazonia* (Gmel.) Exell

Other common names: Cochun, Bolador, Guayabo, Naranjo, Amarillo, Fukadi, and White Olivier.

Occurrence: From southern Mexico throughout Central America and northern South America and in Trinidad.

The tree and wood of Nargusta were described in a previous publication which also included a discussion of the properties and uses of this wood.[1] Subsequent testing of air-dry material from British Guiana, British Honduras, and Panama produced the results shown in the accompanying table. The table also includes green strength data for Nargusta from Panama in addition to the sources represented in the earlier tests.

The wood from Panama was found to be slightly lower in density than that from British Honduras but not appreciably weaker in the green condition except in crushing strength and compression across the grain. The Panama material was particularly low in compression perpendicular to the grain in these tests. Inclusion of data for Nargusta from Panama in the average for the species results in a slight lowering of previously reported values for most properties. These results confirm the work of others insofar as the variability of this species is concerned.

The variability of Nargusta is also evident in its air-dry properties. The strength of the wood from the several sources tested varies generally according to its density, but low compressive strength across the grain of the Panama material appears to be an exception to this generalization.

[1]*Tropical Woods* 95: 119-124.

On the basis of average air-dry strength values, Nargusta is 15-30 percent stronger than White Oak in bending and crushing strength, stiffness, and hardness; comparable to Oak in shock resistance and shearing strength; and somewhat below Oak in compression across the grain, tension across the grain, and cleavage. Insofar as available data permit comparison, these average air-dry values lie between those published for Nargusta from British Honduras and Trinidad.

Upon air drying, Nargusta showed considerable improvement in most properties but only in work to maximum load did the increase exceed that generally shown by domestic hardwoods. Greatest improvement in other properties occurred in elastic resilience and crushing strength followed by bending strength, shear, side hardness and compression across the grain. In both tension across the grain and cleavage, Nargusta lost strength on drying.

Considerable variation in air-seasoning characteristics was shown by material from different sources. Nargusta from British Honduras and Panama dried rapidly with only slight checking and warp. Completed studies for material from British Guiana indicate an even greater variation than previously reported. Moderate rate of drying was accompanied by moderate to severe checking and slight twist. A rating of moderately difficult to season is given the species, although no difficulty was encountered in drying the material from Panama and British Honduras.

The inclusion of shrinkage data for material from Panama results in little change in the average for the species reported in an earlier phase of this study. The data are shown in the accompanying table.

Species and Source	Shrinkage (percent)			
	Radial	Tangential	Longitudinal	Volumetric
Nargusta (*Terminalia amazonia*)				
Panama	4.3	7.7	0.17	12.5
Species Average (Panama, British Guiana, British Honduras)	4.8	7.9	0.18	12.7
British Honduras[1]	4.8[2]	9.4[2]		
Trinidad[1]	6.0[2]	10.6[2]		

[1]Handbook

Species	Source	No. of Logs	Condition	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	Green	64.2	0.82	0.70	9,160	14,980	2,620	1.81	13.8
			Air Dry[1]	12.9			13,160	21,050	2,990	3.22	20.8
	British Honduras	3	Green	80.4	0.71	0.63	7,130	10,470	1,700	1.77	8.9
			Air Dry[1]	14.3			10,390	16,980	2,020	2.98	14.1
	Panama	3	Green	57.4	0.67	0.60	6,830	10,940	1,710	1.53	13.9
			Air Dry[1]	11.4			10,390	15,220	1,900	3.27	14.3
	Average	9	Green	67.3	0.73	0.64	7,710	12,130	2,010	1.70	12.2
			Air Dry[1]	12.9			11,310	17,750	2,300	3.16	16.4
	Trinidad[2]	—	Green	51	—	0.70	—	14,200	2,200	—	—
			Air Dry	12			—	18,800	2,470	—	
	British Honduras[2]	—	Green	83	—	0.58	—	11,700	1,830	—	—
			Air Dry	12			—	17,500	2,070	—	
White Oak[3] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8

Species	Condition	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	Green	5,340	6,820	2,970	1640	1670	1310	1110	1700	440	212.1
	Air Dry[1]	8,130	10,560	3,270	2110	1990	1430	1080*	2220	340*	
British Honduras	Green	4,050	5,110	1,950	1270	1220	1200	660	1290	390	184.6
	Air Dry[1]	7,220	9,930	2,250	2160	1580	1270	470*	1810	240*	
Panama	Green	3,920	4,660	1,760	1160	1080	660	790	1330	360	164.5
	Air Dry[1]	5,490	8,130	2,040	1710	1270	980	470*	1830	220*	
Average	Green	4,440	5,530	2,230	1360	1320	1060	850	1440	400	187.1
	Air Dry[1]	6,950	9,540	2,520	1990	1610	1230	670*	1950	270*	
Trinidad[2]	Green	—	7,330	—	1610	1580	—	—	1750	490	—
	Air Dry	—	10,600		2550	2100	—	—	2280	260	
British Honduras[2]	Green	—	5,530	—	1250	1130	—	—	1460	470	—
	Air Dry	—	9,380		1900	1390	—	—	1910	370	
White Oak[3] (*Quercus alba*) United States	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[4]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]Handbook of Empire Timbers (8).
[3]U. S. Dept. Agr. Tech. Bul. 479 (12).
[4]Value obtained for plank material received from the New York Naval Shipyard.

Durability data now available for material from Panama and British Honduras alter the conclusions reported previously. The heartwood of Nargusta was found to be predominantly very durable in resistance to both white-rot and brown-rot fungi. Nargusta is only fair in its resistance to weathering when exposed without paint protection. Considerable checking and loss of surface smoothness occurred under such conditions.

Heartwood is moderately resistant to moisture absorption, occupying a position intermediate to White Oak and Mahogany in this respect. The wood is moderately easy to glue. It is only fair in steam-bending quality.

Suggested uses for Nargusta listed in a previous report are altered only by the indicated elimination of uses involving superior weathering qualities (7).

GUAYABO DE MONTE *Terminalia guyanensis* Eichl.

Other common name: Guayabo.

Occurrence: Common in the monsoon forests of Venezuela.

The tree and wood of Guayabo de Monte were described in an earlier report which included a discussion of the properties and possible uses of the wood.[1] Subsequently, tests have been conducted to determine the mechanical properties of air-dried material. Results are shown in the accompanying table together with green properties which are included for comparison.

In the air-dry condition Guayabo is appreciably weaker than the closely related Nargusta *(Terminalia amazonia)* in all strength properties, averaging about two-thirds as strong as the heavier Nargusta in static-bending and compression parallel to grain properties. In comparison with Teak, air-dry Guayabo de Monte is slightly lower in static-bending properties (except work to maximum load), compression parallel to the grain, side hardness, and compression across the grain. Guayabo is definitely below Teak in tension perpendicular to the grain and cleavage resistance, but surpasses Teak in end hardness and shear. Hard Maple exceeds Guayabo de Monte in all air-dry properties, particularly in shock resistance, hardness, compression across the grain and shear.

[1] *Tropical Woods* 97: 108-112.

Upon air drying, Guayabo de Monte improved moderately in most strength properties, exceeding the increase shown generally by domestic hardwoods only in work to maximum load. Among other properties, greatest proportionate increase was shown in elastic resilience, followed by maximum crushing strength, compression across the grain, proportional limit stresses in compression parallel to grain and static bending, end hardness, shear, stiffness, and side hardness. In tension across the grain and cleavage resistance the air-dry wood was much weaker than unseasoned wood.

As reported in an early phase of the study, the wood of Guayabo de Monte proved to be easy to air season. A fast rate of drying resulted in only slight checking and slight warp.

Upon completion of decay resistance studies the heartwood is rated durable in its resistance to a white rot and very durable with respect to a brown-rot fungus. When subjected to weathering in an unpainted condition, the wood checks considerably and loses surface smoothness. It is rated fair in weathering quality. Heartwood absorbs moisture readily.

No change is indicated in the previously published uses for which this species is adapted (10).

MASA *Tetragastris balsamifera* (Sw.) Kuntze

Other common names: Palo Cochino, Bois Cochon, and Amacey.

Occurrence: West Indies.

The tree and wood of Masa were described in a previous publication which included a discussion of the properties and uses of the wood.[1] The strength properties of the air-

[1] *Tropical Woods* 95: 124-127.

Species	Source	No. of Logs	Condition	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.
Guayabo de Monte (*Terminalia guyanensis*)	Venezuela	3	Green	73.6	0.62	0.57	5,780	9,400	1,330	1.44	7.8
			Air Dry[1]	10.5			8,110	12,690	1,570	2.36	9.7
Nargusta (*Terminalia amazonia*)	British Guiana, British Honduras, Panama	9	Green	67.3	0.73	0.64	7,710	12,130	2,010	1.70	12.2
			Air Dry[1]	12.9			11,310	17,750	2,300	3.16	16.4
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5
Teak[3] (*Tectona grandis*)	Burma		Green	52	0.62	0.58	7,250	11,380	1,580	1.89	10.0
			Air Dry[1]	11.2			8,160	13,770	1,670	2.51	9.3*

Species	Condition	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
Guayabo de Monte (*Terminalia guyanensis*) Venezuela	Green	3,000	4,240	1,380	1110	960	700	790	1230	340	102.3
	Air Dry[1]	4,250	6,730	1,570	1520	1070	1070	510*	1530	210*	
Nargusta (*Terminalia amazonia*) British Guiana, British Honduras, Panama	Green	4,440	5,530	2,230	1360	1320	1060	850	1440	400	187.1
	Air Dry[1]	6,950	9,540	2,520	1990	1610	1230	670*	1950	270*	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	
Teak[3] (*Tectona grandis*) Burma	Green	4,120	5,490	1,760	900	980	1040	960	1300	420	84.4
	Air Dry[1]	5,180	7,520	1,500*	1010	1100	1190	980	1360	340*	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]A. V. Thomas (15); Handbook of Empire Timbers (8); unpublished Yale results for plank material received from the New York Naval Shipyard.

dry wood have subsequently been determined and are presented in the accompanying table together with green strength data for comparison.

Air-dry Masa is intermediate to Hard Maple and Shagbark Hickory in most properties for which comparative data are available. This applies particularly to bending and crushing strength and stiffness. Masa is exceptionally high in hardness and elastic resilience but is surpassed by both Maple and Hickory in compression across the grain, shear, and work to maximum load in static bending.

Upon air drying, *Tetragastris balsamifera* increased only moderately in most properties. Work to maximum load (indicative of shock resistance) was the only property that improved more than is generally the case with domestic hardwoods. Among other properties, greatest proportionate increase was shown in compression across the grain, followed by elastic resilience, crushing strength, end hardness, proportional limit in static bending, modulus of rupture, side hardness, stiffness, and shear. Approximately one-third of the strength of the green wood in tension across the grain and cleavage resistance was lost upon air drying.

As noted in an earlier report, the wood of Masa is subject to serious checking if permitted to dry rapidly. Completed air-seasoning studies show that a moderate rate of drying was accompanied by moderate end and surface checking. Only slight warp was observed. The wood is classified as moderately difficult to season.

Durability tests now completed on heartwood of this species indicate that Masa is very durable to durable in its resistance to both white-rot and brown-rot fungi, although exhibiting some variation with respect to the latter. Weathering characteristics of Masa are poor as severe surface and end checking develops upon exposure of unpainted wood.

Heartwood is relatively resistant to moisture absorption, occupying a position intermediate to White Oak and Mahogany. The wood is moderately easy to glue. Steam-bending characteristics are fair to good.

The list of potential uses for this species remains unaltered from that presented in an earlier report (7).

Species	Source	No. of Logs	Condition	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.
Masa (*Tetragastris balsamifera*)	Puerto Rico	3	Green	60.5	0.80	0.67	7,600	12,380	1,650	1.96	10.0
			Air Dry[1]	11.2			10,650	16,090	1,890	3.40	13.3
Shagbark Hickory[2] (*Carya ovata*)	United States		Green	60	0.78	0.64	5,900	11,000	1,570	1.28	23.7
			Air Dry	12			10,700	20,200	2,160	3.01	25.8
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	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
Masa (*Tetragastris balsamifera*) Puerto Rico	Green	4,230	5,460	1,730	1740	1760	960	1230	1700	590	222.8
	Air Dry[1]	5,490	8,380	2,300	2570	2150	1730	760*	1770	400*	—
Shagbark Hickory[2] (*Carya ovata*) United States	Green	3,430	4,580	—	—	—	1040	—	1520	—	—
	Air Dry	—	9,210	—	—	—	2170	—	2430	—	—
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	—

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

FIDDLEWOOD *Vitex Gaumeri* Greenm.

Other common name: Yaxnik.

Occurrence: Mexico, Guatemala, British Honduras, and Honduras.

The tree and wood of Fiddlewood were described in a previous publication which included a discussion of the properties and uses of the wood.[1] Subsequent testing has provided data on the mechanical properties of air-dry material which are presented in the accompanying table. Green strength properties are shown for comparison.

In the air-dry condition *Vitex Gaumeri* surpasses the related *Vitex Cooperi* and *V. Kuylenii* in all strength properties. It is also superior to White Oak and Hard Maple in all static-bending properties except work to maximum load, and in crushing strength, even though both are denser woods. Fiddlewood is intermediate to White Oak and Hard Maple in hardness, but lies below both these woods in compression across the grain and other properties for which comparable data are available. The shock resistance of air-dry Fiddlewood is slightly below that of White Oak.

Upon air-drying, Fiddlewood showed a typical high ratio of improvement in elastic resilience, static-bending strength, and crushing strength. Increases in modulus of elasticity, hardness, and shear were slightly below those generally shown by domestic hardwoods. The relatively slight increase in shock resistance is also characteristic of most domestic hardwoods but is not so common among tropical species. Compression across the grain improved much less than is normal, and a striking drop occurred in tensile strength across the grain and cleavage resistance.

Fiddlewood dried at a variable rate in air-seasoning studies completed since the previous report. Seasoning defects were generally slight and the wood can be considered as moderately difficult to season. Slight end checking and moderate surface checking were observed to result from rapid dry-

[1] *Tropical Woods* 97: 112-116.

ing. The only warp noted was in the form of slight crook or bow.

Completion of decay resistance studies involves a minor change in the durability ratings assigned to Fiddlewood. Heartwood was found to be very durable to durable in resistance to attack by a white-rot organism and very durable with respect to a brown rot. Fiddlewood is among the more resistant group of woods with reference to attack by marine borers. As previously reported no deterioration was observed after 10 months' exposure of small specimens at Kure Beach, North Carolina. These specimens were subsequently transferred to Harbor Island, North Carolina, and the tests continued. After 15 months' total exposure, only moderate attack by teredo and pholads had occurred. On this basis *Vitex Gaumeri* is superior to Teak in resisting marine-borer attack. Several domestic woods including Douglas Fir, Southern Pine, Red Oak, and White Oak were heavily attacked within six months under these conditions (4, 5).

Vitex Gaumeri displays only fair weathering characteristics. Considerable surface and end checking occurred as a result of exposure to the weather without protection. Heartwood offers relatively little resistance to moisture absorption. Steam-bending quality is poor.

Proposed uses for Fiddlewood remain unchanged from those previously listed (10).

FLOR AZUL *Vitex Kuylenii* Standl.
RAJATE BIÉN *Vitex Cooperi* Standl.

Other common names: Flor Azul: Fiddlewood, Barbás.

Occurrence: Both species are found in Mexico, Guatemala, and Honduras and the range of Flor Azul extends into British Honduras.

Descriptions of the trees and woods of these species appeared in a previous publication which included a discussion of the properties and uses of the wood.[1] Subsequent testing

[1] *Tropical Woods* 95: 127-132.

Species	Source	No. of Logs	Condition	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.
Fiddlewood (*Vitex Gaumeri*)	British Honduras	3	Green	42.5	0.64	0.56	6,170	10,190	1,600	1.33	9.9
			Air Dry[1]	12.7			11,720	16,550	1,960	3.65	11.1
Rajate Bien (*Vitex Cooperi*) Flor Azul (*Vitex Kuylenii*)	Guatemala / Honduras	4	Green	98.8	0.60	0.53	5,860	9,420	1,490	1.18	7.2
			Air Dry[1]	13.8			8,720	12,890	1,570	2.56	9.0
White Oak[2] (*Quercus alba*)	United States		Green	68	0.71	0.60	4,700	8,300	1,250	1.08	11.6
			Air Dry	12			8,200	15,200	1,780	2.27	14.8
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	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
Fiddlewood (*Vitex Gaumeri*) British Honduras	Green	3,240	4,750	1,870	1180	1040	790	1140	1310	450	143.3
	Air Dry[1]	5,740	8,690	2,140	1700	1390	1100	470*	1700	320*	
Rajate Bien (*Vitex Cooperi*) Guatemala / Flor Azul (*Vitex Kuylenii*) Honduras	Green	3,700	4,780	1,780	1050	1050	1180	650	1280	320	108.0
	Air Dry[1]	5,450	7,010	1,680*	1330	960*	990*	400*	1540	280*	
White Oak[2] (*Quercus alba*)	Green	3,090	3,560	—	1120	1060	830	770	1250	420	144.9[3]
	Air Dry	4,760	7,440	—	1520	1360	1320	800	2000	450	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	

[1]Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2]U. S. Dept. Agr. Tech. Bul. 479 (12).
[3]Value obtained for plank material received from the New York Naval Shipyard.

of air-dry material has been completed with results shown in the accompanying table. Strength properties in the green condition are included for comparison.

The close similarity noted between these woods in their green strength properties is retained in the air-dry condition and the average values are considered representative of both species. The resemblance of these woods to Hard Maple, however, does not apply to their air-dry properties. Based on the average values shown in the table, Rajate Bién and Flor Azul are surpassed by Hard Maple in practically all air-dry properties for which comparison is permitted, and particularly in shock resistance, compression across the grain, and hardness. Maple is about 25 percent stronger than these *Vitex* species in bending. The closely related Fiddlewood (*Vitex Gaumeri*) of British Honduras is apparently superior to Flor Azul and Rajate Bién in all mechanical properties to a much greater degree than would be anticipated on the basis of a rather small difference in specific gravity.

Upon air drying, these woods showed only moderate increases in several properties and appreciable losses in a number of others. Greatest proportional increase occurred in elastic resilience, followed by proportional limit stress in static bending, crushing strength, bending strength, shock resistance, and shear. Only in shock resistance (work to maximum load in static bending) did this increase exceed that shown by most domestic hardwoods. Modulus of elasticity was not appreciably altered upon drying, but side hardness, compression across the grain, cleavage, and tensile strength across the grain all showed decreases.

Both Flor Azul and Rajate Bién are classed as moderately difficult to air season. *Vitex Cooperi* dried at a moderate rate with slight checking and warp. *Vitex Kuylenii* exhibited fast to slow rates of drying with variable checking that ranged from slight to severe and appeared to be independent of the drying rate.

Incorporation of test results for *Vitex Cooperi* with data previously reported for *Vitex Kuylenii* introduces little

change in decay-resistance ratings. The heartwood of these species averaged very durable upon exposure to both white-rot and brown-rot organisms.

The wood of both species exhibits good weathering characteristics. Little surface checking and loss of smoothness occurred and no warp was observed upon exposure of unpainted panels to the weather. Heartwood is moderate in moisture absorption characteristics and is rated somewhat more permeable than Mahogany.

No changes are indicated in the proposed uses for these species as published previously (7).

QUARUBA

Vochysia guianensis Aubl.
Vochysia hondurensis Sprague

Other common names: Cedro-rana, Kwarie, Wanekwalie, Iteballi, and Barba Chele.

Occurrence: British Honduras through Central America to the Guianas and Amazon valley of Brazil.

The trees and woods of these species were described in an earlier report which included a discussion of the properties and uses of the wood.[1] The mechanical properties of air-dried wood have been determined in subsequent tests and are presented in the accompanying table. Green strength values are also shown for comparison.

In the air-dry condition Quaruba continued to show variation similar to that noted in the tests of unseasoned wood. On the basis of average values, air-dry Quaruba compares closely to Yellow Poplar. Slightly lower than Yellow Poplar in static-bending properties, compression and tension across the grain, shear, and cleavage, Quaruba exceeds Yellow Poplar by a small margin in compression parallel to the grain and hardness.

Upon air drying, Quaruba increased considerably in most of its mechanical properties. The general increases shown by most domestic hardwoods are exceeded by Quaruba in

[1] *Tropical Woods* 97: 116-121.

Species	Source	No. of Logs	Condition	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.
Rajate Bién (*Vitex Cooperi*)	Guatemala	2	Green	107.4	0.61	0.54	5,580	9,440	1,460	1.04	8.7
			Air Dry[1]	14.1			9,120	13,000	1,520	2.71	8.5*
Flor Azul (*Vitex Kuylenii*)	Honduras	2	Green	90.1	0.58	0.52	6,150	9,400	1,520	1.32	5.6
			Air Dry[1]	13.5			8,320	12,780	1,620	2.40	9.6
	Average	4	Green	98.8	0.60	0.53	5,860	9,420	1,490	1.18	7.2
			Air Dry[1]	13.8			8,720	12,890	1,570	2.56	9.0
Fiddlewood (*Vitex Gaumeri*)	British Honduras	3	Green	42.5	0.64	0.56	6,170	10,190	1,600	1.33	9.9
			Air Dry[1]	12.7			11,720	16,550	1,960	3.65	11.1
Hard Maple[2] (*Acer saccharum*)	United States		Green	58	0.68	0.56	5,100	9,400	1,550	1.03	13.3
			Air Dry	12			9,500	15,800	1,830	2.76	16.5

Species	Condition	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
Rajate Bién (*Vitex Cooperi*) Guatemala	Green	3,690	4,850	1,760	1110	1140	920	650	1350	280	122.4
	Air Dry[1]	5,380	7,140	1,720*	1240	940*	900*	420*	1380	300	
Flor Azul (*Vitex Kuylenii*) Honduras	Green	3,720	4,700	1,810	990	960	1440	650	1220	360	93.6
	Air Dry[1]	5,520	6,880	1,640*	1420	990	1080*	370*	1700	260*	
Average	Green	3,700	4,780	1,780	1050	1050	1180	650	1280	320	108.0
	Air Dry[1]	5,450	7,010	1,680*	1330	960*	990*	400*	1540	280*	
Fiddlewood (*Vitex Gaumeri*) British Honduras	Green	3,240	4,750	1,870	1180	1040	790	1140	1310	450	143.3
	Air Dry[1]	5,740	8,690	2,140	1700	1390	1100	470*	1700	320*	
Hard Maple[2] (*Acer saccharum*) United States	Green	2,850	4,020	—	1070	970	800	—	1460	—	—
	Air Dry	5,390	7,830	—	1840	1450	1810	—	2330	—	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.
[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

Species	Source	No. of Logs	Condition	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.
Quaruba *(Vochysia guianensis)*	Brazil	1	Green	119.4	0.48	0.43	4,600	6,730	1,380	0.91	5.2
			Air Dry[1]	15.0			6,930	10,330	1,570	1.73	7.3
	Surinam	1	Green	230.0	0.42	0.36	3,820	6,050	1,230	0.68	5.8
			Air Dry[1]	10.6			6,540	9,050	1,440	1.67	5.2*
(Vochysia hondurensis)	Nicaragua	3	Green	226.4	0.37	0.33	3,500	5,580	1,040	0.67	4.6
			Air Dry[1]	11.9			4,930	7,900	1,160	1.20	5.8
	Average	5	Green	191.9	0.42	0.37	3,970	6,120	1,220	0.75	5.2
			Air Dry[1]	12.5			6,130	9,090	1,390	1.53	6.1
Yellow Poplar[2] *(Liriodendron tulipifera)*	United States		Green	64	0.43	0.38	3,400	5,400	1,090	0.62	5.4
			Air Dry	12			6,100	9,200	1,500	1.43	6.8

Species	Condition	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
Quaruba *(Vochysia guianensis)* Brazil	Green	1,900	2,780	1,650	590	620	400	440	750	220	121.6
	Air Dry[1]	4,950	6,230	1,690	500*	740	620	360*	1220	240	
Surinam	Green	2,300	2,890	1,490	900	810	390	420	770	190	95.6
	Air Dry[1]	5,790	7,160	1,790	710*	460*	530	280*	680*	140*	
(Vochysia hondurensis) Nicaragua	Green	2,050	2,610	1,170	510	410	420	440	700	230	73.5
	Air Dry[1]	3,350	4,140	1,160*	670	400*	450	410*	1030	190*	
Average	Green	2,080	2,760	1,490	670	610	400	430	740	210	96.9
	Air Dry[1]	4,700	5,840	1,550	630*	530*	530	350*	980	190*	
Yellow Poplar[2] *(Liriodendron tulipifera)* United States	Green	1,930	2,420	—	390	340	330	450	740	220	—
	Air Dry	3,550	5,290	—	560	450	580	520	1100	280	

[1] Air-dry values adjusted to 12 percent moisture content except where designated (*) in which case the actual moisture content at time of testing (col. 5) applies.

[2] U. S. Dept. Agr. Tech. Bul. 479 (12).

work to maximum load and compressive strength parallel to the grain. Among other properties greatest relative increase was shown in bending strength, compression across the grain, shear, and stiffness. End and side hardness, tension across the grain, and cleavage resistance decreased upon air drying.

Both species are rated moderately difficult to air season on the basis of tests completed since an earlier report. *Vochysia guianensis* is moderate to slow in rate of drying as compared to a rapid rate of drying shown in the case of *Vochysia hondurensis*. *V. guianensis* exhibited slight surface checking, casehardening, and warp, while *V. hondurensis* showed moderate twist accompanied by slight checking and slight crook or bow and cup. In addition, considerable collapse of 1¼-inch boards was observed for the latter species.

Upon completion of decay resistance studies, the heartwood of *Vochysia guianensis* is rated very durable in resistance to attack by a white-rot fungus, although showing some variability in this respect, and moderately durable in resisting a brown rot. *Vochysia hondurensis,* on the other hand, was found to be durable to moderately durable in its resistance to a white rot and moderately durable to non-durable in tests involving a brown-rot organism. Quaruba weathers well showing only a moderate amount of surface roughness and slight surface checking upon exposure without the protection of paint.

The wood exhibits fair steam-bending quality.

The list of potential uses for the species remains unchanged from that reported previously (10).

Photo by Paul J. Shank

FIGURE 6

Quaruba (*Vochysia hondurensis*) in the dense coastal rain forest of Nicaragua.

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Test Material[1]

Tree No.	Species	Source	Tree height, feet	Diameter at stump, inches	Top diameter of test log, inches	Character	Remarks
440	*Cordia alliodora*	Panama	65	14	12	Old growth	Lowland rain forest. Elevation 100 feet.
441	" "	"	67	12	10	Old growth	" " "
442	" "	"	66	14	10	Old growth	" " "
421	*Bombacopsis quinata*	Panama	60	28	23	Old growth	Lowland rain forest. Elevation 100 feet.
422	" "	"	50	22	20	Old growth	" " "
423	" "	"	50	30	20	Old growth	" " "
434	*Hymenaea courbaril*	Panama	90	19	16	Old growth	Lowland rain forest. Elevation 100 feet.
435	" "	"	85	20	15	Old growth	" " "
436	" "	"	92	20	18	Old growth	" " "
221	*Ocotea rubra*	British Guiana			29		
222	" "	" "			20		
223	" "	" "			22		
462[2]	*Swietenia macrophylla*	Central America					
427	*Tabebuia pentaphylla*	Panama	90	22	17	Old growth	Lowland rain forest. Elevation 100 feet.
428	" "	"	100	30	18	Old growth	" " "
429	" "	"	80	16	13	Old growth	" " "
461[2]	*Tectona grandis*	Burma					
430	*Terminalia amazonia*	Panama	70	30	21	Old growth	Lowland rain forest. Elevation 100 feet.
431	" "	"	80	18	17	Old growth	" " "
432	" "	"	85	16	14	Old growth	" " "

[1]This list includes only logs not previously reported in *Tropical Woods* Nos. 95 and 97.
[2]Received in the form of plank from the U. S. Navy Department, New York Naval Shipyard.

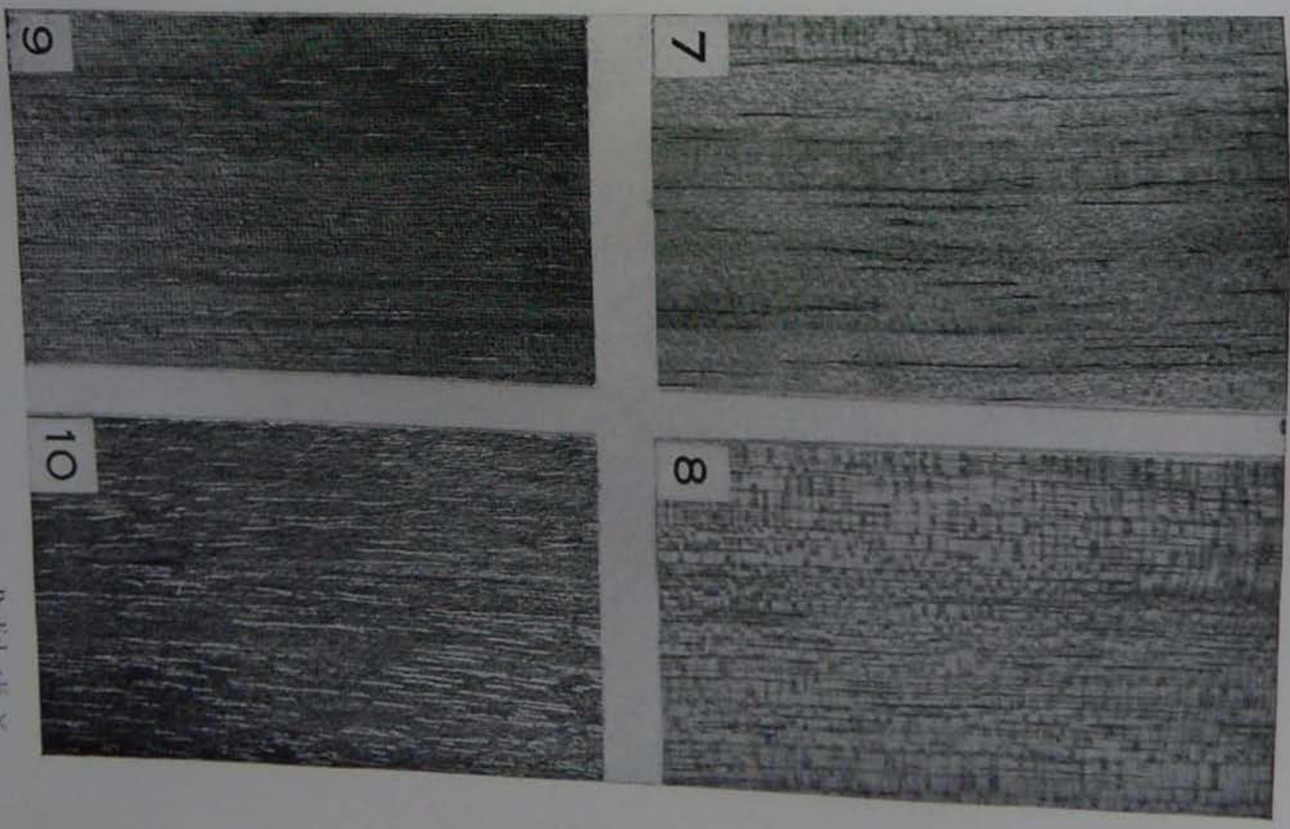

Figure 7. *Hura crepitans* Radial, 1½ ×
Figure 8. *Aniba riparia* Radial, 1½ ×
Figure 9. *Dicorynia paraensis* Radial, 1½ ×
Figure 10. *Carapa guianensis* Tangential, 1½ ×

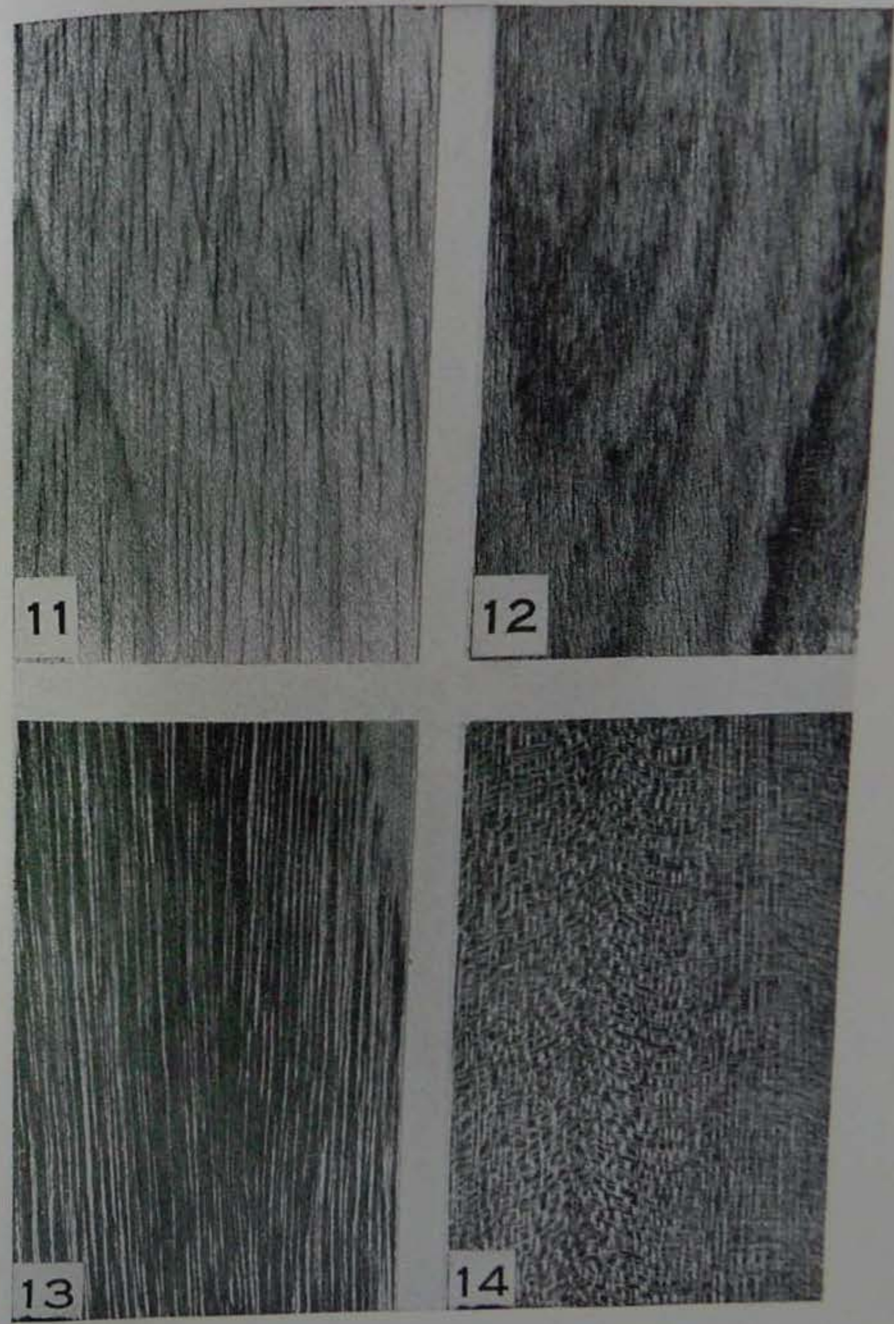

FIGURE 11. *Hymenaea courbaril* (sapwood) Tangential, 1⅓ ×
FIGURE 12. *Cordia alliodora* Tangential, 1⅓ ×
FIGURE 13. *Loxopterygium Sagotii* Tangential, 1⅓ ×
FIGURE 14. *Nectandra concinna* Radial, 1⅓ ×

Figure 15.	*Ocotea rubra*	Tangential, 1⅓ ×
Figure 16.	*Swietenia macrophylla* (plantation-grown)	Tangential, 1⅓ ×
Figure 17.	*Tectona grandis* (plantation-grown)	Radial, 1⅓ ×
	Eschweilera Sagotiana	Radial, 1⅓ ×