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PUERTO RICAN WOODS

Their Machining, Seasoning and Related Characteristics

Agriculture Handbook No. 205

U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE

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PUERTO RICAN WOODS

Their Machining, Seasoning and Related Characteristics

by

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Growth Through Agricultural Progress

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For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 65 cents

INTRODUCTION

More than 500 species of trees are indigenous to the forests of Puerto Rico, ranging from balsa, which produces the lightest commercial wood known, to lignumvitae, one of the heaviest and one of the most valuable of all woods. Yet fewer than one-third of these tree species ordinarily reach saw-log size. Moreover, only 52 of this number, plus 8 introduced species, provide the bulk of all native-grown saw-log size material available for domestic and commercial use. The others either mature below saw-log size or occur too infrequently for commercial use. A few high-quality woods owe their scarcity and small size to past heavy cutting because of their good qualities. Still others are seldom used because they are difficult to season or machine or their properties and uses are poorly known. This does not preclude the possibility that other species will become merchantable when more is known about their characteristics and uses.

Most of the native woods are available only in limited quantities and none are sufficiently abundant for export. Nevertheless, many of them have far more utility and value than their current use would indicate.

At present fewer than a dozen of these tree species are utilized to any appreciable extent for lumber and similar products. The majority either are not used at all or are used principally for fuel, charcoal production, or other low-value products.

This improvident use of a relatively scarce resource cannot be attributed to a lack of markets for wood. Every year some 80 to 90 million board feet of lumber and other wood products are required to meet the expanding requirements of the island. About 1 percent of this volume, some 850,000 board feet, is provided by the local forests; the remainder is imported from the United States, Mexico, and other Caribbean areas. Immense quantities of low-grade but relatively expensive pitch pine and western fir are brought in annually, yet are inferior in some ways to a number of virtually unused native woods.

Relatively little is known about the characteristics and properties of the local woods or the uses for which they are suitable. This is in contrast to the relatively detailed and complete knowledge about the imported woods. Probably no other factor contributes more toward the neglect and misuse of native woods.

Another factor contributing to the neglect of native woods is the erroneous but nevertheless widespread belief that only heavy, dark-colored woods are strong and durable, machine well, or posses attractive figure. Both Honduras mahogany and cedro hembra illustrate the fallacy of this idea. Although moderately light in color and weight, both woods are rated among the all time favorites for cabinetmaking and other exacting uses. Furthermore, most of the imported woods, especially pitch pine, western fir, baboen, and African mahogany, are also light in weight and color but nevertheless have good utility for a multitude of uses.

The utility of Puerto Rican woods is frequently depreciated by a combination of improper seasoning, poor handling, and unsuitable machining practices. This condition results not so much from neglect or unwillingness to employ proper practices but rather from a scarcity of knowledge in these fields. Lack of information concerning the drying, handling, and machining properties of these woods has been an obstacle to wider use. Some of the everyday operations in utilizing local woods have been under investigation at the Tropical Research Center for several years. This handbook summarizes the information that should be useful to the person using or contemplating the use of native woods for domestic or commercial purposes.

The material presented is divided into two parts: Part 1 describes the procedures and summarizes the results of recent determinations of wood properties at the Tropical Forest Research Center in Rio Piedras, Puerto Rico. Of the principal saw-log species of Puerto Rico, 56 were included in the tests, along with plantation-grown teak, eucalyptus, and casuarina. Forest-grown Honduras mahogany from Mexico, also planted extensively on the island, was included for comparison. These native species and planted exotics (table 1) represent the bulk of all saw-log-size timber growing on the island.[1]

[1] Additional information about nearly all these tree species, including descriptions, drawings, ranges, and other common names, is included in the following publication:

Little, Elbert L., Jr., Wadsworth, Frank H., and Marrero, José. Arboles Communes de Puerto Rico e Islas Vírgenes. University of Puerto Rico. (in press.)

Fourteen of the 60 woods as well as a few others from Puerto Rico are described further in the following publication:

Longwood, Franklin R. Present and Potential Timbers of the Caribbean—With Special Reference to the West Indies, the Guianas, and British Honduras. U.S. Dept. Agr. Handbook No. 207. 1961.

TABLE 1.—*The principal native and plantation-grown saw-log woods of Puerto Rico*

Common name in Puerto Rico	Scientific name	English name
Achiotillo	*Alchornea latifolia* Sw	
Aguacatillo	*Meliosma herbertii* Rolfe	
Algarrobo	*Hymenaea courbaril* L	West Indian locust, courbaril.
Almácigo [1]	*Bursera simaruba* (L.) Sarg	Gumbo-limbo.
Almendra [1 2]	*Terminalia catappa* L	Indian-almond.
Ausubo	*Manilkara bidentata* (A. DC.) Chev	Balata, bulletwood.
Caimitillo	*Micropholis chrysophylloides* Pierre	
Caimitillo verde	*M. garciniaefolia* Pierre	
Caoba hondureña [2]	*Swietenia macrophylla* King	Honduras mahogany, Mexican mahogany.
Capá blanco [1]	*Petitia domingensis* Jacq	
Capá prieto [1]	*Cordia alliodora* (Ruiz & Pav.) Oken	Capa.
Caracolillo	*Homalium racemosum* Jacq	
Casuarina [2 3]	*Casuarina equisetifolia* L	Casuarina.
Cedro hembra	*Cedrela odorata* L	Spanish-cedar, Central American cedar.
Ceiba	*Ceiba pentandra* (L.) Gaertn	Silk-cotton tree.
Cucubano	*Guettarda laevis* Urban	
Cupey	*Clusia rosea* Jacq	
Espino rubial	*Zanthoxylum martinicense* (Lam.) DC	Martinique prickly-ash
Eucalipto [1 2 3]	*Eucalyptus robusta* J. E. Smith	Beakpod eucalyptus.
Granadillo	*Buchenavia capitata* (Vahl) Eichl	
Guaba [2]	*Inga vera* Willd	
Guajón	*Beilschmiedia pendula* (Sw.) Benth. & Hook. f	
Guamá	*Inga laurina* (Sw.) Willd	
Guano	*Ochroma pyramidale* (Cav.) Urban	Balsa.
Guaraguao	*Guarea trichilioides* L	American muskwood.
Guayabota	*Eugenia stahlii* (Kiaersk.) Krug & Urban	
Higüerillo [1]	*Vitex divaricata* Sw	White fiddlewood.
Jácana	*Pouteria multiflora* (A. DC.) Eyma	
Jagua	*Genipa americana* L	Genipa.
Jagüey blanco	*Ficus laevigata* Vahl	Shortleaf fig.
Jobo	*Spondias mombin* L	Yellow mombin.
Jusillo	*Calycogonium squamulosum* Cogn	
Laurel amarillo	*Nectandra sintenisii* Mez	
Laurel avispillo	*N. coriacea* (Sw.) Griseb	Jamaica nectandra.
Laurel geo	*Ocotea leucoxylon* (Sw.) Maza	
Laurel prieto	*Nectandra membranacea* (Sw.) Griseb	
Laurel sabino	*Magnolia splendens* Urban	
Mago	*Hernandia sonora* L	Mango.
Mamey [1]	*Mammea americana* L	Mamey, mammee-apple.
Mango [2]	*Mangifera indica* L	
María	*Calophyllum brasiliense* Camb	Santa Maria.
Maricao	*Byrsonima coriaceum* (Sw.) DC	
Masa	*Tetragastris balsamifera* (Sw.) Kuntze	
Moca	*Andira inermis* (W. Wright) H.B.K	Cabbage angelin, angelin.
Motillo	*Sloanea berteriana* Choisy	
Negra lora	*Matayba domingensis* (DC.) Radlk	
Nemocá	*Ocotea spathulata* Mez	
Nuez moscada	*O. moschata* (Meissn.) Mez	
Palo colorado	*Cyrilla racemiflora* L	Swamp cyrilla.
Palo de hueso	*Haenianthus salicifolius* Griseb	
Palo de matos	*Ormosia krugii* Urban	
Panapén [2]	*Artocarpus altilis* (Parkinson) Fosberg	Breadfruit.
Roble blanco	*Tabebuia heterophylla* (DC.) Britton	"White-cedar."
Samán [1 2]	*Pithecellobium saman* (Jacq.) Benth	Rain-tree.
Tabaiba	*Sapium laurocerasus* Desf	
Tabonuco	*Dacryodes excelsa* Vahl	Candlewood, gommier.
Teca [2 3]	*Tectona grandis* L. f	Teak.
Ucar [1]	*Bucida buceras* L	Oxhorn bucida.
Yagrumo hembra	*Cecropia peltata* L	Trumpet-tree.
Yagrumo macho	*Didymopanax morototoni* (Aubl.) Dec. & Planch	Matchwood.

[1] Sample material limited to 2 or 3 sample logs.
[2] Introduced species.
[3] Plantation grown.

The tests of the 60 species included determinations of specific gravity and weight per cubic foot, shrinkage, seasoning characteristics, machineability, and resistance to dry-wood termites. The density and shrinkage values are based on well-prescribed conditions and procedures which can be repeated. These data then are significant for each species. The opposite is true for the other tests, in which seasoning conditions, machining techniques, and other factors affect the numerical ratings of the different species. In these tests, the comparative ratings of the different woods are more important that the numerical grades assigned on the basis of the test results.

Certain other characteristics or properties, such as stability after manufacture, weathering characteristics, permeability to preservatives, and durability in or near the ground, are also important in certain uses but were not considered in the study. The purpose of this series of tests was to provide a broad general knowledge of certain important characteristics of the principal lumber species.

The study was not intended to develop detailed and complete knowledge of the different aspects of the uses of the different woods but rather to evaluate some of their more important properties so that the potential producer or user can either grow or utilize them more efficiently. It is only a beginning; much more needs to be done before the different woods can be most efficiently utilized in the local economy.

Part 2 contains a brief summary of the important characteristics and properties of the same 60 timbers of potential importance in Puerto Rico. Figures showing representative plainsawed and quartersawed sections are also included for each species.[2]

Timber descriptions are based on the tests described in Part 1, and on other observations made over several years at the Wood Testing Laboratory in Rio Piedras. Physical descriptions of the timbers are based on the average for several hundred specimens prepared in the laboratory from trees cut in the local forests. Information on conversion, seasoning, green and air-dry[3] weight, shrinkage, machining properties, and certain insect and fungous enemies was derived from tests and observations in the Laboratory. This was supplemented by local knowledge of the trees and their woods and a limited amount of reference material. Data on resistance to dry-wood termites was provided by Dr. G. N. Wolcott of the University of Puerto Rico from results of previous research, and from current studies using wood specimens prepared at the Wood Testing Laboratory.

Recommended uses are listed for each species on the basis of its physical and mechanical characteristics. Since a number of the woods appeared to be comparable to other well-known woods, they were recommended for similar uses. Wherever possible, acceptable local uses are also shown for those species currently being utilized. This information is supplemented by listing current uses for those species or for other closely related species growing in other areas of the Caribbean. In some instances, recommendations by reliable sources outside the Caribbean area were included, but only if they conformed with the known characteristics of the wood. Additional research and experience with the different species will undoubtedly add many specific uses to those mentioned in the text.

[2] Photographs were taken and processed by Antonio Atiles of the University of Puerto Rico Extension Service, using specimens prepared at the Wood Testing Laboratory in Rio Piedras.

[3] All air-dry weights were calculated on the basis of 15 percent moisture content.

PART 1. DETERMINATION OF MACHINING CHARACTERISTICS AND RELATED PROPERTIES

Selection of Sample Material

All sample material required for determinations of shrinkage, specific gravity, air seasoning, machining properties, and screw splitting, was taken from one set of sample logs for each species. Except as noted, all sample material was obtained from five or more typical saw-log-size sample trees of each species. These trees were selected at random from the local forests or plantations. One sample log, 9 feet 6 inches long, was cut from each sample tree, starting at a point 8 feet above the butt swell. For certain species that normally have clear boles less than 16 feet long, the sample logs were cut from the center of the merchantable part of the trees. The first 8-foot section of some sample trees was also selected for use in the machining and air-seasoning tests when insufficient volume was available in the regular sample logs. These are referred to as lumber logs.

The logs were flatsawed into random-width lumber in a small circular sawmill. Boards were supposed to be cut 1⅛ inch thick, but were more often 1¼ inch thick because of the extremely poor condition of the mill. Six sample boards were selected from each sample log during sawing. Four of these were typical flatsawed boards 4 inches or more wide, one from each of the four quadrats of the log, for use in specific gravity and shrinkage tests. One board was taken from the periphery, one near the pith, and two from the area of representative or average growth. In addition to the above, two 8½-inch boards were selected from opposite quadrats of each sample log for use later in warp tests.

The lumber logs cut from the butt sections of some trees were sawed into flat-grain lumber in the same manner as the sample logs but no sample boards were selected. The selection and preparation of the lumber and test material for the various tests and the procedures followed in these tests are described in the later sections dealing with the individual subjects.

Air-Seasoning Characteristics

Lumber and other wood products cut from saw logs are generally kiln-dried or air-seasoned prior to use. The time required for seasoning and the type and severity of defects occurring during the process vary greatly among woods and are of primary importance in their utility. A wood may be attractive and may possess very satisfactory machining and mechanical characteristics, yet it may have limited use because of poor seasoning characteristics. Other things being equal, woods that season readily and with a minimum of degrade are preferred. With good control, most woods can be kiln-dried with less degrade than occurs in air-seasoning. However, lumber generally is partially air-seasoned before it is put into the kiln. Considerable warping and checking in the preliminary air-seasoning are sometimes improved during the kiln-drying process. Consequently, the air-seasoning characteristics of a wood are important whether it is to be kiln-dried or seasoned only in the open.

The tests involved two parts: one was a study of the time required to air-season conventionally piled green lumber and of the type and frequency of defects occurring during the process; the other was a warp-test study in which 4-foot boards were allowed to season without restraint of any kind so that the natural warping tendencies of the different woods could be observed and measured.

PROCEDURE

Preparation of Lumber

Lumber used in the air-seasoning tests was typical random-width commercial-quality flat-grain boards, 1⅛ inches to 1¼ inches thick and 8 feet 2 inches long. All material was first end-trimmed to exact size and then dipped for 3 minutes in an aqueous solution containing benzene hexachloride and a mild fungicide to prevent insect attack and development of molds and sap-staining fungi. After dipping, the boards were end-coated and piled under cover for air-seasoning. All defects evident in the boards at the time of piling were marked to distinguish them from defects developing during seasoning.

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FIGURE 1.—Puerto Rican woods stacked for air-seasoning at the Wood Testing Laboratory in Rio Piedras, Puerto Rico.

The lumber was seasoned on specially prepared pile foundations in sheds open on three sides and partially open on the fourth side. The pile foundations, 6 feet wide by 8 feet 2 inches long, were built on cement-block supports. Supports were centered at 2-foot intervals in 3 rows running the length of the pile, requiring 15 supports for each pile (fig. 1). Six-inch square timbers were placed on the 3 tiers of supports lengthwise and 4- by 4-inch cross members positioned over them at 2-foot intervals. Piles were spaced 4 feet apart to allow adequate air circulation and working space. This type of foundation meets the accepted standards for good air-seasoning practices. None of the subsequent warpage was attributed to faulty pile foundations.

Stacking Lumber

The lumber was piled as shown in figure 1, leaving ½-inch spacing between boards up to 8½ inches wide and 1-inch spacing between wider boards. Dry softwood stickers, $^{25}/_{32}$ inch thick and 1¾ inches wide, were placed between each layer of boards at 24-inch intervals directly above the pile supports and cross members. Piles were stacked 8 feet high. They were topped off with surplus lumber and anchored in place with 300 to 400 pounds of concrete weights.

Determination of Moisture Content

To record the drying rate of each species, it was necessary to determine the moisture content at the start of drying, at frequent intervals during the seasoning process, and finally when the lumber was air-dry. For this, six sample boards, predominantly heartwood, were prepared for each species. These samples, 19 inches long, were cut from the center of green boards, and a wafer approximately 1½ inches long was sawed from each end for determining their initial green moisture content and ovendry weight.

The 16-inch samples were then end-coated with plastic-asphalt roof coating, weighed to the nearest 2 grams, and placed in the lumber piles on specially prepared cradles (fig. 2).

These pile samples were removed from the lumber stacks at 2-week intervals, weighed, and returned to the piles. The moisture content of each sample was calculated each time, according to the following formula:

$$\text{Moisture content in percent} = \frac{\text{current weight} - \text{calculated ovendry weight}}{\text{calculated ovendry weight}} \times 100$$

When no loss was recorded over a 4-week period, the samples were considered to have been air-dry at the start of the 4-week period. A final check on the air-dry moisture content was then calculated by means of five or more cross sections cut from each pile sample.

Measurement of Drying Defects

After each wood became air-dry, 50 or more air-dry boards were inspected for the presence and severity of warping and checking that had developed during seasoning. Seasoning defects were rated on this basis: A=none, B=very slight, C=slight, D=moderate, E=severe, and F= very severe.

The use of badly warped lumber requires increased labor, and it causes waste in manufacture. Warp may also cause trouble later. Warped boards usually require heavy planing or must be cut into short or narrow pieces, or both.

Warp was separated into four categories: cup, twist, crook, and bow. The first two are the most serious. **Cup** is defined as "a deviation flatwise from a straight line across the width of the board"; **twist** is "a distortion caused by the turning or winding of the edges of a board so that the four corners of any face are no longer in the same plane"; **bow** is "the distortion in a board that deviates from flatness lengthwise but not across its face"; **crook** is "a distortion of a board in which there is a deviation edgewise from a straight line from end to end of the board." [4]

[4] Forest Service. Wood Handbook. U.S. Dept. Agr. Handb. 72, 479–490. 1955.

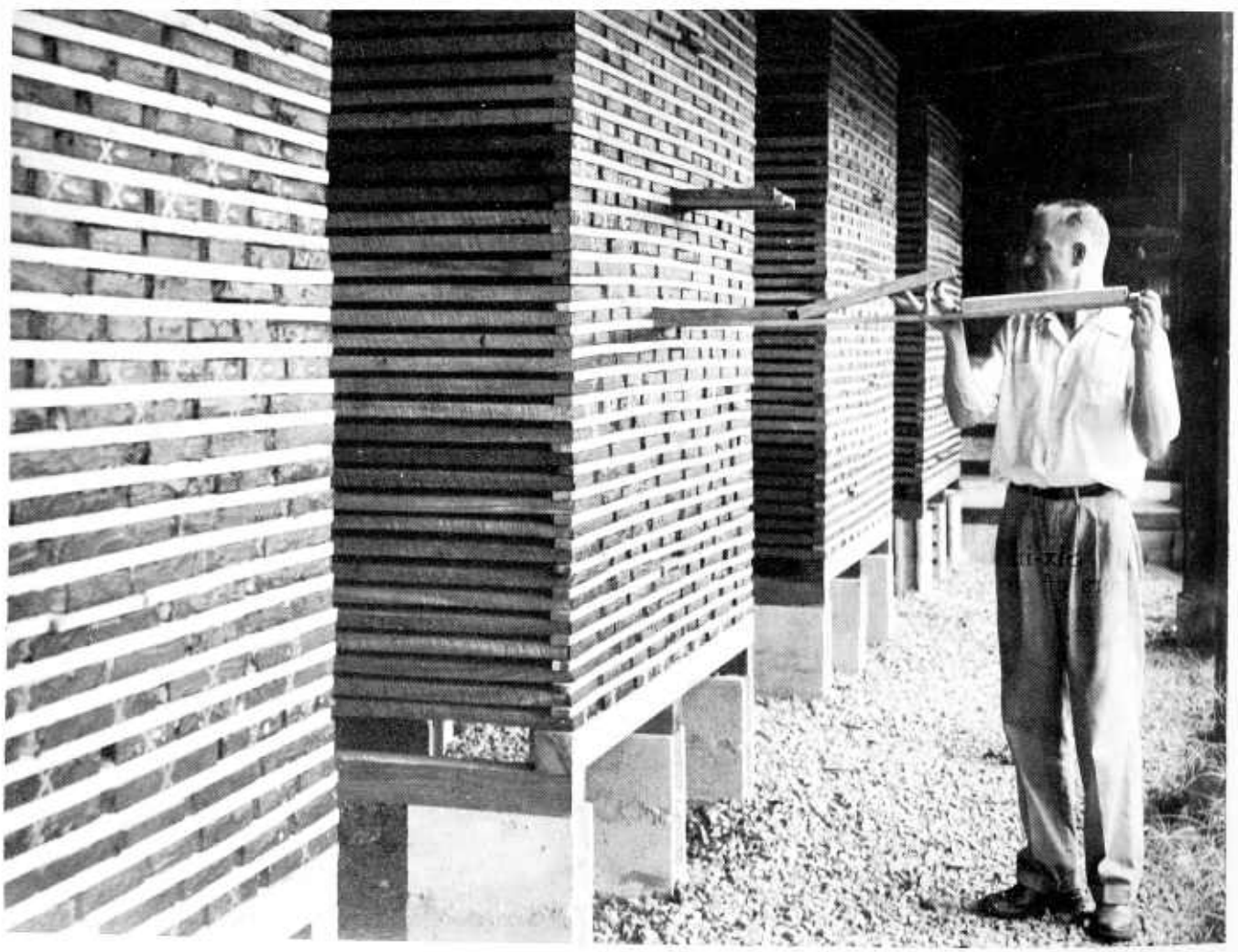

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FIGURE 2.—Sample boards for determining the moisture content of stacked lumber were placed in the stacks in specially fitted cradles.

Checking may occur either on the surface of boards or at the ends. It may be superficial and easily removed during planing or trimming, but it may be so deep as to make the piece worthless.

RESULTS

Seasoning Time and Final Moisture Content

Most of these woods were thoroughly air-seasoned in 6 months or less, some requiring only 3 to 4 months and others 10 months or longer. Table 2 shows the approximate number of weeks required to air-season the different woods and the final air-dry moisture content reached when 1⅛- to 1¼-inch lumber is piled for seasoning under cover in the San Juan area. These figures represent the average for each wood, and they vary slightly according to the density of individual pieces of a species; particularly, dense specimens of any wood will normally have a somewhat lower moisture content than those that are lighter than average. The final air-dry moisture content values range considerably among the different woods, from a low of 16 percent for seven different woods to a high of 22 percent for mamey. In comparison, thoroughly air-dry Honduras mahogany used in the machining tests contained an average moisture content of 16 percent.

TABLE 2.—*Approximate time to air-season green 1⅛- to 1¼-inch rough lumber in San Juan, Puerto Rico*

Species	Time to season	Final moisture content	Species	Time to season	Final moisture content
	Weeks	*Percent*		*Weeks*	*Percent*
RAPID					
Guaba	11	19	Guano	22	17
Caimitillo verde	12	18	Ceiba	23	18
Almendra	13	18	Nemocá	23	17
Yagrumo hembra	14	17	Samán	23	17
Yagrumo macho	14	16	Eucalipto	24	19
Laurel sabino	14	17	Güayabota	24	18
Granadillo	15	18	Algarrobo	25	17
Roble blanco	15	17	Jusillo	25	18
Nuez moscada	15	18	Cucubano	25	18
Masa	15	17	Laurel amarillo	25	17
Capá blanco	15	18	Laurel avispillo	25	17
Cedro hembra	16	20	Laurel prieto	25	16
Caimitillo	16	17	Ucar	25	17
Ausubo	16	19	Caracolillo	26	18
Tabonuco	16	17	Cupey	26	17
Guamá	17	18	Palo de hueso	26	17
Teca	17	17	Jobo	26	16
Espino rubial	17	18	Tabaiba	26	17
Mago	17	17	Maraicao	26	16
Almácigo	17	18			
MODERATE			**SLOW**		
Casuarina	19	18	Jagüey blanco	27	17
Laurel geo	19	16	Palo de matos	27	16
Mamey	19	22	María	27	18
Mango	19	19	Jácana	29	17
Achiotillo	20	17	Negra lora	29	19
Aguacatillo	20	17	Jagua	30	20
Moca	20	17	Guaraguao	31	19
Panapén	20	19	Palo colorado	41	19
Motillo	22	16	Guajón	45	20
Capá prieto	22	18	Higüerillo [1]	52+	----

[1] Required more than 1 year to air-dry under test conditions.

Some variations in the final air-dry moisture content values occur during different parts of the year in the San Juan area. Consequently, the moisture contents presented in table 2 are approximate and may vary for some woods as much as 3 to 4 percent according to season. However, it is evident that most Puerto Rican woods will air-season to between 16 and 19 percent in the San Juan area. In general, it should be safe to assume that lumber is air-dry in the San Juan area when all samples show 18 percent or less moisture content. The additional shrinkage between this point and the lower moisture content reached by some woods will have little effect on their utility in service.

Seasoning would be more rapid and the final air-dry moisture content somewhat lower in the dry climate prevailing along the south side of the island than in the San Juan area on the north coast, where these tests were conducted. The opposite conditions would occur in the humid mountain regions of the interior where it is nearly impossible to season lumber without protection from the heavy and frequent rainfall, which may reach 200 inches annually at the higher elevations. It is probably impractical to air-dry lumber under these conditions.

In addition to climate, the method of piling and the amount of ventilation has considerable effect on the rapidity of air-seasoning. In this study the woods were seasoned under conditions that were considered normal for the area. However, closer piling and less ventilation probably would have retarded the rate of seasoning and, as a result, would have reduced the amount and severity of surface checking. But warping would not have been materially changed. Conversely, more open piling and increased air movement probably would have reduced the drying time and increased checking.

The proximity of one species to another in the piles, or its location within the pile, may have influenced the drying rate of some woods. And the season when the wood is dried may be of even greater importance.

Seasoning Degrade

A summary of the degrade occurring in the different woods as a result of seasoning under the test conditions is presented in table 3. All but 13 of the woods seasoned satisfactorily, 17 with only minor degrade, and 29 with a moderate but acceptable amount of degrade. For most purposes, the woods in class 1 and 2 are quite acceptable for commercial use. But those in class 3 could probably be improved by slower seasoning.

Most of the degrade occurred in the form of bow and twist whereas cup and crook was of minor importance in most woods. With the exception of mamey, casuarina, and palo colorado, surface checks and end splitting during seasoning were not serious. The amount of end splitting was undoubtedly reduced by the use of end coatings. However, the application of end-coating material is recommended when seasoning hardwoods and is considered a common practice.

TABLE 3.—*Rating of Puerto Rican woods for degrade occurring during air-seasoning of 1⅛- to 1¼-inch rough lumber* [1]

CLASS 1—MINOR DEGRADE

Species	Warp				Checks and splits	
	Cup	Bow	Twist	Crook	Surface	End
Almácigo	B	B	C	A	A	A
Ausubo	B	C	B	B	A	A
Caimitillo	A	B	A	A	A	A
Cedro hembra	B	B	B	A	A	A
Guajón	B	C	B	B	A	A
Granadillo	A	B	B	A	A	A
Higüerillo	B	C	C	B	A	B
Jagua	B	C	C	B	A	A
Jagüey blanco	B	C	C	B	A	A
Laurel prieto	B	C	B	B	A	A
Laurel sabino	A	B	C	A	A	A
Mago	B	C	C	B	A	A
Mango	B	C	C	B	A	A
Masa	A	B	B	A	A	A
Nuez moscada	B	C	B	B	A	B
Tabonuco	B	C	C	A	A	B
Teca	B	C	B	B	A	B

See footnotes at end of table.

TABLE 3.—*Rating of Puerto Rican woods for degrade occurring during air-seasoning of 1⅛- to 1¼-inch rough lumber* [1]—Continued

Species	Warp				Checks and splits	
	Cup	Bow	Twist	Crook	Surface	End
CLASS 2—MODERATE DEGRADE						
Achiotillo	C	C–D	C	B	B	A
Almendra	B	D	C	C	A	A
Caimitillo verde	B	C–D	C	B	A	A
Capá blanco	B	D	D	A	A	A
Capá prieto	B	D	C	B	A	A
Caracolillo	B	D	C	B	B	B
Ceiba	C	C	C	B	D	A
Cucubano	C	C	C	B	D	C
Cupey	C	C	D	C	C	B
Guaraguao	C	D	C	B	A	A
Guaba	A	D	B	A	A	A
Guamá	A	D	B	B	A	A
Guano	C–D	C	C	B	B	B
Guayabota	C	C	D	B	C	B
Jobo	B	D	C	C	B	B
Jusillo	B	D	C	B	B	B
Laurel amarillo	B	D	C	B	A	B
Laurel avispillo	D	C	C	C	A	A
Maricao	B	D	C	C	B	B
Moca	B	D	A	A	A	A
Motillo	C	C–D	C	B	D	C
Negra lora	C	C	D	C	D	D
Nemocá	B	D	C–D	D	B	A
Palo de hueso	B	D	C	B	C	B
Palo de matos	C	D	C	B	B	B
Panapén	C	D	C	C	A	A
Roble blanco	A	D	B	A	A	A
Tabaiba	C	D	B	B	C	A
Ucar	B	C–D	C	B	C	B
CLASS 3—CONSIDERABLE DEGRADE						
Aguacatillo	E	D	C–D	D	D	C
Algarrobo	D	D–E	D–E	D	D	C
Casuarina	E	D–E	D–E	B	E	C
Espino rubial	B	D	D	D	B	A
Eucalipto	D–E	D	D–E	C	B	B
Jácana	D	D	D	B	D	C
Laurel geo	D	D	D	D	A	A
Mamey	E	D	E	D	E	D
María	D	E	E	E	A	B
Palo colorado	F	F	F	F	F	F
Samán	B	D–E	C	D–E	A	A
Yagrumo hembra [2]	D	D–E	D–E	D	A	A
Yagrumo macho	D–E	D–E	D	D	A	A

[1] Severity of defects are coded as follows:
A—None D—Moderate
B—Very slight E—Severe
C—Slight F—Very severe

[2] Subsequent tests indicate that yagrumo hembra can be air-dried with only moderate degrade under what may have been more favorable conditions.

The frequency and severity of defects causing degrade, particularly those causing surface checking, are often increased by overrapid drying. This can be prevented by closer piling, less ventilation below, above, and around the piles, and by using thinner stickers. Some warp may have been caused by the "thick and thin" nature of the lumber, which complicated piling. However, this condition is not unusual in material sawed in small sawmills, and it was accepted as a condition that will usually prevail whenever rough lumber is seasoned.

Tendency to Warp

PROCEDURE

The inherent tendency of a wood to warp is an important factor in the degrade that occurs during seasoning and in stability and behavior of the wood after manufacture. Woods having an inherent tendency to warp will generally incur more degrade during seasoning, and may warp in use. To determine this tendency for each wood, 10 or more 4-foot lengths of 1⅛ inch thick green lumber 6 to 9 inches wide were end-racked and allowed to air-season to equilibrium with the surrounding atmosphere (fig. 3). This method permitted the test samples to warp without restraint.

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FIGURE 3.—Four-foot boards end-racked for drying, a test of tendency to warp.

After becoming air-dry, the boards were placed on a flat surface and measured for bow, cup, and twist. A long wedge (fig. 4), calibrated so that each small division on the hypotenuse represented a vertical distance of 0.01 inch from the adjacent divisions, was used in the measuring. The amount of warp was read in hundredths of an inch at the worst point, because the maximum defect in any piece determines the amount of waste during manufacture. These readings were averaged for the 10 or more samples for each species.

Results of the warp tests may be useful as a guide in pointing out the need for selecting seasoning techniques that will overcome or at least reduce the inherent tendencies of certain woods to distort during air-drying.

RESULTS

The comparative ratings of the woods in the warp test (table 4) are in reasonably close agreement with results obtained in the air-seasoning study, although some differences are apparent between the two tests. Some woods showing a tendency to undergo severe distortion in the warp tests seasoned with only moderate degrade during air-seasoning. However, others showing up poorly in the warp tests were also subject to moderate to heavy degrade when air-seasoned.

Two tentative conclusions can be drawn from these results: (1) warp tests reveal the inherent tendencies of the different woods to distort during seasoning; and (2) the tendency of any wood to

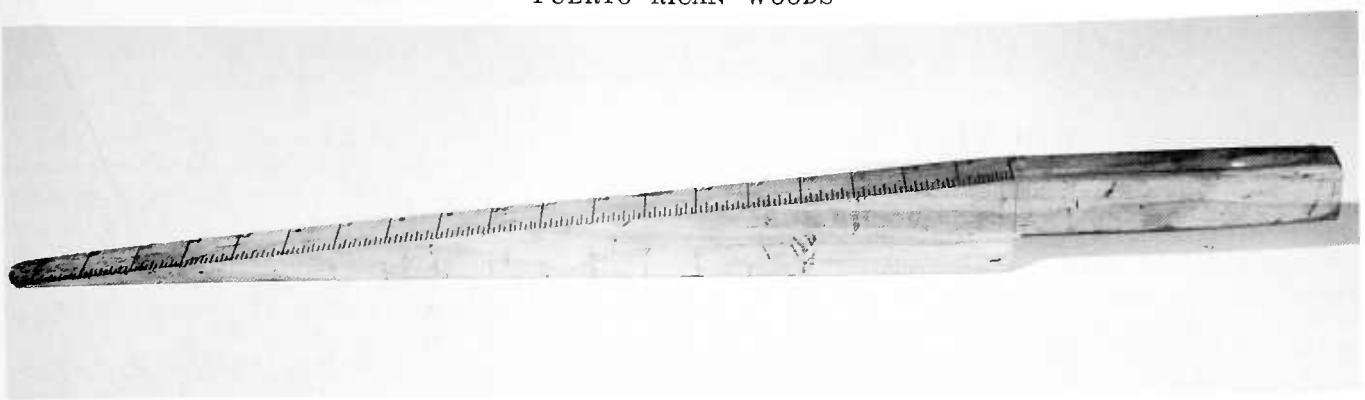

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FIGURE 4.—Calibrated wedge used to measure warp.

distort during seasoning is, to some extent, overcome by proper seasoning practices in the air-drying tests. It is well known that piling boards so that they are under restraint is effective in reducing cup, twist, and bow. Similarly, piling lumber in a way that will reduce the rapidity of drying will also reduce surface tension and the accompanying checking and distortion.

TABLE 4.—*Twist, cup, and bow occurring in hardwoods when air-dried without restraint, arranged in order from worst to best* [1]

Species	Twist	Cup	Bow	Species	Twist	Cup	Bow
	Inch	*Inch*	*Inch*		*Inch*	*Inch*	*Inch*
Palo colorado	3. 009	0. 365	0. 599	Caimitillo verde	0. 112	0. 051	0. 084
Mamey	. 997	. 273	. 230	Cucubano	. 126	. 035	. 099
María	. 473	. 057	. 201	Achiotillo	. 092	. 039	. 114
Casuarina	. 271	. 094	. 193	Caimitillo	. 077	. 015	. 153
Aguacatillo	. 225	. 139	. 170	Laurel prieto	. 105	. 034	. 101
Eucalipto	. 206	. 175	. 142	Laurel sabino	. 104	. 045	. 050
Panapén	. 271	. 106	. 105	Palo de matos	. 080	. 024	. 132
Yagrumo macho	. 266	. 104	. 087	Jobo	. 063	. 027	. 143
Algarrobo	. 109	. 072	. 265	Motillo	. 085	. 034	. 111
Cupey	. 194	. 056	. 166	Capá blanco	. 063	. 027	. 132
Maricao	. 094	. 044	. 248	Samán	. 063	. 019	. 136
Yagrumo hembra	. 197	. 087	. 100	Guaba	. 038	. 044	. 136
Jácana	. 191	. 050	. 127	Caracolillo	. 074	. 030	. 113
Jusillo	. 196	. 008	. 164	Almendra	. 090	. 044	. 183
Nuez moscada	. 118	. 056	. 190	Laurel geo	. 048	. 040	. 128
Ceiba	. 188	. 101	. 074	Masa	. 063	. 030	. 121
Laurel avispillo	. 107	. 066	. 186	Guamá	. 032	. 031	. 142
Jagüey blanco	. 124	. 040	. 189	Laurel amarillo	. 061	. 014	. 124
Guano	. 111	. 114	. 126	Capá prieto	. 045	. 027	. 122
Jagua	. 150	. 043	. 158	Moca	. 043	. 056	. 100
Palo de hueso	. 120	. 030	. 201	Negra lora	. 069	. 198	. 090
Guayabota	. 135	. 080	. 135	Ausubo	. 037	. 046	. 106
Almácigo	. 146	. 044	. 149	Tabonuco	. 073	. 046	. 064
Nemocá	. 158	. 032	. 136	Roble blanco	. 022	. 028	. 129
Mago	. 149	. 045	. 128	Guaraguao	. 054	. 035	. 087
Ucar	. 137	. 018	. 160	Tabaiba	. 017	. 032	. 126
Guajón	. 104	. 049	. 149	Teca	. 042	. 006	. 086
Espino rubial	. 070	. 042	. 180	Granadillo	. 033	. 019	. 066
Cedro hembra	. 070	. 032	. 167	Higüerillo	. 014	. 039	. 083
Mango	. 054	. 039	. 171				

[1] Based on 1- by 7-inch by 4-foot boards, adjusted to 7-inch width where necessary.

Physical Properties

SPECIFIC GRAVITY AND MOISTURE CONTENT

Specific gravity is a fairly reliable indicator of both the strength and machinability of wood. In general, heavy woods are stronger and machine better but with somewhat more difficulty than lightweight woods. However, a number of exceptions to this were found in tests of machining properties; some lightweight woods machined better than others of greater density.

Specific gravity is used to express the relative weight of wood. Technically, specific gravity is the ratio of the weight of a given volume of wood to that of an equal volume of water. Inasmuch as the weight of a given volume of wood changes with shrinkage or swelling caused by changes in the moisture content, specific gravity is an indefinite value unless the conditions under which it is obtained are specified.

Procedure

Specimens for determining specific gravity, weight per cubic foot, moisture content, and shrinkage were cut from the four sample boards selected from each sample log as described previously. Cross sections were cut from the center and one or both ends of the sample boards after trimming had removed any part that may have lost moisture during conversion. The cross sections were then planed to a uniform thickness of 1.0 inch, and test specimens were prepared with a smooth-cutting table saw. Most specimens measured 1.0 inch along the radial plane, 2.5 inches along the tangential plane, and 4 inches on the longitudinal plane. Specimens were selected to be truly flat grained, but a nominal slope of the growth rings characteristic of good-quality flat-sawed boards was allowed.

Immediately after cutting, the specimens were weighed to the nearest $\frac{1}{10}$ gram and the three dimensions were determined to the nearest $\frac{1}{1000}$ inch. A specially adapted dial micrometer was used for these measurements (fig. 5). The specimens were weighed and measured again when air-dry and again finally after being placed in an oven at 103° C. until ovendry. The data on specific gravity, shrinkage, and weight per cubic foot (tables 5, 6, and 7) were computed from the weights and measurements of these specimens.

Results

Table 5 shows the specific gravity for each species, based on three different conditions: (1) green volume and ovendry weight; (2) air-dry volume at 15 percent moisture content and ovendry weight; and (3) ovendry volume and ovendry weight. The gravity data based on ovendry volumes and weights is termed "true" specific gravity, because it represents conditions that may occur simultaneously. The other two specific gravities are based on conditions that could not occur simultaneously. These so-called "nominal" specific gravities are useful in computing the true specific gravities at any moisture content above the fiber saturation point [5] and below the

[5] The point at which the cell walls are saturated with water but no free water remains in the cell cavities. Generally this is at about 30 percent moisture content.

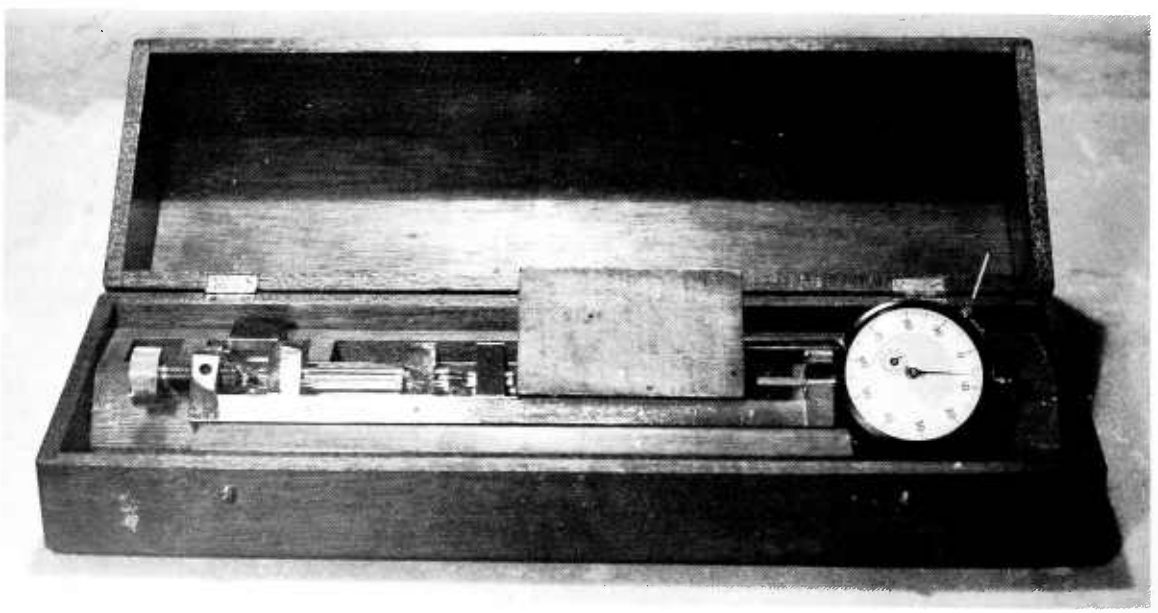

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FIGURE 5.—Dial micrometer adapted for measuring wood specimens to determine shrinkage and specific gravity.

fiber saturation point when the shrinkage rate is known. The true air-dry specific gravity for any moisture content below 30 percent may also be determined by the application of the factor in column 6 of table 5.

TABLE 5.—*Specific gravity of green, air-dry, and ovendry wood*

Species	Moisture content of green wood (percent)	Specific gravity based on ovendry weight and—			Factor for adjusting specific gravity [2]
		Green volume	Air-dry volume [1]	Ovendry volume	
(1)	(2)	(3)	(4)	(5)	(6)
Achiotillo	109	0. 39	0. 40	0. 43	0. 00244
Aguacatillo	88	. 42	. 46	. 50	. 00236
Algarrobo	63	. 70	. 74	. 80	. 00314
Almácigo	157	. 29	. 30	. 32	. 00215
Almendra	81	. 59	. 61	. 65	. 00335
Ausubo	48	. 82	. 89	. 98	. 00228
Caimitillo	54	. 68	. 74	. 79	. 00321
Caimitillo verde	54	. 64	. 68	. 73	. 00307
Capá blanco	73	. 66	. 68	. 75	. 00277
Capá prieto	92	. 57	. 59	. 63	. 00289
Caracolillo	50	. 77	. 81	. 90	. 00231
Casuarina	42	. 81	. 89	. 99	. 00208
Cedro hembra	83	. 45	. 46	. 50	. 00275
Ceiba	242	. 23	. 24	. 25	. 00184
Cucubano	69	. 65	. 69	. 75	. 00283
Cupey	71	. 67	. 72	. 78	. 00314
Espino rubial	84	. 46	. 48	. 52	. 00252
Eucalipto	115	. 51	. 58	. 63	. 00287
Granadillo	78	. 61	. 64	. 67	. 00409
Guaba	70	. 59	. 62	. 65	. 00340
Guajón	91	. 54	. 57	. 61	. 00270
Guamá	74	. 62	. 65	. 70	. 00290
Guano	97	. 22	. 23	. 24	. 00151
Guaraguao	123	. 51	. 53	. 57	. 00282
Guayabota	58	. 73	. 80	. 87	. 00263
Higüerillo	86	. 62	. 63	. 69	. 00433
Jácana	60	. 74	. 82	. 91	. 00220
Jagua	55	. 66	. 70	. 77	. 00282
Jagüey blanco	119	. 40	. 42	. 45	. 00252
Jobo	133	. 41	. 43	. 45	. 00276
Jusillo	65	. 74	. 78	. 84	. 00378
Laurel amarillo	58	. 55	. 57	. 61	. 00295
Laurel avispillo	74	. 47	. 50	. 53	. 00269
Laurel geo	77	. 45	. 47	. 50	. 00276
Laurel prieto	65	. 45	. 47	. 50	. 00274
Laurel sabino	98	. 59	. 62	. 65	. 00352
Mago	94	. 29	. 30	. 31	. 00192
Mamey	85	. 62	. 74	. 80	. 00416
Mango	72	. 55	. 57	. 61	. 00307
María	92	. 55	. 60	. 64	. 00287
Maricao	68	. 64	. 67	. 73	. 00304
Masa	52	. 63	. 68	. 72	. 00346
Moca	87	. 63	. 67	. 71	. 00323
Motillo	51	. 80	. 86	. 95	. 00216
Negra lora	64	. 70	. 75	. 84	. 00227
Nemocá	62	. 62	. 65	. 71	. 00296
Nuez moscada	63	. 59	. 62	. 67	. 00320
Palo colorado [3]	118	. 53	----------	. 74	. 01335
Palo de hueso	52	. 81	. 86	. 95	. 00253
Palo de matos	124	. 50	. 53	. 56	. 00260

See footnotes at end of table.

TABLE 5.—*Specific gravity of green, air-dry, and ovendry wood*—Continued

Species	Moisture content of green wood (percent)	Specific gravity based on ovendry weight and—			Factor for adjusting specific gravity [2]
		Green volume	Air-dry volume [1]	Ovendry volume	
(1)	(2)	(3)	(4)	(5)	(6)
Panapén	124	0. 27	0. 28	0. 30	0. 00180
Roble blanco	63	. 58	. 60	. 64	. 00304
Samán	145	. 44	. 45	. 48	. 00298
Tabaiba	96	. 38	. 39	. 41	. 00257
Tabonuco	57	. 53	. 56	. 59	. 00299
Teca	83	. 55	. 56	. 58	. 00372
Ucar	37	. 93	. 96	1. 06	. 00336
Yagrumo hembra	125	. 29	. 30	. 32	. 00198
Yagrumo macho	81	. 36	. 39	. 41	. 00252

[1] Air-dry values are adjusted to 15 percent moisture content using factors listed in column 6.

[2] Factor represents the change in true specific gravity for each 1 percent change in moisture content between 0 and 30 percent moisture content.

[3] Values are approximate because of occurrence of severe distortion during seasoning of test specimens. Values were computed from green to ovendry measurements and weights, assuming an equilibrium moisture content of 30 percent.

WEIGHT PER CUBIC FOOT

The weight of wood per cubic foot is useful in determining the weight of finished articles or in estimating freight and handling costs. It is also a common denominator used to compare the density of one wood with that of another and it often has more meaning to wood users than a specific-gravity figure. However, the condition of the wood, whether air-dry or green, or the actual moisture content for which the weight per cubic foot is quoted must be specified. This is essential because the weight or specific gravity of wood is influenced by the moisture content. Furthermore, when the moisture content is below the fiber saturation point, around 30 percent moisture content, a further reduction in the moisture content is accompanied by shrinkage and a loss in volume.

The weights per cubic foot for air-dry wood at 15 percent moisture content and for green wood at the moisture content specified as shown in table 6 are calculated from data in table 5. The weight per cubic foot can also be determined for any moisture content from 0 to 30 percent moisture content by means of the factor in column 5 of table 6. Weight per cubic foot for wood at any moisture content above 30 percent can be determined by multiplying the specific gravity in column 5 of table 5 by 62.4 and then multiplying this value by 1 plus the moisture content of the wood expressed as a decimal.

TABLE 6.—*Weight of green and air-dry wood*

Species	Green wood (at moisture content listed)		Air-dry wood (15 percent moisture content)	
	Moisture content	Weight per cubic foot	Weight per cubic foot	Factor for adjusting weight per cubic foot [1]
(1)	(2)	(3)	(4)	(5)
	Percent	*Pounds*	*Pounds*	
Achiotillo	109	51	29	0. 1525
Aguacatillo	88	49	33	. 1471
Algarrobo	63	71	53	. 1962
Almácigo	157	47	22	. 1342
Almendra	81	66	44	. 2092
Ausubo	48	76	64	. 1424
Caimitillo	54	66	52	. 2002
Caimitillo verde	54	61	49	. 1918
Capá blanco	73	71	49	. 1729
Capá prieto	92	68	42	. 1805

See footnote at end of table.

TABLE 6.—*Weight of green and air-dry wood*—Continued

Species	Green wood (at moisture content listed)		Air-dry wood (15 percent moisture content)	
	Moisture content	Weight per cubic foot	Weight per cubic foot	Factor for adjusting weight per cubic foot [1]
(1)	(2)	(3)	(4)	(5)
	Percent	*Pounds*	*Pounds*	
Caracolillo	50	72	58	.1443
Casuarina	42	72	64	.1297
Cedro hembra	83	51	34	.1714
Cieba	242	50	17	.1152
Cucubano	69	69	50	.1767
Cupey	71	72	52	.1961
Espino rubial	84	53	35	.1573
Eucalipto	115	69	42	.1790
Granadillo	78	68	46	.2555
Guaba	70	62	44	.2119
Guajón	91	64	41	.1684
Guamá	74	67	46	.1811
Guano	97	27	17	.0943
Guaraguao	123	71	38	.1759
Guayabota	58	72	57	.1639
Higüerillo	86	72	47	.2703
Jácana	60	74	59	.1376
Jagua	55	64	51	.1757
Jagüey blanco	119	55	30	.1574
Jobo	133	60	31	.1726
Jusillo	65	76	56	.2358
Laurel amarillo	58	54	41	.1840
Laurel avispillo	74	51	36	.1678
Laurel geo	77	50	34	.1725
Laurel prieto	65	46	34	.1708
Laurel sabino	98	72	44	.2198
Mago	94	35	21	.1198
Mamey	85	71	54	.2595
Mango	72	59	41	.1917
María	92	66	43	.1792
Maricao	68	67	48	.1897
Masa	52	60	48	.2157
Moca	87	74	47	.2015
Motillo	51	75	61	.1347
Negra lora	64	72	54	.1418
Nemocá	62	62	47	.1851
Nuez moscada	63	60	44	.1997
Palo colorado	118	71	[2] 59	[2] .8334
Palo de hueso	52	77	61	.1579
Palo de matos	124	70	37	.1621
Panapén	124	38	20	.1126
Roble blanco	63	59	42	.1896
Samán	145	68	32	.1858
Tabaiba	96	46	28	.1604
Tabonuco	57	52	40	.1866
Teca	83	62	40	.2324
Ucar	37	79	69	.2101
Yagrumo hembra	125	41	22	.1239
Yagrumo macho	81	40	28	.1570

[1] Factors for adjusting weight per cubic foot for each 1 percent change in moisture content between 0 and 30 percent moisture content.

[2] Approximate values.

SHRINKAGE

The average shrinkage values (table 7) for the Puerto Rican woods involved are considerably below similar values for hardwoods of comparable density from the United States. This accounts in part for the generally satisfactory manner in which most of the Puerto Rican woods can be air-seasoned.

The ratio of tangential to radial shrinkage is an indicator of the amount and severity of the warp and surface checking that develops during seasoning. The so-called nonrefractory woods, such as mahogany, have nearly equal radial and tangential values. Woods undergoing tangential shrinkage not more than two times the radial shrinkage will generally season without excessive warping or checking. But those with a ratio of 2½ or more will usually season rather unsatisfactorily unless given more than average care.

TABLE 7.—*Shrinkage values, in percent of original green measurements*

Species	Green to air-dry [1]				Green to ovendry			
	Radial	Tangential	Longitudinal	Volumetric	Radial	Tangential	Longitudinal	Volumetric
Achiotillo	0.8	2.4	0.04	3.3	2.9	5.7	0.28	8.8
Aguacatillo	2.5	7.5	.07	9.8	4.9	11.3	.36	15.9
Algarrobo	1.7	3.5	.20	5.4	4.4	8.3	.54	12.9
Almácigo	1.1	2.1	.28	3.4	2.6	4.2	.71	7.3
Almendra	1.8	2.5	.11	4.3	4.5	5.7	.36	10.3
Ausubo	2.5	4.5	.10	7.0	6.6	10.1	.34	16.3
Caimitillo	2.6	3.6	.21	6.3	5.9	7.8	.41	13.6
Caimitillo verde	2.1	3.4	.13	5.6	5.0	7.8	.31	12.7
Capá blanco	1.2	2.2	.06	3.4	4.3	7.1	.23	11.3
Capá prieto	1.0	2.0	.04	3.0	3.5	6.4	.25	9.8
Caracolillo	1.8	3.1	.04	4.8	5.9	8.5	.19	14.1
Casuarina	2.4	5.8	.04	8.1	6.4	11.7	.29	17.6
Cedro hembra	2.1	3.0	.11	5.1	4.5	6.1	.27	10.6
Ceiba	.8	3.2		3.8	2.1	5.2	.11	7.1
Cucubano	2.0	4.0	.10	6.0	5.0	8.8	.33	13.6
Cupey	2.1	4.7	.21	6.8	4.7	9.4	.49	14.1
Espino rubial	1.5	2.6	.10	4.2	4.2	6.3	.38	10.6
Eucalipto	3.3	9.7	.08	12.7	6.2	13.3	.30	18.9
Granadillo	1.1	2.5	.15	3.8	2.8	5.7	.30	8.6
Guaba	1.0	2.0	.06	3.1	3.6	6.0	.30	9.6
Guajón	2.0	3.6	.08	5.6	4.8	7.7	.39	12.5
Guamá	1.6	2.7	.07	4.4	4.0	6.6	.26	10.6
Guano	1.3	4.7	.11	6.1	3.0	7.6	.47	10.8
Guaraguao	1.4	3.7	.02	5.1	3.8	7.7	.13	11.3
Guayabota	2.8	5.8	.06	8.4	6.2	11.2	.20	16.9
Higüerillo	1.6	3.5	.21	5.2	3.0	6.3	.36	9.4
Jácana	3.6	5.4	.06	8.9	7.9	10.7	.27	17.9
Jagua	1.7	4.1	.04	5.7	4.6	9.1	.18	13.5
Jagüey blanco	1.0	2.8	.06	3.9	2.9	6.4	.22	9.3
Jobo	.9	1.9	.04	2.7	2.7	4.7	.13	7.5
Jusillo	2.2	3.9	.10	6.0	4.8	8.0	.29	12.7
Laurel amarillo	1.1	2.0	.08	3.1	3.7	6.0	.21	9.6
Laurel avispillo	1.4	3.3	.12	4.9	3.9	6.9	.41	10.9
Laurel geo	1.2	2.4	.08	3.7	3.4	5.8	.27	9.3
Laurel prieto	1.3	3.0	.10	4.4	3.6	6.4	.22	10.0
Laurel sabino	1.5	2.6	.02	4.1	3.8	6.2	.13	9.8
Mago	1.4	2.4	.05	3.8	3.2	5.2	.30	8.6
Mango	.8	2.3	.18	3.3	3.0	6.1	.59	9.5
Mamey	5.4	12.1	.38	17.0	7.7	15.2	.71	22.0
María	3.0	4.6	.03	7.5	6.2	8.4	.30	14.3
Maricao	1.5	3.5	.07	5.0	4.0	8.2	.39	12.2
Masa	2.1	3.4	.18	5.6	4.8	7.3	.25	12.0
Moca	1.2	2.5	.06	3.8	3.6	7.1	.24	10.6
Motillo	2.4	4.5		6.8	6.7	10.1	.16	16.3
Negra lora	2.7	4.8	.07	7.4	6.5	10.0	.27	16.1

See footnote at end of table.

TABLE 7.—*Shrinkage values, in percent of original green measurements*—Continued

Species	Green to air-dry [1]				Green to ovendry			
	Radial	Tangential	Longitudinal	Volumetric	Radial	Tangential	Longitudinal	Volumetric
Nemocá	1.8	3.4	0.08	5.2	4.9	7.4	0.35	12.3
Nuez moscada	1.8	3.1	.08	5.0	4.6	7.0	.18	11.4
Palo colorado [2]	5.1	10.3	.31	14.5	10.1	20.6	.62	29.1
Palo de hueso	2.2	3.5	.10	5.8	6.3	8.7	.35	14.8
Palo de matos	1.1	3.0	.01	4.1	3.6	7.4	.14	10.9
Panapén	1.0	2.7	.13	3.8	2.7	5.7	.47	8.7
Roble blanco	1.2	1.6	.18	3.0	4.1	5.5	.28	9.7
Samán	.7	1.2	.16	2.0	2.4	4.2	.40	6.9
Tabaiba	.6	1.8	.03	2.4	2.4	4.8	.07	7.1
Tabonuco	1.4	2.7	.12	4.2	4.1	6.4	.24	10.5
Teca	.5	1.1	.02	1.6	2.1	3.8	.35	6.2
Ucar	1.3	2.3	.06	3.6	4.4	7.9	.24	12.2
Yagrumo hembra	[3]	[3]	[3]	[3]	2.0	6.2	.22	8.3
Yagrumo macho	3.1	5.6	.06	8.5	4.9	8.2	.16	12.8

[1] At 15 percent moisture content.
[2] Approximate values.
[3] Reliable data not available for shrinkage percent from green to air-dry.

Relatively few of the Puerto Rican woods exhibited excessive directional or volumetric shrinkage. However, those that did, including aguacatillo, algarrobo, casuarina, eucalipto, mamey, and yagrumo hembra also developed excessive degrade during seasoning. Longitudinal shrinkage was relatively high in several woods having interlocked grain. This is a normal occurrence for woods with this type of grain and is not necessarily accompanied by excessive degrade. Longitudinal shrinkage of more than 0.3 percent is usually indicative of excessive warp. Palo colorado, with a longitudinal shrinkage of 0.62 percent, is a notable example. This wood, having tightly interlocked grain, developed very severe warp along with equally severe surface and end checking.

Machining Characteristics

PROCEDURE

The machining procedures were designed to test the different woods under a uniform and fairly typical set of conditions prevailing in Puerto Rico.[6] The woodworking machines and accessories used in the tests were typical of the small hobby-shop size equipment found in most woodworking shops on the island. Except for the use of forms and jigs to assure uniform handling of the test specimens, the methods and techniques of machining were typical of those used in working Mexican mahogany in Puerto Rico.

The procedures were not selected as the most suitable for the different woods but rather to show what actually happens under the specified conditions. Thus the results show the comparative machining qualities of the woods under one set of uniform conditions.

[6] Tests were patterned, with changes as required to meet local conditions, after procedures developed by E. M. Davis at the U.S. Forest Products Laboratory and published in Machining and Related Characteristics of Southern Hardwoods, U.S. Dept. Agr. Tech. Bul. 824, 42 pp. 1942.

SELECTION OF TEST MATERIAL

Nominal flat-grain, air-dry lumber free of knots and seasoning defects was used in all machining tests. Fifty boards of each species, 7 inches or more wide, were selected at random, planed to $^{25}/_{32}$ inch thickness, and cut into machining specimens for the different tests (fig. 6). Test specimens were essentially heartwood, but pieces containing sapwood were not discarded nor were specimens rejected having some cross grain, irregular grain, or density lower or higher than average.

GRADING

The smoothness of machined surfaces is the most important factor in judging the machinability of different woods. Accordingly, in this study the test samples were examined for machining defects after each operation and were graded on a

numerical scale based on smoothness of cut. A grade of 5 was considered *excellent*, 4 *good*, 3 *fair*, 2 *poor*, 1 *very poor*, and 0 *reject*. Both the frequency and severity of defects were considered. Each wood was finally rated numerically [7] according to the weighted average grade of all specimens in each test. The percent of specimens grading *good* to *excellent* or *fair* to *excellent* is also shown for most tests. This figure, which combines two or more grades and is expressed in percent, is not necessarily comparable to the numerical rating based on the weighted sum of the assigned grades.

The woods were also separated into five broad groups under each machining test, based on the calculated ratings and the experience of the operators making the tests. Separating the woods into *excellent*, *good*, *fair*, *poor*, and *very poor* groups under the respective machining tests necessitated placing certain woods in the top of one group though they were only very slightly inferior to those in the bottom of the next higher group. This condition and the necessity for introducing personal opinion in making the separation into groups should be considered by the reader when comparing the relative machinability of the different woods.

PLANING

Planing is one of the most important operations in most woodworking plants in Puerto Rico. Woods that plane poorly are difficult to use where smooth surfaces are required. Consequently the planing characteristics of the different woods is of primary importance in determining their utility for specific uses, especially in furniture manufacture. The tests were designed to measure and compare the planing qualities of the different woods under uniform and fairly typical local conditions.

Procedure

The machine used in the tests was a 4- by 12-inch single-surface cabinet planer designed for fine work in small woodworking shops. More than 90 percent of all planers used on the island are of this type. The cutter head, holding three 12-inch knives, revolved at 4,500 r.p.m., making 60 cuts per inch. All tests were made with a knife angle of 29° and at a feed rate of 17½ feet per minute. The 29° cutting angle is somewhat greater than the 20° to 25° generally recommended for hardwoods, but it is typical for the type of machines used in Puerto Rico. The knives were kept sharp at all times by frequent light sharpening and occasional grinding and jointing in a machine specially designed for that purpose.

Test specimens were essentially clear, flat-grain material, 4 inches wide, 3 feet long, and 25/32 inch thick. All material was air-dry. The tests involved planing 50 specimens of each wood at 1/32, 1/16, and 1/8 inch depth of cut, totaling 150 different tests for each species. Grading was based on the frequency and severity of defects occurring during the planing; namely, chipped grain, raised grain, fuzzy grain, and chip marks (fig. 7). The number and severity of chip marks was fairly constant at each depth of cut for the different woods, so this test was eliminated from the final analysis. The final grade of each specimen was based on the lowest rating for any type of defect present, because defect determines the amount of sanding required to make the piece acceptable for commercial use.

Results

Nearly two-thirds of all the woods rated good to excellent in planing. This was based on a weighted average of all specimens planed to three depths of cut (table 8). Of the 60 woods tested, only 6 were considered poor to very poor in planing properties, and 16 rated fair. Slightly more than one-half of the woods planed better than Honduras mahogany.

Specific gravity and texture appear to have little effect on planing qualities. Woods having uniformly straight grain generally plant better than those with irregular grain, although certain woods with heavily interlocked grain, such as palo colorado, planed very well. Chip marks were few in all woods at 1/32 inch depth of cut, moderate at 1/16 inch, and frequent to severe at 1/8 inch. However, an efficient exhaust system would have eliminated nearly all of this defect.

The proportion of pieces rating good to excellent at different depths of cut varied according to species, but, in general, better surfaces were obtained at 1/8- and 1/16-inch cuts than at 1/32 inch. Table 9 shows that the heaviest cut, 1/8 inch, frequently gave the best results.

This is contrary to the results obtained with larger cabinet planers. The difference is due to the vibrations that occur when very thin cuts are made in a small single-surface planer of the type used in these tests. Inasmuch as the test was designed to compare and rate the different woods under uniform and fairly typical conditions, most of those exhibiting fair to very poor planing qualities might be improved if better equipment and techniques were used.

[7] Calculated by totaling the numerical grades of all samples and multiplying this sum by 0.4 when 50 samples were used, 0.2 for 100 samples, and 0.1333 for 150 samples.

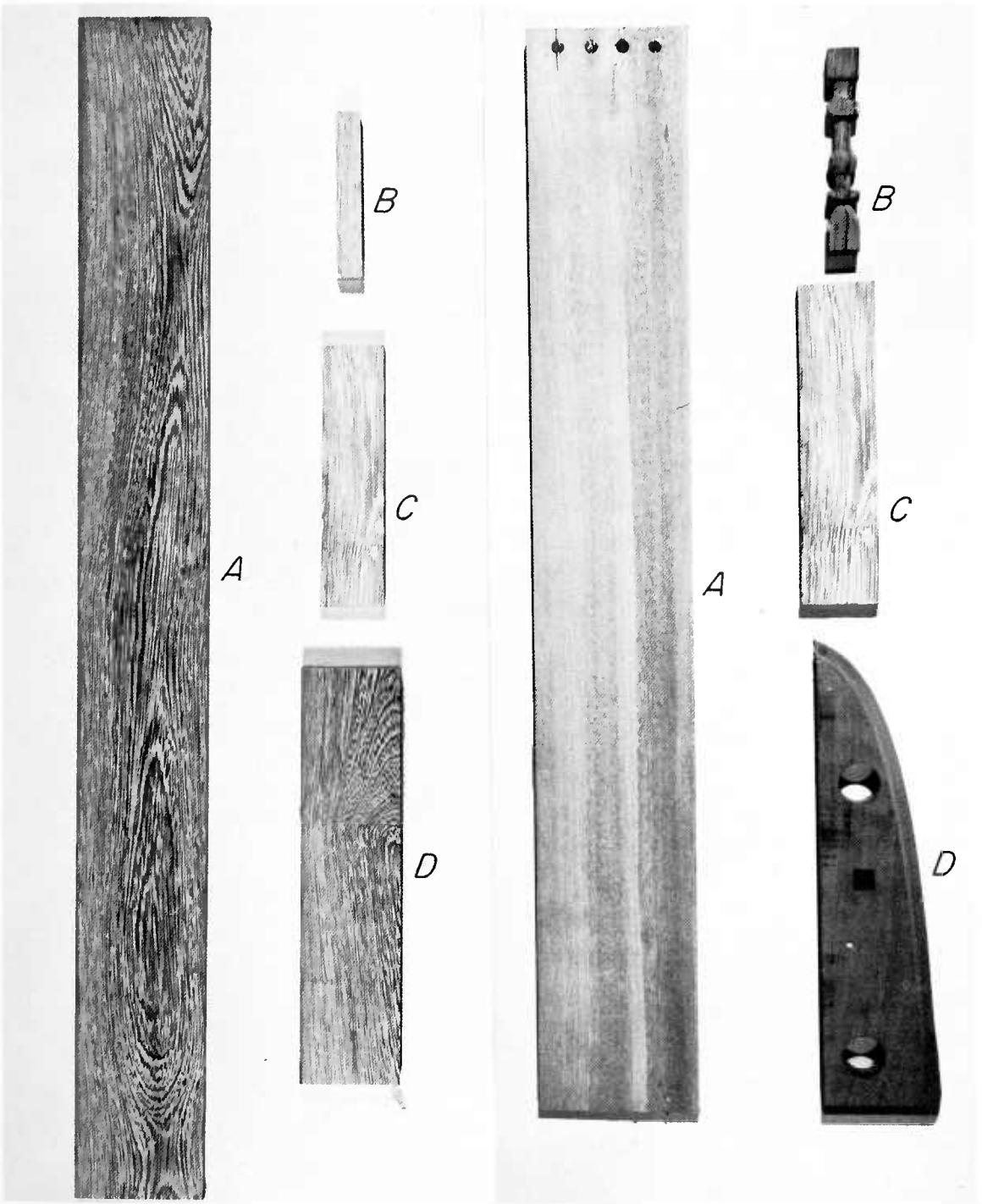

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FIGURE 6.—For each species, a set of sample pieces was prepared for the machining tests. Left, Before machining; right, after machining. *A*, Planing and screw splitting; *B*, turning; *C*, sanding; and *D*, shaping, mortising, and boring.

TABLE 8.—*Planing: comparative rating of all species, based on averages for three depths of cut* [1]

Species	Rating [2]	Species	Rating [2]	Species	Rating
EXCELLENT		GOOD—Continued		FAIR—Continued	
Ceiba	96	Guayabota	83	Mango	66
Tabaiba	93	Yagrumo macho	82	Roble blanco	66
Palo colorado	93	Cucubano	82	Masa	65
Moca	93	Guano	82	Nemocá	65
Guaraguao	91	Laurel geo	82	María	65
Aguacatillo	90	Almácigo	82	Espino rubial	63
Jagua	90	Palo de matos	81	Nuez moscada	63
Jobo	90	Eucalipto	80	Laurel sabino	63
GOOD		Samán	79	Capá blanco	63
Capá prieto	89	Laurel prieto	78	Negra lora	63
Mamey	89	Laurel avispillo	77	Panapén	62
Caimitillo verde	89	Granadillo	76	POOR	
Caracolillo	88	Tabonuco	76	Jusillo	61
Teca	88	Guaba	74	Higüerillo	60
Cedro hembra	87	Caoba hondureña	72	Laurel amarillo	59
Ausubo	87	Guajón	72	Mago	57
Jagüey blanco	86	Guamá	72	Palo de hueso	57
Achiotillo	85	FAIR		VERY POOR	
Maricao	85	Cupey	70	Almendra	52
Yagrumo hembra	84	Algarrobo	69		
Motillo	84	Jácana	68		
Caimitillo	83	Casuarina	68		
		Ucar	67		

[1] 1/8, 1/16, and 1/32 inch depth of cut.

[2] Calculated by totaling the numerical grades of the 150 samples of each wood and multiplying this sum by the factor 0.1333 (100 divided by the possible total if all pieces were blemish-free. 150×5=750).

TABLE 9.—*Planing: percentage of samples rated good to excellent at different depths of cut* [1]

Species	Depth of cut			Species	Depth of cut		
	1/8 inch	1/16 inch	1/32 inch		1/8 inch	1/16 inch	1/32 inch
Achiotillo	94	86	78	Jobo	100	82	82
Aguacatillo	100	96	92	Jusillo	6	14	12
Algarrobo	50	30	36	Laurel amarillo	24	8	8
Almácigo	80	88	54	Laurel avispillo	74	66	64
Almendra	6	0	4	Laurel geo	88	72	70
Ausubo	88	74	80	Laurel prieto	62	80	54
Caimitillo (mesa)	74	82	74	Laurel sabino	20	22	20
Caimitillo verde	86	90	86	Mago	4	2	6
Caoba hondureña	64	34	44	Mango	32	32	32
Capá blanco	20	15	25	Mamey	88	96	88
Capá prieto	100	96	92	Mariá	16	20	28
Caracolillo	92	78	74	Maricao	92	86	62
Casuarina	36	36	28	Masa	20	30	34
Cedro hembra	100	100	91	Moca	90	90	94
Ceiba	100	100	100	Motillo	78	74	64
Cucubano	64	74	80	Negra lora	34	6	18
Cupey	38	52	46	Nemocá	42	26	14
Espino rubial	32	28	14	Nuez moscada	34	14	24
Eucalipto	66	82	72	Palo colorado	96	96	98
Granadillo	58	70	48	Palo de hueso	4	6	4
Guaba	48	44	60	Palo de matos	78	76	62
Guajón	56	42	42	Panapén	24	20	26
Guamá	52	48	36	Roble blanco	34	24	36
Guano	82	96	94	Samán	68	80	64
Guaraguao	92	82	90	Tabaiba	98	94	90
Guayabota	90	70	62	Tabonuco	56	46	46
Higüerillo	8	8	4	Teca	96	82	90
Jácana	54	36	16	Ucar	31	36	28
Jagua	78	92	96	Yagrumo hembra	70	80	86
Jagüey blanco	92	86	92	Yagrumo macho	86	84	58

[1] Considering all defects except chip marks.

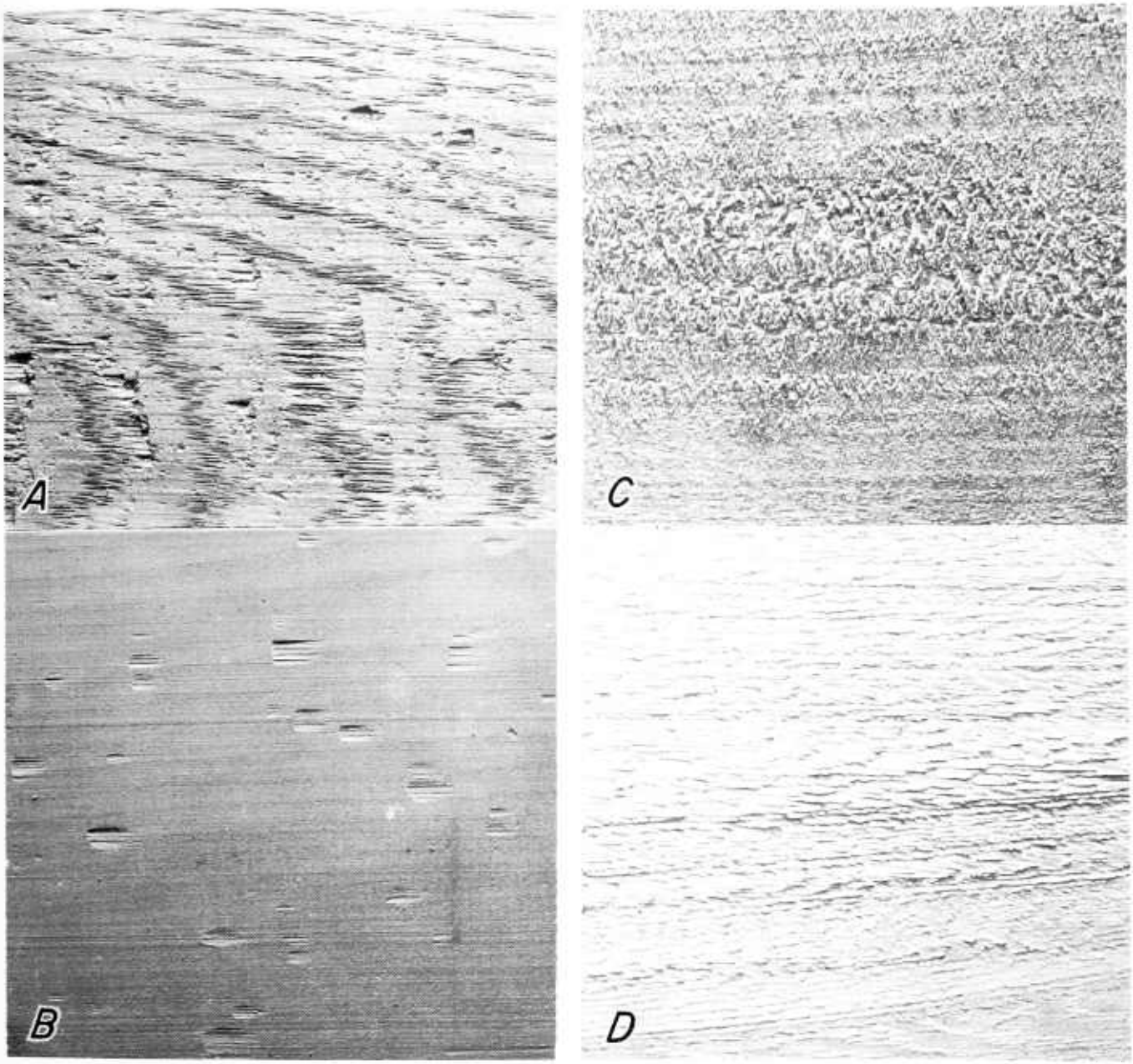

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FIGURE 7.—Planning defects: *A*, Torn grain; *B*, chip marks; *C*, raised grain; *D*, fuzzy grain.

SHAPING

Shaping is a common operation in woodworking plants, particularly those that manufacture furniture and related items. The operation generally involves cutting a pattern on the edge of exposed surfaces such as tabletops and shelving. Its primary function is to add to the attractiveness of the finished products. Consequently, the smoothness and detail of the shaping is of primary importance and was used as a basis for grading the tests specimens.

Procedure

The machine selected for the tests was a single-spindle type, operated at 11,000 r.p.m. by a belt-driven 1½-horsepower electric motor, and fed by hand. Small machines of this type are used in most furniture plants in Puerto Rico. A 2½-inch cutter head holding three steel knives was used throughout the tests. The knives were of a common commercial pattern, cutting an outline varying from right angles to parallel to the grain. Knives were sharpened at frequent intervals and were replaced when any appreciable wear was evident.

Test specimens of each species consisted of 50 pieces of typical flat-grain material, 4 by 18 inches in dimension and $^{25}/_{32}$ inch thick. Specimens were first handsawed to a curved outline on one side and one end and then fastened to jigs and handfed in two operations past the cutters. One operation involved shaping along the end at right angle to the grain and the other followed the curved outline previously cut on each sample (fig. 8).

After shaping, the samples were graded on the basis of four types of defects: torn grain, chipped grain, raised grain, and fuzziness. For all practical purposes, the most defective place on a shaping determines its grade, as the defect at that point controls the amount of sanding required to make the piece acceptable for commercial use (fig. 9).

Results

More than two-thirds of the woods rated good to excellent in shaping, and only 10 were considered poor or very poor. The most unsatisfactory woods were in all cases light to extremely light in weight, whereas the medium to very heavy woods generally gave the best results.

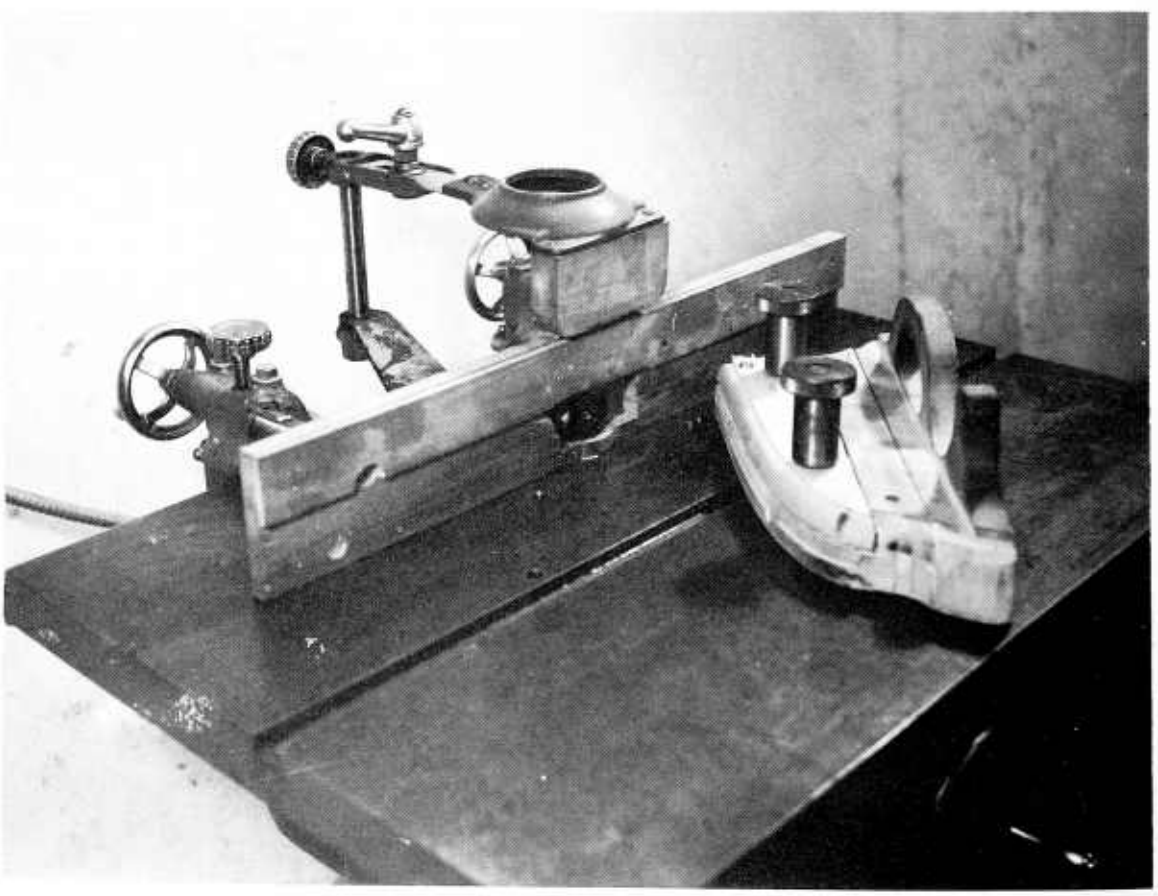

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FIGURE 8.—Finished shaping held in the jig used in the test.

TABLE 10.—*Shaping: comparative rating of all species based on smoothness of cut when considering all side and end defects*

Species	Rating	Good to excellent shaping
EXCELLENT		*Percent*
Ausubo	99	100
Guayabota	97	96
Caimitillo	96	98
Caimitillo verde	96	96
Motillo	95	96
Mamey	94	100
Roble blanco	94	98
Jagua	92	96
GOOD		
Caoba hondureña	91	90
Jácana	91	88
Caracolillo	90	86
Nemocá	89	86
Negra lora	89	76
Palo de matos	88	92
Ucar	88	92
Cucubano	88	92
Palo colorado	86	88
Casuarina	86	84
Masa	85	78
Jusillo	85	76
Yagrumo macho	84	76
Nuez moscada	83	86
Granadillo	83	90
Algarrobo	82	78
Laurel prieto	82	82
Cedro hembra	81	92
Guaraguao	80	96
Eucalipto	80	90
Laurel avispillo	80	88
Capá prieto	80	88
Cupey	80	76
María	80	76
Laurel amarillo	80	70
GOOD—Continued		*Percent*
Maricao	79	72
Capá blanco	78	88
Laurel sabino	78	76
Guajón	77	64
Teca	76	74
Tabonuco	75	76
Higüerillo	75	64
Laurel geo	74	60
FAIR		
Mango	72	56
Palo de hueso	70	54
Tabaiba	68	48
Moca	68	42
Samán	66	40
Almendra	65	46
Yagrumo hembra	62	38
Guamá	61	8
Espino rubial	60	24
POOR		
Jagüey blanco	59	22
Cieba	58	28
Guano	58	22
Guaba	56	6
Achiotillo	54	10
Aguacatillo	52	14
Jobo	52	8
VERY POOR		
Almácigo	46	0
Panapén	33	4
Mago	24	0

Shaping characteristics were not always related to specific gravity, for some of the heaviest woods, such as higüerillo and casuarina, rated well down the list. On the other hand, ausubo, a very heavy wood, produced the best shapings of all, while Honduras mahogany was ninth in the list of 60 woods studied (table 10).

Inasmuch as this test compared the shaping qualities of the different woods under typical and reasonably uniform conditions, those exhibiting fair to poor shaping qualities might have been improved if special machining techniques were employed to overcome their specific problems.

TURNING

Wood turning in Puerto Rico is generally limited to bed posts and a few similar items in the manufacturing of furniture. Imported Honduras mahogany is customarily used. Of the local woods, tabonuco is usually selected for this work, although numerous other species have equal or superior turning qualities. Most shops use small, handfed, hobby-shop size machines, but a few semiautomatic machines are coming into use.

Procedure

The tests were made with a small hand lathe embodying the back-lathe principle with certain modifications. The knife was a special milled-to-pattern type suitable for turning small pieces with considerable detail. It was held in a compound rest of the type used for metal turning. Test material consisted of 50 pieces of each wood, $^{25}/_{32}$ inch square and 5 inches long. The test involved most of the common cuts in turning, including turning a bead, cove, and fillet, plus cuts at several different angles to the grain on each test specimen. All turning was done at 3,300 r.p.m.

Turnings were graded on the basis of smoothness of cut and sharpness of detail, with the poorest point determining the grade for the specimen.

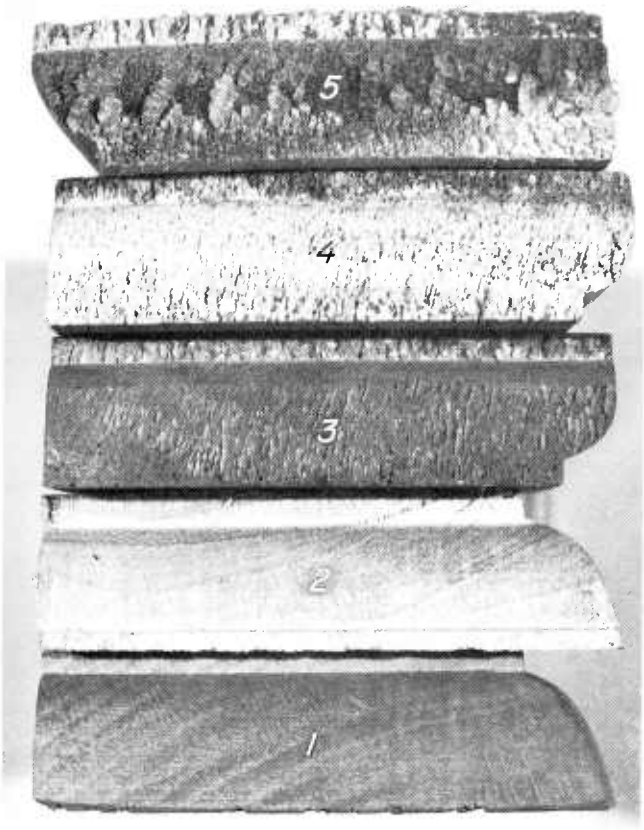

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FIGURE 9.—Test samples showing different degrees of defect when shaped at right angles to the grain.

The governing factor was the amount of sanding required to bring each specimen to an acceptable standard. Grading was done on a basis of 0 to 5 (fig. 10), as described on page 17.

Results

Three-quarters of the woods rated fair to excellent when turned under what is considered severe turning conditions (table 11). In general, the heavier woods turned better than those of low density.

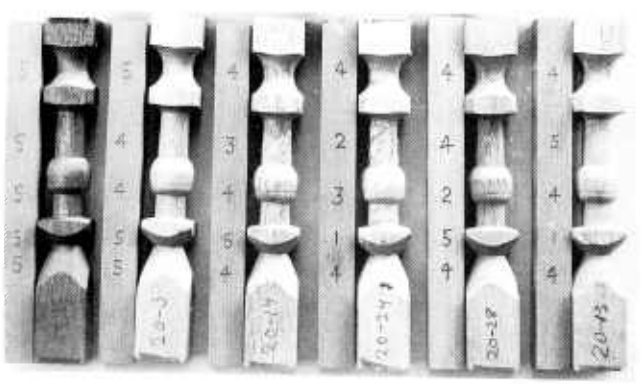

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FIGURE 10.—Defects and different degrees of defects that develop during turning.

All of the woods that rated very poor are very light in weight. However, only part of the woods rated excellent are extremely heavy. For example, moca is moderately heavy, yet it is an excellent wood to turn. Twelve species turned better than caoba hondureña, which is well liked in the turning trade. Tabonuco, the favorite turning wood in Puerto Rico, and cedro hembra, another well-regarded wood for turning, rated only fair on the basis of these tests. Surprisingly, ausubo, one of the heavier woods, turned poorly under the test conditions. Inasmuch as the tests were conducted to determine the comparative turning qualities of the woods, it is evident most of them might give better results with more careful handling.

BORING

Boring is a common operation in woodworking plants that make furniture and other wood products in which dowels, rungs, spindles, or screws are used in the assembly process. Machines used in boring vary in size from small single-spindle drill presses to modern multiple-spindle boring machines capable of boring a dozen or more holes simultaneously. Many different types of wood drills and bits are available for the varied and often highly specialized boring operations. Although boring work is generally concealed in the finished product, the smoothness of cut and accuracy of hole size are of primary importance when dowels or rungs are used. A clean, smooth cut with a minimum tearing of the grain provides a tight fit and good glue-holding surfaces. Accurately sized holes are also important for obtaining a tight fit and a strong, thin glue bond between the hole surfaces and the dowel or rung.

Procedure

A single-spindle, motor-driven boring machine operating at 1,725 r.p.m. was used in the tests. The bit was a 1-inch, spear point, single twist, solid center type. It was maintained in good cutting condition by frequent sharpening, and it was replaced at the first sign of wear or damage. Test specimens were held securely during boring in a special jig, and the bit was fed into the wood at a uniform rate by a hand-feed mechanism (fig. 11). Mechanical means of feeding the bit into the wood would have been desirable but were not available.

Two holes were bored in each 50 test specimens of each species, $^{25}/_{32}$ inch thick. The 100 holes for each wood were then graded for smoothness of cut, and they were rated according to the numerical system described on page 17 (fig. 12).

The accuracy of hole size was measured for several species and was found to be at least as uniform as the size of the bits and doweling available on the local market. Because of the difficulty of making accurate measurements of hole size, this part of the test was abandoned.

TABLE 11.—*Turning: comparative rating of all species, based on smoothness of cut*

(Based on percent of turnings graded fair to excellent)

Species	Rating	Species	Rating	Species	Rating
EXCELLENT		GOOD—Continued		FAIR—Continued	
Guayabota	100	Palo de heuso	80	Tabaiba	40
Teca	100	Eucalipto	76	Yagrumo hembra	40
Jagua	98	Jácana	76	Palo de matos	38
Higüerillo	98	Negra lora	76		
Ucar	96	Guaba	72	POOR	
Cucubano	96	Guaraguao	72		
Moca	96	Laurel sabino	70	Almendra	30
Algarrobo	96	Cupey	68	Ausubo	28
Capá blanco	94	Nemocá	68	Jobo	28
Capá prieto	92	Laurel amarillo	64	Mariá	28
		Caimitillo	60	Espino rubial	24
GOOD		Laurel geo	60	Jagüey blanco	24
		Nuez moscada	58	Aguacatillo	18
Granadillo	90	Roble blanco	58	Samán	14
Caimitillo verde	90			Achiotillo	10
Caoba hondureña	90	FAIR			
Masa	90			VERY POOR	
Caracolillo	86	Cedro hembra	50		
Palo colorado	86	Laurel avispillo	50	Ceiba	6
Motillo	84	Tabonuco	50	Yagrumo macho	2
Mamey	84	Casuarina	48	Almácigo	0
Jusillo	82	Guajón	48	Guano	0
Guamá	82	Mango	46	Mago	0
Maricao	80	Laurel prieto	44	Panapén	0

Results

The majority of these woods bored satisfactorily. Only 4 of the 60 woods exhibited very poor qualities in this respect, and 11 rated poor. Specific gravity appeared to be an important factor, with the heavier woods producing considerably better holes than light to medium density woods. All woods rated very poor and most of those rated poor were among the lightest used in the tests.

The test was designed to treat all woods alike in order to develop comparative ratings for the different species. Consequently, most of the woods exhibiting unsatisfactory boring qualities could be handled more satisfactorily under different and less severe conditions. Even woods like guano and panapén, although very difficult to bore, can be bored satisfactorily if special techniques and the proper bits are used.

A limited number of measurements of hole size indicated that hole size was most accurate in the woods rated good and poorest in those producing rough, torn holes. Holes were generally undersize in the dense, good-boring woods—actually smaller than the bit. Holes were considerably oversize in the woods with rough, torn borings. Charring is a difficulty frequently encountered in boring very dense wood, but this can be eliminated by increasing the rate of feed.

MORTISING

Mortise-and-tenon joints have been used for centuries in fabricating all types of wooden structures, furniture, and other objects. The mortise, usually a rectangular hole made to receive the tenon of another member, was for many years cut by hand. When nails, screws, and other fastening devices became plentiful and cheap, this type of joinery was no longer necessary. Such joints are still used, but now most mortises are cut by machines, principally in furniture and millwork

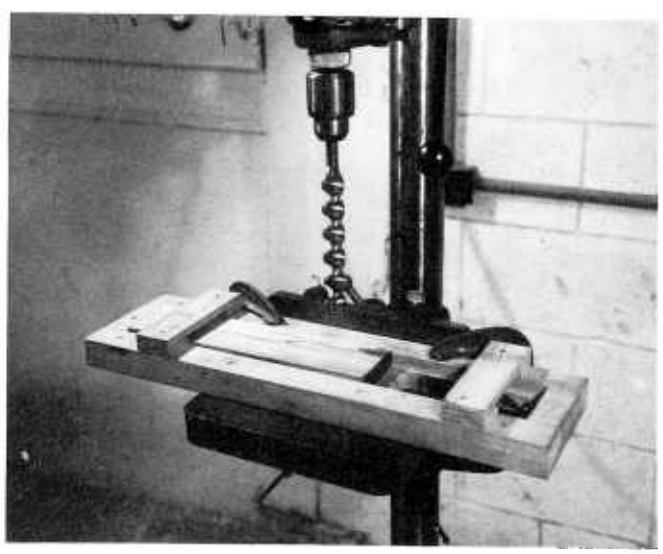

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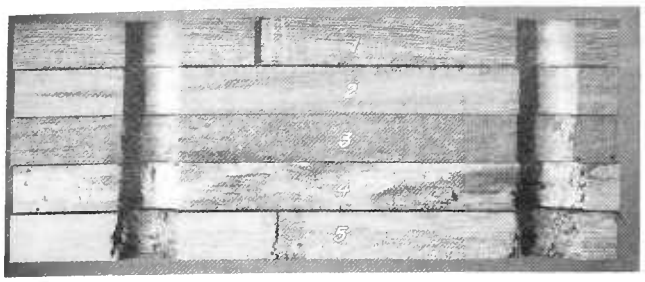
FIGURE 11.—Blank held in jig ready for boring test.



F–495319

FIGURE 12.—Boring test samples, showing the variation in smoothness of cut.

plants. Since tenoning is done in operations similar to shaping and planing, separate tests of tenoning were not made in this study.

The mortising tests were made with a hollow-chisel mortising tool operating in a conventional drill press. This type of mortising tool consists of a specially designed bit revolving within a hollow square chisel. It cuts a square hole. As the tool is pressed into the wood, the bit bores a round hole, and the hollow chisel, following close behind the bit, cuts out the corners.

Procedure

Fifty specimens of each wood, $^{25}/_{32}$ inch thick, were used for the test. One mortise was cut in each test sample with a standard ½-inch mortising tool, the bit revolving at 1,250 r.p.m. Test specimens were held snugly in place during mortising by means of a special jig. Because the machine used was of the hand-fed type, considerable care was taken to maintain a uniform rate of feed for all species. Both the bit and chisel were sharpened at frequent intervals and replaced whenever any wear or damage was evident.

The finished mortises (figs. 13 and 14) were graded for smoothness of cut in accordance with the numerical grading system described on page 17. An attempt to measure the accuracy of mortise size with a steel gage was impractical, because the variation in size of mortising tools and the inaccuracy of measurements appeared to be greater than the variation in mortise dimensions of different woods.

Results

Most of the Puerto Rican woods mortised satisfactorily. Ten of them mortised better than caoba hondureña and all but 15 gave good to excellent results. Specific gravity appears to be an important factor, with the heavier woods generally producing better mortises than the light-weight softwoods. In general, cuts parallel to the grain were acceptably smooth in most woods. However, cuts across the grain varied widely, some of them showing considerable crushing and tearing. The comparative rating of the woods as listed in table 13 is based largely on smoothness of cut across the grain.

TABLE 12.—*Boring: comparative rating of all species based on smoothness of cut*

Species	Rating	Good to excellent holes
		Percent
EXCELLENT		
Ausubo	100	100
Ucar	100	100
Maricao	100	100
Capá blanco	100	100
Motillo	100	100
Guayabota	100	100
Caracolillo	100	100
Palo de hueso	100	100
Roble blanco	99	100
Jácana	99	100
Jagua	96	100
Laurel amarillo	95	100
Caimitillo	95	99
Capá prieto	95	98
GOOD		
Masa	94	100
Nemocá	94	97
Guamá	93	100
Granadillo	92	98
Moca	92	98
Caimitillo verde	91	97
Palo colorado	91	94
Algarrobo	91	90
Jusillo	90	100
Negra lora	89	96
Mamey	87	95
Teca	86	85
Higüerillo	85	98
Casuarina	84	90
Laurel sabino	84	79
Laurel avispillo	83	92
Nuez moscada	82	89
Guaba	82	79
Mango	81	80
Caoba hondureña	81	76
FAIR		
Palo de matos	80	79
Cucubano	79	82
Samán	77	76
Guaraguao	76	66
Eucalipto	75	73
Cupey	75	68
Tabonuco	74	54
Espino rubial	73	62
Almendra	73	54
Laurel prieto	71	51
Laurel geo	70	46
POOR		
Cedro hembra	68	44
Yagrumo macho	67	42
María	67	37
Tabaiba	63	16
Jagüey blanco	62	16
Guajón	60	19
Jobo	59	11
Ceiba	59	26
Almácigo	53	7
Aguacatillo	53	9
Achiotillo	51	2
VERY POOR		
Guano	48	11
Yagrumo hembra	45	2
Mago	42	0
Panapén	30	7

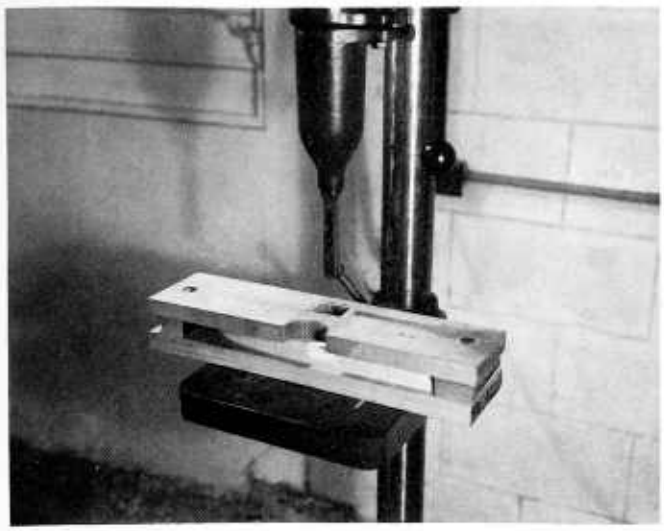


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FIGURE 13.—Test samples held in jig for mortising test with hollow mortising chisel.

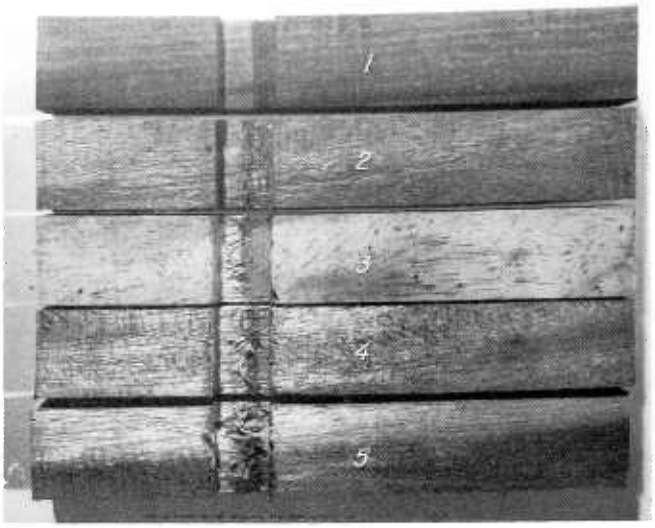

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FIGURE 14.—Test samples cross-sectioned to show different degrees of tearing that occurred in mortising.

TABLE 13.—*Mortising: comparative rating of all species, based on smoothness of cut*

Species	Rating	Good to excellent mortises	Species	Rating	Good to excellent mortises
EXCELLENT		*Percent*	GOOD—Continued		*Percent*
Capá blanco	100	100	Laurel sabino	85	94
Jagua	100	100	Mango	84	96
Nuez moscada	100	100	Tabonuco	84	86
Roble blanco	99	100	Cupey	84	86
Ucar	99	100	Yagrumo macho	84	82
Ausubo	98	100	Casuarina	83	100
Maricao	97	100	Samán	82	90
Masa	96	100	Higüerillo	82	90
Palo de hueso	95	100	Mamey	82	86
Nemocá	95	100	María	81	94
			Laurel prieto	81	90
GOOD			Laurel geo	81	88
Caoba hondureña	94	96	FAIR		
Laurel amarillo	93	100			
Caracolillo	93	100	Palo de matos	80	82
Caimitillo verde	93	100	Ceiba	80	82
Motillo	93	98	Guajón	80	72
Caimitillo	92	100	Almendra	77	78
Algarrobo	92	98	Espino rubial	73	56
Cucubano	92	98			
Guayabota	91	100	POOR		
Guaba	90	100			
Laurel avispillo	90	100	Tabaiba	67	36
Palo colorado	90	98	Achiotillo	66	34
Negra lora	90	98	Jagüey blanco	65	28
Guamá	90	96	Yagrumo hembra	62	24
Jácana	89	100	Jobo	62	16
Moca	89	98	Aguacatillo	58	18
Eucalipto	89	94			
Capá prieto	88	98	VERY POOR		
Jusillo	88	96			
Teca	88	86	Guano	48	12
Guaraguao	86	94	Almácigo	46	0
Cedro hembra	85	100	Panapén	44	14
Granadillo	85	98	Mago	42	0

SANDING

Sanding is an important operation in preparing many products for paint, varnish, or other finishes; it removes planing defects such as chip marks, torn or raised grain, knife marks, fuzz, and small scratches or dents. Some coarse or open-grain woods also require considerable sanding to provide a smooth surface for finishing. The higher grade products, such as furniture and cabinetwork, are carefully sanded before finishing. Blemishes that are not removed in the sanding are often magnified when clear or partially opaque finishes are applied. Consequently, woods selected for high-quality products must possess reasonably good sanding characteristics.

Procedure

The tests were made with a small power-driven belt sander using 6-inch-wide endless sanding belts approximately 14 feet long. Fifty 2- by 10-inch test specimens of each wood were sanded with 1/0 grit, 50 with 2/0 grit, and 50 with 3/0 grit. Garnet abrasives were used in all tests. The abrasive paper was replaced frequently to avoid the effects of wear, which reduces the size of the grit. Sanding was done parallel to the grain in a special jig holding eight test specimens at one time. Pressure of the sanding belt against the test specimens was applied by hand as uniformly as possible. Duration of the sanding varied according to the size of the grit; the finest grit required the most time. A watch was used to keep sanding time constant for each size of abrasive paper. After sanding, the samples were inspected visually for both fuzz and scratches, and they were graded on degree of freedom from these defects.

Results

The woods exhibited generally satisfactory sanding properties, with caoba hondureña at the top of the list and teca at the bottom (table 14). Thirty-eight of the 60 woods tested rated good to excellent, and only 11 were in the poor to very poor class. Specific gravity did not appear to be a dominant factor in sanding properties, although lightweight, open-textured woods tended to fuzz up more than others. Scratches were more readily visible on the surface of dense, fine-textured woods, just as fine scratches stand out on a mirror or polished metal surface. In general, fine-grained wood required a finer abrasive than coarse-grained wood. The tests indicated that 3/0 grit abrasive is normally required to reduce scratching and fuzzing to an acceptable minimum for high-quality finishes.

TABLE 14.—*Sanding: comparative rating of all species, based on percentage of scratch- and fuzz-free pieces* [1]

Species	Rating	Species	Rating	Species	Rating
EXCELLENT		GOOD—Continued		FAIR—Continued	
				Jobo	19
Caoba hondureña	91	Jagüey blanco	34	Palo colorado	18
Nuez moscada	90	Casuarina	33	Higüerillo	17
Moca	83	Masa	32	Laurel prieto	17
Ceiba	79	Maricao	32	Caimitillo	14
Ausubo	68	Yagrumo hembra	32	Laurel geo	13
Guamá	67	Almendra	31	Cucubano	11
Guaraguao	66	Capá prieto	30		
Roble blanco	60	María	29	POOR	
		Negra lora	29		
GOOD		Capá blanco	28	Guayabota	6
Guaba	53	Eucalipto	27	Espino rubial	6
Jácana	51	Ucar	26	Mango	5
Yagrumo macho	49	Caimitillo verde	25	Jusillo	5
Motillo	45	Caracolillo	23	Mamey	5
Granadillo	45	Cupey	23	Panapén	1
Algarrobo	43	Jagua	23	Mago	1
Samán	43	Laurel amarillo	23		
Almácigo	41	Guajón	22	VERY POOR	
Nemocá	41				
Cedro hembra	40	FAIR		Achiotillo	0
Aguacatillo	39	Guano	20	Tabaiba	0
Palo de matos	35	Palo de hueso	20	Laurel avispillo	0
Tabonuco	35	Laurel sabino	20	Teca	0

[1] Weighted average for 1/0, 2/0, and 3/0 grit sanding belts.

Related Properties

SCREW SPLITTING

In Puerto Rico, screws are usually driven with handtools. Consequently, handtools were adopted for these tests of Puerto Rican woods. Screws have the greatest holding power when driven snugly into prebored lead holes that are equal to the core diameter of the screw at a point half way down from the top of the threads. Normally screws are located as far from wood edges as possible. However, since the object here was to evaluate screw-splitting tendencies of the different species, considerably more severe test conditions were employed.

Procedure

Test material consisted of 25 boards $\frac{3}{8}$ inch thick, 4 inches wide, and 3 feet long. Four lead holes, $\frac{1}{16}$ inch in diameter, were bored in a line $\frac{1}{2}$ inch from one end of each board and approximately $\frac{3}{4}$ inch apart and from each edge. They were about one-half the proper size for the No. 8 screws used in the tests. The lead holes were bored with a hand-operated drill press to insure straightness. Four screws were driven through the lead holes in each board into a softwood backing, using a hand brace and screwdriver bit. Screws were driven to a uniform depth, the base of the head being flush with the top of the board (fig. 15).

After the screws were driven, the boards were inspected for complete splits at the points where the screws were sunk. A complete split was considered to be one that extended through the end of the board and back beyond the screw. It also had to be visible on both sides of the board. The woods were then rated according to their comparative resistance to splitting under the test conditions (table 15).

Results

The tests indicated that woods having uniformly straight grain are more susceptible to splitting than those having cross (interlocked) grain. Lightweight woods also were less susceptible to splitting than heavy, dense woods. All Puerto Rican woods rated excellent in resistance to screw splitting were either light in weight or possessed

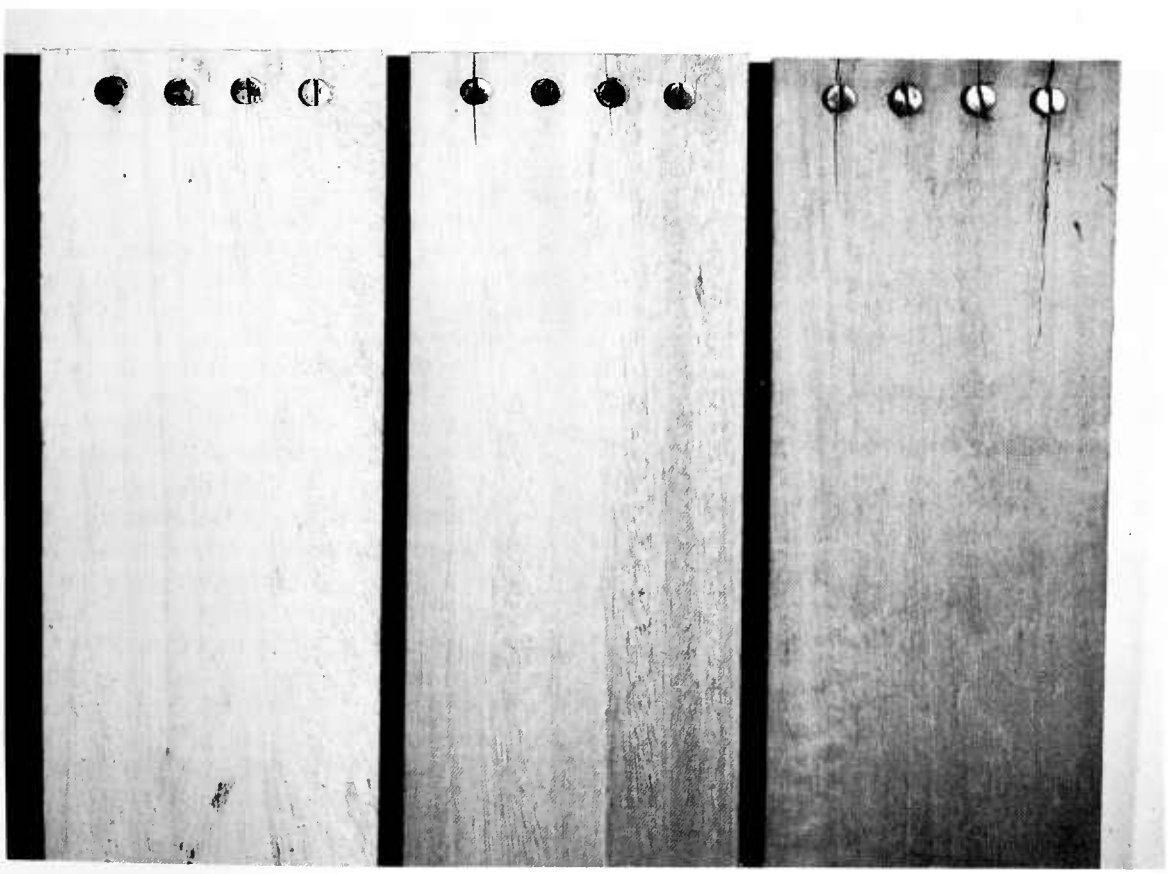

FIGURE 15.—Test samples illustrating screw splitting. Left, 0; center, 2; right, 3.

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TABLE 15.—*Screw splitting: comparative rating of all species, based on percentage of split-free pieces* [1]

Species	Rating	Species	Rating	Species	Rating
EXCELLENT		GOOD—Continued		FAIR	
Guano	100	Laurel geo	57	Masa	24
Ceiba	100	Espino rubial	55	Caimitillo	23
Almácigo	100	Tabonuco	53	Ausubo	22
Palo colorado	100	Almendra	53	Palo de hueso	22
Mago	99	Nuez moscada	51	Jácana	22
Mamey	97	Palo de matos	51	Negra lora	21
Yagrumo macho	96	Cupey	49	Roble blanco	20
Aguacatillo	91	Caimitillo verde	46	POOR	
Achiotillo	89	Laurel sabino	46	Jusillo	19
Panapén	89	Laurel amarillo	44	Cucubano	18
Jagüey blanco	86	Moca	43	Higüerillo	17
Yagrumo hembra	83	Algarrobo	43	Motillo	14
Eucalipto	81	Guaba	40	Capá prieto	14
GOOD		Nemocá	40	Maricao	14
Jobo	79	Guamá	38	VERY POOR	
Mango	75	Jagua	37	Caracolillo	8
Laurel prieto	69	Granadillo	36	Ucar	8
Caoba hondureña	68	Teca	35	Guayabota	5
Guajón	65	María	34		
Samán	63	Capá blanco	34		
Tabaiba	62	Guaraguao	32		
Laurel avispillo	60	Casuarina	32		

[1] Cedro hembra not included for lack of suitable material.

interlocked grain. Conversely, most of the woods rated low were dense and characterized by straight grain.

Because these tests were designed to produce comparative results, the lead holes were purposely made too small and screws were driven close enough to the ends and edges of boards to obtain a sufficient amount of splitting for comparative purposes. Using larger lead holes and spacing screws farther from the ends of boards would reduce splitting in most of these woods, but this would not change their inherent susceptibility to splitting.

RESISTANCE TO DRY-WOOD TERMITES

The West Indian dry-wood termite, or "polilla," *Cryptotermes brevis* Walker, is possibly the most destructive wood-boring insect in Puerto Rico. With few exceptions, it can destroy any native or imported woods. The winged adults move about with ease, infesting wood wherever they find it—the woodwork or framing in a house, the picture frames on the wall, or the oxcart in the field. The frequency and extent of damage by this termite often is sporadic and unpredictable. Woods rated very susceptible to attack often give long and satisfactory service. Yet at other times the same woods are attacked and almost completely destroyed within a few years, or sometimes in a few months. Despite this inconsistency, the wood user should recognize the relative susceptibilities of the different woods to damage and ultimate destruction by this voracious enemy. He can then either use woods having natural resistance to termites in especially vulnerable locations or protect the susceptible woods with chemicals prior to use.

Procedure

Tests to determine the resistance of the different woods to damage by the dry-wood termite were conducted by Dr. G. N. Wolcott of the University of Puerto Rico Agricultural Experiment Station, using small test specimens prepared as part of this study. Only heartwood was used in the tests, because sapwood is always less resistant and in most cases very susceptible to termite attack. The specimens were placed in petri dishes with a small number of termites at room temperature and without light. Relative resistance was established by progressive removal of the blocks attacked. The basic numerical ratings were West Indies mahogany, 80; capá prieto, 60; and laurel sabino, 40.

Results

Only 2 of the 60 species tested were rated very resistant to attack by the dry-wood termites; one of these, teca, is an exotic tree grown only in plantations in Puerto Rico (table 16). Six species were rated resistant, 13 moderately resistant, and the remaining 39 very susceptible. On this basis,

TABLE 16.—*Natural resistance of woods to attack by the West Indian dry-wood termite* [1]

Species	Rating	Species	Rating	Species	Rating
VERY RESISTANT		MODERATELY RESISTANT—Continued		VERY SUSCEPTIBLE—Continued	
Algarrobo	88	Moca	46–52	Tabonuco	31
Teca	80	Masa	45	Eucalipto	30
RESISTANT		Higüerillo	42	Mamey	30
		Laurel sabino	40	Cucubano	29
Ucar	75	VERY SUSCEPTIBLE		Guajón	29
Caracolillo	71			Laurel avispillo	29
Guaraguao	70			Guamá	28
Granadillo	69	Maricao	39	Nemocá	28
Cedro hembra	61	Panapén	39	Yagrumo hembra	28
Capá prieto	60	Aguacatillo	38	Cupey	27
MODERATELY RESISTANT		Caimitillo verde	37	Espino rubial	27
		Casuarina	37	Guaba	27
		María	37	Laurel amarillo	27
		Nuez moscada	36	Laurel prieto	27
Caoba hondureña	59	Palo colorado	36	Negra lora	27
Ausubo	58	Palo de hueso	35	Yagrumo macho	27
Samán	57	Jusillo	35	Jagüey blanco	26
Motillo	53	Palo de matos	35	Mago	26
Capá blanco	51	Jagua	34	Ceiba	25
Caimitillo	48	Roble blanco	34	Tabaiba	24
Laurel geo	48	Guano	33	Jobo	24
Mango	48	Guayabota	33	Almácigo	23
Jácana	46	Almendra	32	Achiotillo	21

[1] Tests conducted and ratings established by Dr. G. N. Wolcott, University of Puerto Rico Agricultural Experiment Station.

about two-thirds of the native species reaching saw-log size are used at considerable risk of termite attack. Nevertheless, this is not so serious as it first seems; woods like African mahogany, Philippine mahogany, and baboen—rated 30, 33, and 31 respectively in natural resistance to termites—are used extensively on the island without serious losses.[8] Similarly, furniture made of maple and birch from the United States has given excellent service although rated very susceptible to termite attack.

In many instances, furniture made of susceptible woods becomes obsolete or worn out before being seriously damaged by termites. Even the most susceptible woods can be made more or less immune to termite attack if impregnated with one of the numerous chemicals recommended for this purpose.

Summary and Conclusions

All woods possess a number of properties that affect their utility for different purposes, and this should be considered in selecting material for any specific purpose or product. Other properties that are of only occasional significance are usually ignored except in circumstances when they have an effect on the usefulness of the wood. This study has been limited to certain properties that are of primary importance in the wood-using industry. The summation of these properties provides a fairly reliable estimate of the general utility of each wood and its suitability for specific purposes. The tests also show how each wood compares in different qualities with other woods, its good qualities, and the difficulties that may be encountered in its utilization for certain purposes.

The different tests covered in this study are summarized in tables 17 and 18. The reader can obtain a general idea of the characteristics of each wood by reading across the tables and can compare the individual properties of the different woods by following the respective columns from top to bottom.

It is apparent that in general utility the Puerto Rican woods are equal or possibly superior to a comparable number of hardwood timbers from the United States or Europe. In general, the Puerto Rican woods air-season more satisfactorily than woods from the temperate zone, have equal or perhaps more favorable shrinkage properties, and machine somewhat more satisfactorily. This is clearly evident in the tables on machining characteristics, in which Honduras mahogany (caoba hondureña)—a wood highly regarded in this respect—was rated considerably below a number of Puerto Rican woods in most machining properties.

[8] Wolcott, George N. An index of the termite-resistance of woods. Univ. Puerto Rico Agr. Sta. Bul. 85, 26 pp. 1950.

TABLE 17.—*Summary of physical properties*

Species	Specific gravity [1]	Weight per cubic foot		Shrinkage from green to ovendry			Air-seasoning characteristics		Resistance to dry-wood termites [5]
		Green	Air-dry [2]	Radial	Tangential	Volumetric	Rates [3]	Amount of degrade [4]	
	Percent	*Pounds*	*Pounds*	*Percent*	*Percent*	*Percent*			
Achiotillo	0.39	51	29	2.9	5.7	8.8	M	2	VS
Aguacatillo	.42	49	33	4.9	11.3	15.9	M	3	VS
Algarrobo	.70	71	53	4.4	8.3	12.9	M	3	VR
Almácigo	.29	47	22	2.6	4.2	7.3	R	1	VS
Almendra	.59	66	44	4.5	5.7	10.3	R	2	VS
Ausubo	.82	76	64	6.6	10.1	16.3	R	1	MR
Caimitillo	.68	66	52	5.9	7.8	13.6	R	1	MR
Caimitillo verde	.64	61	49	5.0	7.8	12.7	R	2	VS
Capá blanco	.66	71	49	4.3	7.1	11.3	R	2	MR
Capá prieto	.57	68	42	3.5	6.4	9.8	M	2	R
Caracolillo	.77	72	58	5.9	8.5	14.1	M	2	R
Casuarina	.81	72	64	6.4	11.7	17.6	M	3	VS
Cedro hembra	.45	51	34	4.5	6.1	10.6	R	1	R
Ceiba	.23	50	17	2.1	5.2	7.1	M	2	VS
Cucubano	.65	69	50	5.0	8.8	13.6	M	2	VS
Cupey	.67	71	52	4.7	9.4	14.1	M	2	VS
Espino rubial	.46	53	35	4.1	6.3	10.6	R	3	VS
Eucalipto	.51	69	42	6.2	13.3	18.9	M	3	VS
Granadillo	.61	68	46	2.8	5.7	8.6	R	1	R
Guaba	.59	62	44	3.6	6.0	9.6	R	2	VS
Guajón	.54	64	41	4.8	7.7	12.5	S	1	VS
Guamá	.62	67	46	4.0	6.6	10.6	R	2	VS
Guano	.22	27	17	3.0	7.6	10.7	M	2	VS
Guaraguao	.51	71	38	3.8	7.7	11.3	S	2	R
Guayabota	.73	72	57	6.2	11.2	16.9	M	2	VS
Higüerillo	.62	72	47	3.0	6.3	9.4	S	1	MR
Jácana	.74	74	59	7.9	10.7	17.9	S	3	MR
Jagua	.66	64	51	4.6	9.1	13.5	S	1	VS
Jagüey blanco	.40	55	30	2.9	6.4	9.3	S	1	VS
Jobo	.41	60	31	2.7	4.7	7.5	M	2	VS
Jusillo	.74	76	56	4.8	8.0	12.7	M	2	VS
Laurel amarillo	.55	54	41	3.7	6.0	9.6	M	2	VS
Laurel avispillo	.47	51	36	3.9	6.9	10.9	M	2	VS
Laurel geo	.45	50	34	3.4	5.8	9.3	M	3	MR
Laurel prieto	.45	46	34	3.6	6.4	10.0	M	1	VS
Laurel sabino	.59	72	44	3.8	6.2	9.8	R	1	MR
Mago	.29	35	21	3.2	5.2	8.6	R	1	VS
Mamey	.62	71	54	7.7	15.2	22.0	M	3	VS
Mango	.55	59	41	3.0	6.1	9.5	M	1	MR
María	.55	66	43	6.2	8.4	14.3	S	3	VS
Maricao	.64	67	48	4.0	8.2	12.2	M	2	VS
Masa	.63	60	48	4.8	7.3	12.0	R	1	MR
Moca	.63	74	47	3.6	7.1	10.6	M	2	MR
Motillo	.80	75	61	6.7	10.1	16.3	M	2	MR
Negra lora	.70	72	54	6.5	10.0	16.1	S	2	VS
Nemocá	.62	62	47	4.9	7.4	12.3	M	2	VS
Nuez moscada	.59	60	44	4.6	7.0	11.4	R	1	VS
Palo colorado	[6] .53	71	[6] 59	[6] 10.1	[6] 20.6	[6] 29.1	S	3	VS
Palo de hueso	.81	77	61	6.3	8.7	14.8	M	2	VS
Palo de matos	.50	70	37	3.6	7.4	10.9	S	2	VS

See footnotes at end of table.

TABLE 17.—*Summary of physical properties*—Continued

Species	Specific gravity [1]	Weight per cubic foot		Shrinkage from green to ovendry			Air-seasoning characteristics		Resistance to dry-wood termites [5]
		Green	Air-dry [2]	Radial	Tangential	Volumetric	Rates [3]	Amount of degrade [4]	
Panapén	0. 27	38	20	2. 7	5. 7	8. 7	M	2	VS
Roble blanco	. 58	59	42	4. 1	5. 5	9. 7	R	2	VS
Samán	. 44	68	32	2. 4	4. 2	6. 9	M	3	R
Tabaiba	. 38	46	28	2. 4	4. 8	7. 1	M	2	VS
Tabonuco	. 53	52	40	4. 1	6. 4	10. 5	R	1	VS
Teca	. 55	62	40	2. 1	3. 8	6. 2	R	1	VR
Ucar	. 93	79	69.	4. 4	7. 9	12. 2	M	2	R
Yagrumo hembra	. 29	41	22	2. 0	6. 2	8. 3	R	3	VS
Yagrumo macho	. 36	40	28	4. 9	8. 2	12. 8	R	3	VS

[1] Based on green volume and ovendry weight.
[2] At 15 percent moisture content.
[3] Rate of drying for 1⅛-inch lumber properly piled under cover.
R—Rapid (11–17 weeks)
M—Moderate (18–26 weeks)
S—Slow (27 weeks or more)
[4] Based on frequence and amount of cup, twist, bow, crook, and end and surface checking occurring from green to air-dry.
1—Minor degrade
2—Moderate degrade
3—Considerable degrade
[5] VR—very resistant; R—resistant; MR—moderately resistant; VS—very susceptible.
[6] Approximate values.

TABLE 18.—*Summary of machining characteristics*

Species	Planing	Shaping	Turning	Boring	Mortising	Sanding	Resistance to screw splitting
Achiotillo	Good	Poor	Poor	Poor	Poor	V. poor	Exc.
Aguacatillo	Exc	do	do	do	do	Good	Do.
Algarrobo	Fair	Good	Exc	Good	Good	do	Good.
Almácigo	Good	V. poor	V. poor	Poor	V. poor	do	Exc.
Almendra	V. poor	Fair	Poor	Fair	Fair	do	Good.
Ausubo	Good	Exc	do	Exc	Exc	Exc	Fair.
Caimitillo	do	do	Good	do	Good	Fair	Do.
Caimitillo verde	do	do	do	Good	do	Good	Good.
Caoba hondureña	do	Good	do	do	do	Exc	Do.
Capá blanco	Fair	do	Exc	Exc	Exc	Good	Do.
Capá prieto	Good	do	do	do	Good	do	Poor.
Caracolillo	do	do	Good	do	do	do	V. poor.
Casuarina	Fair	do	Fair	Good	do	do	Good.
Cedro hembra	Good	do	do	Poor	do	do	
Ceiba	Exc	Poor	V. poor	do	Fair	Exc	Exc.
Cucubano	Good	Good	Exc	Fair	Good	Fair	Poor.
Cupey	Fair	do	Good	do	do	Good	Good.
Espino rubial	do	Fair	Poor	do	Fair	Poor	Do.
Eucalipto	Good	Good	Good	do	Good	Good	Exc.
Granadillo	do	do	do	Good	do	do	Good.
Guaba	do	Poor	do	do	do	do	Do.
Guajón	do	Good	Fair	Poor	Fair	do	Do.
Guamá	do	Fair	Good	Good	Good	Exc	Do.
Guano	do	Poor	V. poor	V. poor	V. poor	Fair	Exc.
Guaraguao	do	Good	Good	Fair	Good	Exc	Good.
Guayabota	do	Exc	Exc	Exc	do	Poor	V. poor.
Higüerillo	Poor	Good	do	Good	do	Fair	Poor.
Jácana	Fair	do	Good	Exc	do	Good	Fair.
Jagua	Exc	Exc	Exc	do	Exc	do	Good.
Jagüey blanco	Good	Poor	Poor	Poor	Poor	do	Exc.

TABLE 18.—*Summary of machining characteristics*—Continued

Species	Planing	Shaping	Turning	Boring	Mortising	Sanding	Resistance to screw splitting
Jobo	Exc	Poor	Poor	Poor	Poor	Fair	Good.
Jusillo	Poor	Good	Good	Good	Good	Poor	Poor.
Laurel amarillo	do	do	do	Exc	do	Good	Good.
Laurel avispillo	Good	do	Fair	Good	do	V. poor	Do.
Laurel geo	do	do	Good	Fair	do	Fair	Do.
Laurel prieto	do	do	Fair	do	do	do	Do.
Laurel sabino	Fair	do	Good	Good	do	do	Do.
Mago	Poor	V. poor	V. poor	V. poor	V. poor	Poor	Exc.
Mamey	Good	Exc	Good	Good	Good	do	Do.
Mango	Fair	Fair	Fair	do	do	do	Good.
María	do	Good	Poor	Poor	do	Good	Do.
Maricao	Good	do	Good	Exc	Exc	do	Poor.
Masa	Fair	do	do	Good	do	do	Fair.
Moca	Exc	Fair	Exc	do	Good	Exc	Good.
Motillo	Good	Exc	Good	Exc	do	Good	Poor.
Negra lora	Fair	Good	do	Good	do	do	Fair
Nemocá	do	do	do	do	Exc	do	Good.
Nuez moscada	do	do	do	do	do	Exc	Do.
Palo colorado	Exc	do	do	do	Good	Fair	Exc.
Palo de hueso	Poor	Fair	do	Exc	Exc	do	Fair.
Palo de matos	Good	Good	Fair	Fair	Fair	Good	Good.
Panapén	Fair	V. poor	V. poor	V. poor	V. poor	Poor	Exc.
Roble blanco	do	Exc	Good	Exc	Exc	Exc	Fair.
Samán	Good	Fair	Poor	Fair	Good	Good	Good.
Tabaiba	Exc	do	Fair	Poor	Poor	V. poor	Do.
Tabonuco	Good	Good	do	Fair	Good	Good	Do.
Teca	do	do	Exc	Good	do	V. poor	Do.
Ucar	Fair	do	do	Exc	Exc	Good	V. poor.
Yagrumo hembra	Good	Fair	Fair	V. poor	Poor	do	Exc.
Yagrumo macho	do	Good	V. poor	Poor	Good	do	Do.

A considerable number of the Puerto Rican woods possess unusual attractiveness, fitting them for a variety of uses where this property is important. This quality plus a wide range in density, hardness, and strength, among the woods tested—from guano (balsa) at the lower level to ucar and ausubo at the top—provides the consumer with an extensive choice of woods for any specific purpose.

In general, one or more and frequently several of these woods are suitable for most of the common wood uses on the island. Their utilization to the fullest extent possible in preference to imported material would encourage better management of the forests and, at the same time, would materially benefit the local economy.

PART 2. TIMBER DESCRIPTIONS

ACHIOTILLO

Alchornea latifolia Sw. (spurge family, Euphorbiaceae)

Achiotillo (fig. 16) is a pale creamy-brown color throughout, except for frequent reddish-brown "resin ductlike" canals, which are alined in a radial direction. On flatsawed surfaces, these blemishes range in size from minute round specks to fairly large ones and may be either filled with a opaque brown substance, partly occluded, or open. The wood has medium texture, straight to slightly wavy grain, low luster, and lacks characteristic odor or taste when seasoned. Growth rings are not evident. The wood is fairly soft and moderately light, yet firm and strong for its weight of 29 pounds per cubic foot when air-dry and 51 pounds when green.

Achiotillo air-dries at a moderate rate. Green lumber 1⅛ inch thick dries to about 17 percent moisture content in 5 months under cover in the San Juan area. Moderate degrade occurs during seasoning, mostly in the form of cup, bow, and twist, and a very small amount of surface checking. Sliced veneer stock is also reported to dry satisfactorily with a minimum of checking and splitting. Seasoning is accompanied by moderate and fairly uniform shrinkage. Flatsawed boards shrink at the rate of $\frac{1}{10}$ inch (0.9 percent) per foot across the growth rings and $\frac{1}{3}$ inch (2.4 percent) per foot parallel to the growth rings from green to air-dry.

The wood saws and works very easily in all machining operations. Good surfaces are obtained in planing, but in most other machining operations, because of the wood's moderate density and softness, it is badly torn and crushed and tends toward fuzziness. Special care is necessary in machining to keep such defects to an acceptable minimum. Screws and nails can be driven easily into the wood with a minimum of splitting.

Achiotillo is very susceptible to damage by the dry-wood termite and other insects, and it is quickly destroyed by decay when in contact with the ground. Logs are soon damaged by pinhole borers and discolored by sap-staining fungi if the tree is not processed immediately after felling. Green lumber is also subject to blue stain unless the surface is allowed to dry quickly after sawing or is treated with an antistain solution.

The wood is moderately strong for its density and has unusually good bending qualities when dry. Recent tests indicate it is very acceptable for kite sticks and other small bent parts. It may also be well suited for match splints, veneer flatware, and other similar uses. Achiotillo lacks the strength and durability for most outdoor construction but with preservative treatment would be useful for light carpentry and some types of exterior construction. It is also suitable for boxes, crates, toys, and temporary cement forms, and it has been recommended for utility veneer in British Guiana.

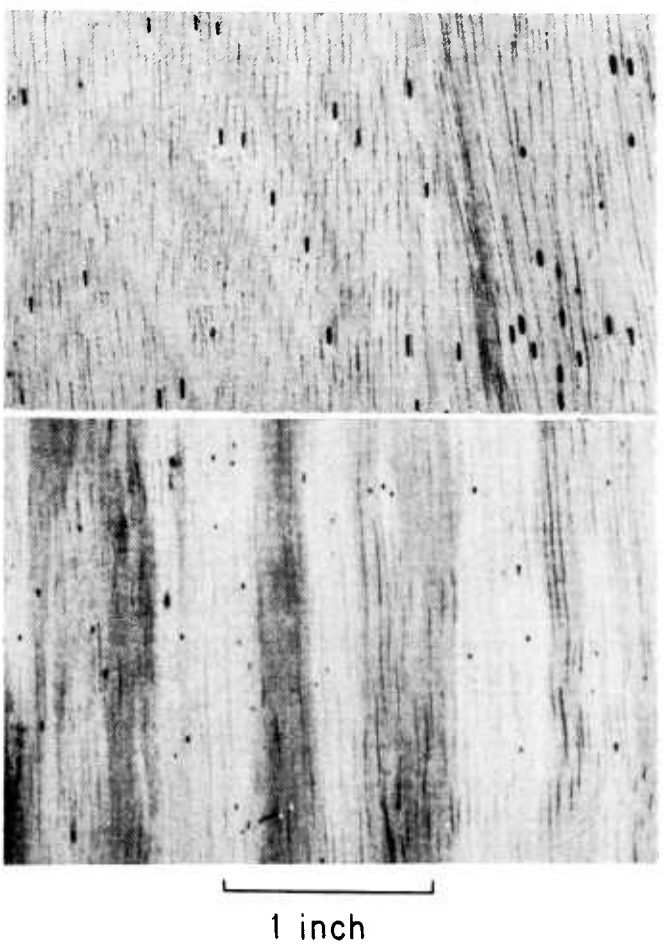

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FIGURE 16.—Achiotillo: *Top*, flatsawed; *bottom*, quartersawed.

AGUACATILLO

Meliosma herbertii Rolfe (sabia family, Sabiaceae)

Aguacatillo (fig. 17) has pale-brown heartwood, often with an attractive orange overcast, which is not readily separated from the lighter colored sapwood. Growth rings are faintly marked by zones of darker colored tissue that appear on the radial surface as fine scratches or lines, giving the wood a rather attractive appearance resembling cedro hembra. The wood has medium luster, moderately coarse texture, and straight to frequently interlocked grain. Seasoned wood has no distinctive odor and taste. Aguacatillo is moderately heavy, firm, and tough, weighing 33 pounds per cubic foot when air-dry and 49 pounds when green.

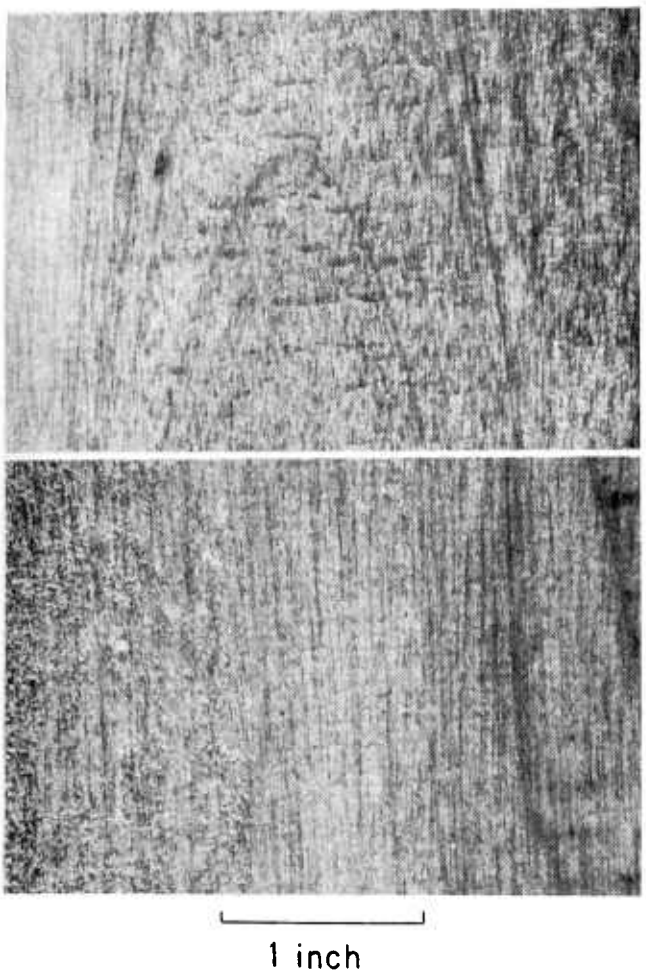

FIGURE 17.—Aguacatillo: *Top*, flatsawed; *bottom*, quartersawed.

The wood seasons at a moderate rate but develops considerable degrade in the process. Green 1⅛ inch lumber requires 5 months to air-dry to about 17 percent moisture content under cover in the San Juan area. Seasoning is accompanied by considerable degrade. Cupping is particularly troublesome, along with a moderate amount of bow, twist, crook, and surface checking. Sap-staining fungi are also active during the early stages of drying unless the wood is dipped in an antistain solution or is surface-dried immediately after sawing.

Seasoning is accompanied by relatively high and uneven shrinkage. Flatsawed lumber shrinks at the rate of 5/16 inch (2.5 percent) per foot across the growth rings and 7/8 inch (7.5 percent) per foot parallel to the growth rings in seasoning from green to air-dry.

Despite the presence of silica in the wood rays, aguacatillo saws and machines easily, but with generally unsatisfactory results. It gives good results in planing and can be sanded to a smooth, even surface. The results are poor in most other machining operations because of the wood's tendency to tear and crush in these operations. However, because of its softness and frequently interlocked grain, aguacatillo is rated excellent in resistance to screw splitting. It should also accept and hold nails well, glue satisfactorily, and take a good polish.

Aguacatillo is very susceptible to termites and other insects and poorly resistant to decay. The wood's low durability, poor seasoning properties, and difficulty in working hampers its utilization, and the infrequent occurrence of aguacatillo and the relatively small size of the logs also reduce its importance as a commercial timber. However, it is attractive and suitable for furniture, cabinetwork, paneling, interior trim, and other decorative purposes if the user is willing to contribute sufficient time and care in machining and sanding operations. It can also be used for boxes, crates, general interior and exterior construction, and carpentry. In general, the wood should be used only where high durability or great strength are not essential.

ALGARROBO (COURBARIL)

Hymenaea courbaril L. (legume family, Leguminosae)

Algarrobo (fig. 18), also known as courbaril and West Indian locust, is one of the best known and most useful woods of the American tropics. The heartwood is salmon red to orange brown in color when freshly cut, changing to russet, often with dark streaks, upon seasoning and exposure. Heartwood is distinct from sapwood. At times it may have a golden luster. The white to gray sapwood is abnormally thick, particularly in rapidly grown second-growth trees. Interlocked grain is

characteristic, but occasionally straight grain is seen. The wood is mostly medium textured and without distinctive odor or taste when seasoned. Growth layers are not readily evident.

The wood is particularly attractive on the radial surface, resembling sugar maple (*Acer saccharum*) in this respect. Its radial surface is distinguished by a lustrous sheen and scattered lines of vessels. This is a very heavy wood, weighing 53 pounds per cubic foot when air-dry and 71 pounds when green.

Algarrobo is difficult to season. In the tests, green lumber seasoned at a moderate rate, requiring approximately 6 months to air-season to about 17 percent moisture content under cover in the San Juan area. Considerable degrade occurred in the form of moderate cup, crook, and surface checking, moderate to severe bow and twist, slight end checking, and a moderate amount of casehardening.

Shrinkage during seasoning is moderate in all directions, especially for a wood of algarrobo's density. It compares very favorably in this respect with black locust (*Robinia pseudoacacia*) of the United States, which it noted for its low shrinkage in relation to its high density. Green algarrobo lumber shrinks $\frac{2}{10}$ inch (1.7 percent) per foot across the growth rings and about $\frac{4}{10}$ inch (3.5 percent) per foot along the growth rings in drying to 15 percent moisture content. It is reported to absorb moisture rather quickly but is considered reasonably stable in use.

The wood is very strong, tough, and hard, and is superior in strength to white oak (*Quercus alba*) of the United States in both green and air-dry condition. It also compares favorably with teak in most strength properties. Algarrobo is moderately difficult to saw and machine because of its high density, but except in planing it can be machined to a smooth surface. The wood is somewhat difficult to plane because of the tendency to tear easily in pieces having roey grain. It is difficult to nail but has good resistance to splitting by screws; it takes glue well and finishes satisfactorily, but does not take a high polish. The wood steam-bends very well, being comparable to white oak in this respect.

Algarrobo is reported to be unusually variable in decay resistance, ranging from nondurable to very durable in contact with the ground. It is readily damaged by marine borers but it is very resistant to dry-wood termites, rating well above the West Indian and Honduras mahoganies and teca in this respect. The wood weathers badly, and heavy checking occurs when the wood is exposed without the protection of paint.

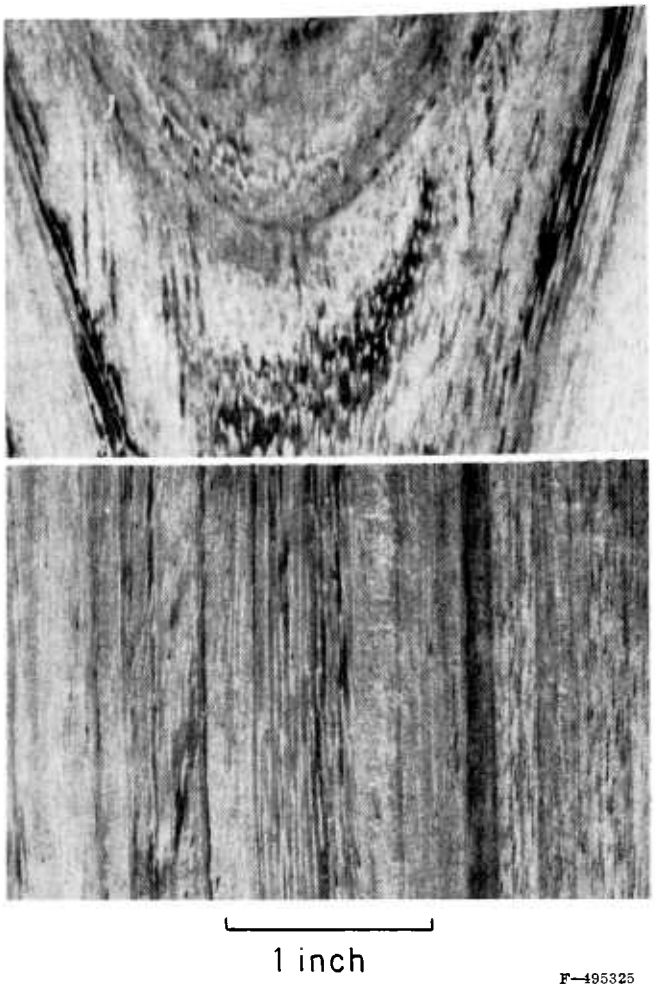

FIGURE 18.—Algarrobo: *Top*, flatsawed; *bottom*, quartersawed.

Algarrobo's high shock resistance fits it admirably for use in sporting goods and tool handles in place of white ash (*Fraxinus americana*). It is also quite suitable for steam-bent boat parts or other similar items for which oak is generally used. It provides a highly wear-resistant surface for flooring and stair treads. Wood from the wide layer of sapwood in second-growth timber is considered exceptionally good for natural and blond-finish furniture.

Both the sapwood and heartwood should be particularly attractive as veneer and plywood as well as for furniture, cabinetwork, interior trim, and turnery. The wood is currently used in the American tropics for ship planking, gear cogs, wooden-wheel parts, heavy and durable building construction, and loom harnesses. Because of its high resistance to abrasion, algarrobo is preferred for sugar-mill and other mill-machinery parts, lock gates in nonteredo areas, shoe heels, and ice sheathing.

ALMÁCIGO (GUMBO-LIMBO)

Bursera simaruba (L.) Sarg. (bursera family, Burseraceae)

This tree is called almácigo in Puerto Rico and gumbo-limbo in Florida. The logs are generally short and often crooked, but they are usually available in medium to large diameters. Although sap stain develops in freshly cut logs soon after the tree is felled, it can be controlled if the logs are milled immediately after felling and the lumber is dipped in an antistain solution before piling. Both the heartwood and sapwood of almácigo are a uniform cream to light-brown color throughout (fig. 19). However, because of sap-staining, almácigo is most often known as a wood of bluish-gray color. The wood has fine texture, straight to sometimes irregular grain, moderate luster, and possesses no distinctive order or taste. Growth rings are either absent or indistinct.

Seasoned wood is soft and light yet firm, tough, and fairly strong for its weight. Almácigo's best mechanical property is its good resistance to splitting. Air-dry wood weighs 22 pounds per cubic foot and green wood about 47 pounds per cubic foot at 17 percent moisture content.

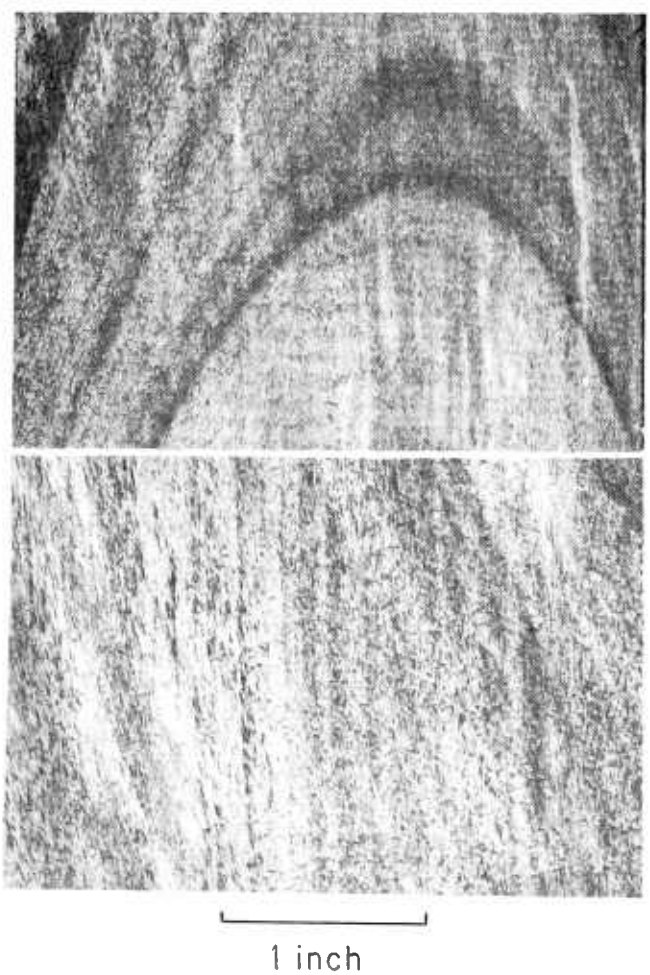

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FIGURE 19.—Almácigo: *Top*, flatsawed; *bottom*, quartersawed.

Almácigo air-seasons rapidly with minor degrade in the form of very slight cup and bow and slight twist. Crook, surface checking, and end defects are not troublesome. Green lumber 1⅛ inches thick air-seasons to about 18 percent moisture content in slightly over 4 months under cover in the San Juan area. Exceptionally low shrinkage occurs during seasoning. Flatsawed boards shrink approximately ¼ inch (2.1 percent) per foot in width and ⅛ inch (2.1 percent) per foot in thickness during seasoning.

The wood works easily with either hand or machine tools but—except in planing and sanding—the surfaces are severely torn and crushed in the machining operations. Although the wood is rated good in planing and sanding, slight fuzziness may occur in both operations. The use of very sharp, thin cutting edges and reduced feed rates are required to reduce tearing and crushing to a minimum. The wood has excellent resistance to screw splitting, holds nails firmly without splitting, and can be stained and finished satisfactorily.

The logs are reported to peel well on rotary lathes in Mexico without preliminary heating or bark removal, although some logs produce veneer with a "woolly" surface. Yield of acceptable face veneer averages 30 to 40 percent. The veneer has numerous pin knots, some mineral streaks, and occasionally a "birds-eye" figure like that in sugar maple.

Almácigo is very susceptible to termites and other insects, very perishable in the soil, and presumably has little resistance to marine borers. Logs are subject to early and severe attack by pinhole borers in addition to the above mentioned sap-staining fungi. However, both heartwood and sapwood are easily impregnated with preservatives, giving the wood good resistance to decay and insects.

Almácigo does not possess sufficient attractiveness and strength for use in furniture, but it is recommended for boxes, crates, cement forms, interior carpentry, and all types of light construction. It has been used for match splints in Jamaica. Despite almácigo's relatively poor machining qualities, the wood's low and uniform shrinkage indicates that it may be suitable for patternmaking and other similar uses where a lightweight, easily worked, and stable wood is required. In some areas the principal use of the tree is for posts and poles which take root and develop into living fence posts and telegraph poles.

The wood is used for utility plywood in Mexico under the name "Mexican white birch"; it is also considered a good material for core stock. In general, almácigo can be used as a substitute for pine or other lightweight conifers but lacks the strength of these woods.

ALMENDRA

Terminalia catappa L. (combretum family, Combretaceae)

Almendra, or Indian-almond, has become naturalized in Puerto Rico and elsewhere in tropical America. The seasoned heartwood is a medium reddish brown, marked with slightly darker colored stripes (fig. 20). The sapwood is indistinct and somewhat lighter in color. The grain is generally irregular and often interlocked; texture medium; luster rather high. A slight odor is often noticeable in seasoned wood. Long, narrow zones of tension wood occur often and cause considerable trouble in machining operations. The wood is moderately heavy, weighing 44 pounds per cubic foot when air-dry and 66 pounds when green. It is moderately strong, hard, and tough.

The wood seasons rapidly, 1⅛-inch green lumber reaching approximately 18 percent moisture content in slightly over 3 months under cover in the San Juan area. A moderate amount of warping occurs during seasoning, but surface and end checking are almost absent under the usual drying conditions.

Shrinkage is moderate and uniform during seasoning, indicating that almendra should be stable after manufacture. Green lumber shrinks at the rate of $\frac{2}{10}$ inch (1.8 percent) per foot across the growth rings and $\frac{3}{10}$ inch (2.5 percent) per foot along the growth rings during seasoning to 15 percent moisture content.

Almendra saws and machines rather easily, but with generally unsatisfactory results. Torn and fuzzy grain is very common in planing, shaping, and turning, especially in pieces containing tension wood or irregular grain. Rough and torn grain is also common in boring and mortising. It sands to a fairly good surface and has good resistance to screw splitting. Careful machining is necessary to keep machine defects to an acceptable minimum for most uses.

Almendra is very susceptible to dry-wood termites. On the basis of tests on closely related species, it should be durable in contact with the ground but probably is quite susceptible to attack by marine borers.

The wood is very attractive when finished and would be useful for millwork, furniture, veneer, and cabinetwork if carefully handled. If almendra possesses the durability of other species of the genus, it should be acceptable for many uses in exterior construction that require a moderately strong, hard, durable wod. It has been recommended in other Caribbean areas for framing, planking, and other parts of boats; general construction, bridge timbers, railway crossties, and flooring. It is also used to some extent for boxes, crates, and other shipping containers.

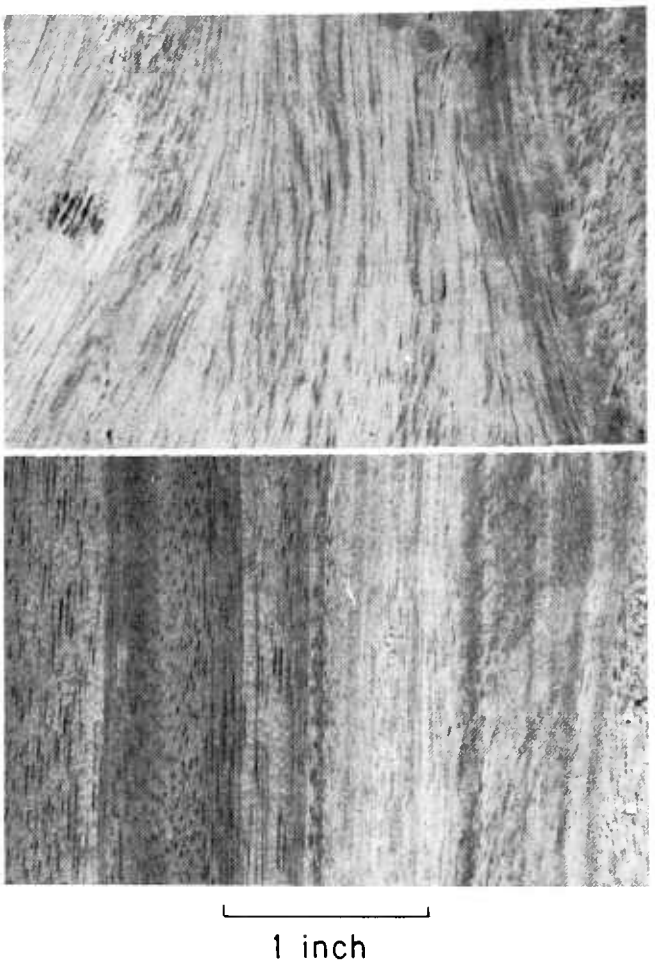

FIGURE 20.—Almendra: *Top*, flatsawed; *bottom*, quartersawed.

AUSUBO (BALATA)

Manilkara bidentata (A. DC.) Chev. (sapodilla family, Sapotaceae)

Ausubo, also known as balata, is one of the strongest and most attractive woods available for commercial use in Puerto Rico. The whitish to pale-brown sapwood (fig. 21) is distinct but not easily separated from the heartwood. Green heartwood is light red when cut, turning to a dark-reddish color when dry. The wood has a uniformly fine texture without pronounced figure; the grain is usually straight but may be coarsely interlocked at times. A characteristic odor is sometimes present in green wood but is not evident after seasoning, although dry wood does have a characteristic oily feel. Ausubo is exceptionally hard and heavy, weighing 64 pounds per cubic foot when air-dry and 75 pounds when green.

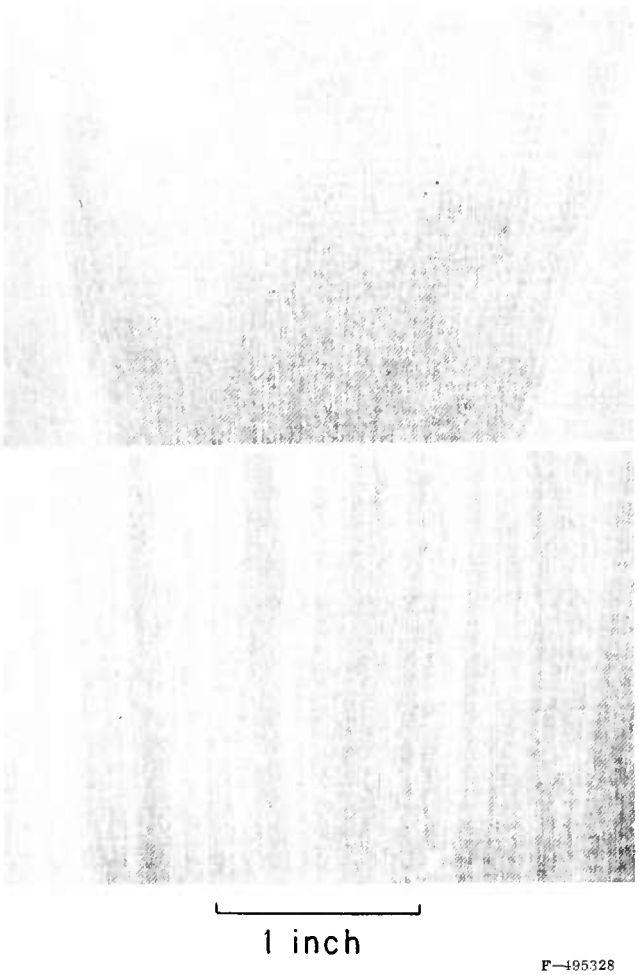

FIGURE 21.—Ausubo: *Top*, flatsawed; *bottom*, quartersawed.

Despite its density, ausubo air-seasons at a fairly rapid rate, reaching an air-dry moisture content of 19 percent in 4 months under cover in the San Juan area. Seasoning degrade is limited to a small amount of cup and bow and slight twist. Surface checking and end splitting were not evident in the tests.

Ausubo undergoes moderate shrinkage for a wood of its density. Green wood is reduced approximately $\frac{3}{10}$ inch (2.5 percent) per foot of width across the growth rings and $\frac{9}{16}$ inch (4.5 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Ausubo is moderately hard to machine because of its high density but cuts cleanly in ripping and crosscutting without appreciable dulling of the cutting edges. The wood gives good to excellent results in most machining operations except turning, which must be done slowly and carefully to avoid tearing and rough surfaces. It is also difficult to nail and is susceptible to splitting by screws. Ausubo is an excellent wood to steam-bend, comparable to oak in this respect, but is difficult to glue. It finishes beautifully and rather easily, the finished wood resembling mahogany.

The wood is considered very resistant to decay, very susceptible to marine borers, moderately resistant to dry-wood termites, and very resistant to subterranean termites. Pinhole borers will attack the sapwood of green logs if left in the woods for several weeks, and powderpost beetles may damage the sapwood after seasoning. Sap-staining fungi are not troublesome during seasoning. Ausubo does not weather well; it develops severe checks when exposed to the weather without the protection of paint.

This wood is one of the strongest growing in the American tropics, equaling greenheart (*Ocotea rodiaei*) in most strength properties and exceeding white oak in all respects except resistance to splitting. Ausubo's excellent steam-bending properties make it well fitted for boat frames and other bent work. The wood's fine texture, straight grain, high density, and good finishing properties qualify it for use in shuttles, loom harnesses, and other textile items, billiard cues, violin bows, and furniture. Its great strength and high resistance to wear recommends it for use as ice sheathing, boat frames, mill rollers, keel shoes, and pulpmill equipment such as beater liners, bed plates, and alligator bars.

Ausubo is also used extensively for railway ties, utility poles, ax and tool handles, heavy construction, flooring, and bridge work. It is used very satisfactorily in many areas for all types of furniture cabinetwork because of its attractiveness, great strength, and good finishing qualities. The wood is also highly recommended for flooring, bench tops, and stair treads in industrial plants and machine shops.

CAIMITILLO

Micropholis chrysophylloides Pierre (sapodilla family, Sapotaceae)

The heartwood (fig. 22) of caimitillo, or mesa, is a uniform light yellowish brown without pronounced figure. Seasoned wood resembles that of sugar maple and yellow birch (*Betula alleghaniensis*) in appearance. The sapwood is lighter in color and not clearly differentiated from the heartwood. Growth rings are indistinct. The wood has uniformly fine texture, straight grain, medium luster, and is ordorless and tasteless. Air-dry wood weighs about 52 pounds per cubic foot and green wood 66 pounds per cubic foot.

Caimitillo air-seasons rapidly, reaching 17 percent moisture content in 4 months under cover in the San Juan area. Only minor degrade occurs during seasoning, in the form of slight bow. No

surface or end checking, casehardening, or other defects were apparent in the study.

Shrinkage is moderate and very uniform for a wood of caimitillo's high density. Green wood shrinks 5/16 inch (2.6 percent) per foot across the growth rings and slightly over 7/16 inch (3.6 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Silica in the wood makes sawing and machining moderately difficult and causes a rapid dulling of saw teeth and cutting edges. However, caimitillo machines to a glassy-smooth surface in most operations. It is rated good to excellent in all woodworking operations except sanding. The typically straight-grained material shows scratches readily in sanding. Also, it splits easily when screws or nails are driven unless adequately sized lead holes are used. Caimitillo finishes smoothly and takes a high polish.

The wood is hard, strong, and tough, resembling sugar maple and yellow birch in strength properties. It is considered moderately resistant to drywood termites and decay and has little resistance to marine borers, based on tests in Hawaiian waters.

Caimitillo is an excellent wood for furniture, cabinetwork, interior trim, flooring, paddles, agricultural implements, and tool handles. Its close resemblance to sugar maple and yellow birch should make it suitable for veneer and plywood and for numerous other purposes for which those species are commonly used. The wood is also well suited for all types of interior and exterior construction, and general carpentry, and for piling in nonteredo areas.

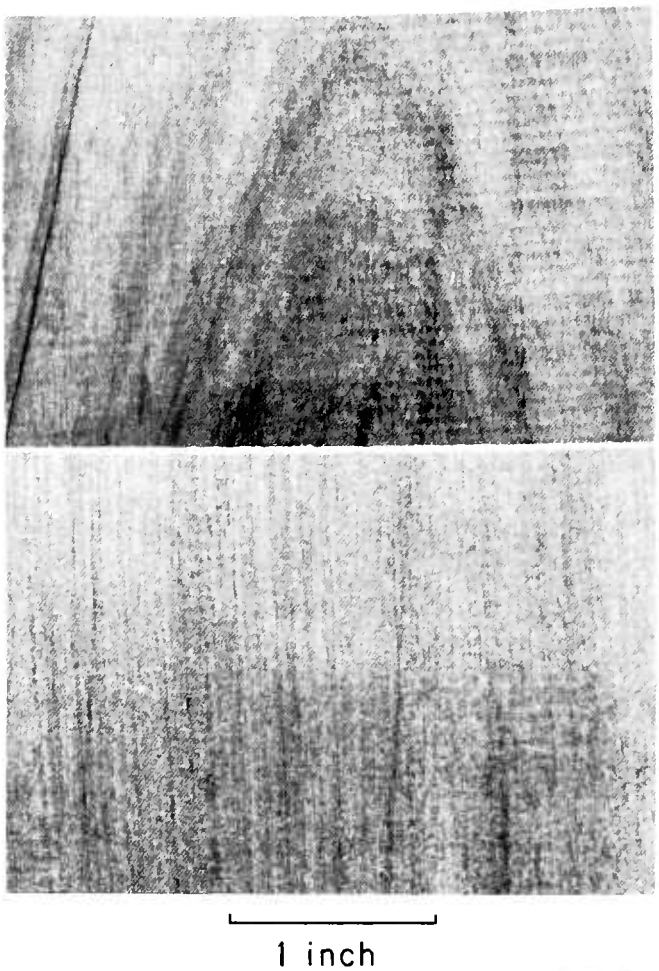

FIGURE 22.—Caimitillo: *Top*, flatsawed; *bottom*, quartersawed.

CAIMITILLO VERDE

Micropholis garciniaefolia Pierre (sapodilla family, Sapotaceae)

Caimitillo verde (fig. 23) is very similar to caimitillo in appearance and physical properties, the two woods being almost inseparable when mixed. The heartwood is a uniform light yellowish brown and not readily separated from the lighter colored sapwood. The wood is similar to that of sugar maple in general appearance but tends to be somewhat darker in color. It has uniformly fine texture, straight grain, medium luster, and is odorless and tasteless. Growth rings are not distinct. The wood is moderately heavy, weighing about 49 pounds per cubic foot when air-dry and 61 pounds when green. In comparison, sugar maple weighs 44 pounds when air-dry.

Caimitillo verde air-seasons rapidly with moderate degrade. Green lumber seasons to about 18 percent moisture content in 3 months under cover in the San Juan area. Degrade consists of a moderate amount of warping and almost no surface or end checking. Shrinkage is especially low and uniform for a wood of caimitillo verde's density. From green to air-dry, green lumber shrinks at the rate of 1/4 inch (2.1 percent) per foot across the growth rings and 3/8 inch (3.4 percent) per foot parallel to the growth rings.

The wood is moderately difficult to saw and machine, because of high density and the presence of silica that rapidly dulls saw teeth and cutting edges. However, caimitillo verde machines with good to excellent results in all opera-

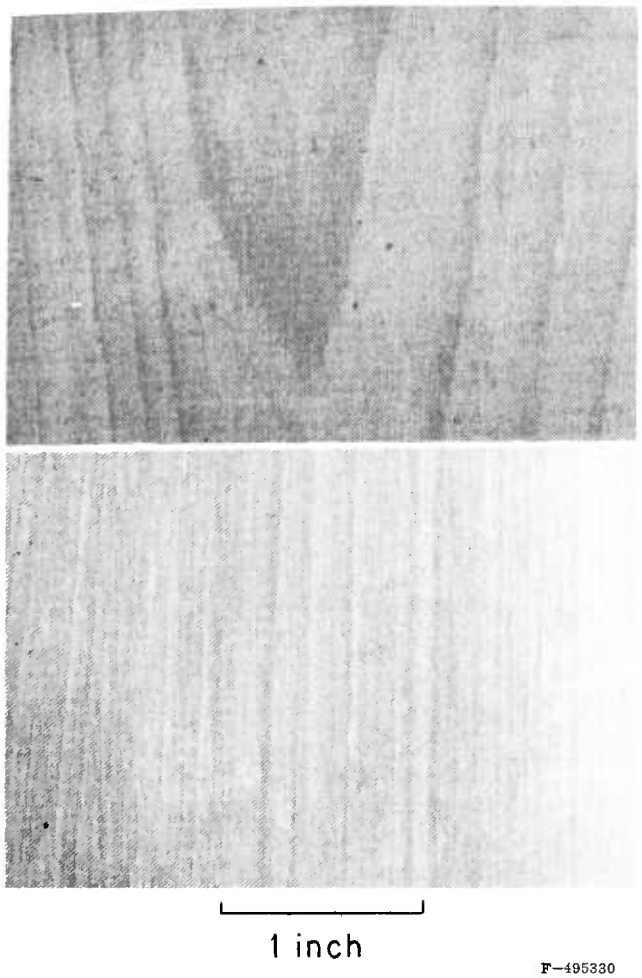

FIGURE 23.—Caimitillo verde: *Top*, flatsawed; *bottom*, quartersawed.

tions. It also has a good resistance to screw splitting and should take nails equally well, generally somewhat better than caimitillo (mesa) in this respect. The wood finishes very smoothly and takes a high polish.

Caimitillo verde is hard, strong, and tough, resembling sugar maple in these properties. It is considered very susceptible to dry-wood termites, as compared with caimitillo (mesa) which is rated moderately resistant. Its similarity to caimitillo otherwise would indicate the wood is moderately resistant to decay and very susceptible to damage by marine borers.

This wood is suitable for most of the same products that sugar maple and yellow birch are used for in the United States, particularly veneer and plywood, furniture, cabinetmaking, turning, interior trim, flooring, agricultural implements, and tool handles. It should also give good service in all types of interior and exterior construction, piling in nonteredo waters, and in general carpentry. Caimitillo verde is one of the highest quality woods growing on the island, and it should be used for purposes that utilize its superior decorative and strength properties.

CAOBA HONDUREÑA (HONDURAS MAHOGANY)

Swietenia macrophylla King (mahogany family, Meliaceae)

More caoba hondureña is used in furniture manufacture in Puerto Rico than any other wood. It is obtained in the form of rough air-dry lumber from Mexico. The tree is not native to Puerto Rico but has been planted extensively in the Luquillo Mountains and to a lesser extent in other areas. Occasionally limited amounts of small-size plantation-grown logs are available for commercial use. The tree grows well when planted on the proper sites, but it is easily uprooted during hurricanes and may never become available in large quantities. The tree and wood are called caoba hondureña, Mexican mahogany, and Honduras mahogany in Puerto Rico.

The heartwood (fig. 24) is pinkish to salmon colored when freshly cut, later becoming light reddish brown with a golden luster. The yellowish-white sapwood is generally 1 to 2 inches wide and clearly demarcated from the heartwood. The grain is commonly interlocked, producing a wide attractive stripe figure on quartersawed surfaces. Occasionally a mottled, fiddleback, raindrop, roey, or curley figure is present. The texture of the wood is medium to rather fine and uniform. Growth layers are indistinct. Seasoned heartwood is without characteristic odor or taste.

Much of the caoba hondureña used in Puerto Rico contains tension wood composed of soft gelatinous fibers that are conducive to excessive longitudinal shrinkage and increased internal stresses during seasoning. This causes increased warping during seasoning and the development of fuzziness during sawing and other machining operations.

Plantation-grown wood averages about 31 pounds per cubic foot when air-dry and 40 pounds when green. Forest-grown wood is slightly heavier, weighing about 44 pounds per cubic foot green and 33 pounds air-dry.

Caoba hondureña seasons rapidly and with very minor degrade unless tension wood is present.

The wood is world-renowned for its unusually low and uniform shrinkage and good stability after manufacture. It is considered one of the few nonrefractory woods in the world. However, pieces containing tension wood develop considerable cup and bow and are subject to distortion during manufacture.

Caoba hondureña is one of the easiest and most satisfactory woods to work with, either with machine or handtools, and has very little dulling effect on cutting edges. However, as already mentioned, the presence of tension wood is troublesome in some pieces and requires the use of very sharp cutting edges. The wood is easy to glue, takes nails and screws well, and can be given an excellent polish by any of the accepted methods. It is one of the most satisfactory woods to slice or rotary-cut into veneer, although flitches frequently develop cracks unless properly boiled. A 60-hour boiling process, starting with a cold soaking and followed by gradual increase of temperature to 170° F., is recommended.

The heartwood is resistant to decay and moderately resistant to dry-wood termites, but it is quite vulnerable to marine borers. The sapwood is very susceptible to both insects and decay. Logs may be damaged by pinhole and flathead borers if not protected by insecticides soon after felling.

The wood possesses excellent weathering characteristics; only minor surface checking develops when it is exposed to the weather without the protection of paint. It is highly resistant to impregnation with preservatives.

Caoba hondureña is extremely strong for its weight and was used extensively at one time for airplane propellers. It is one of the most popular cabinetwoods known, and its use is generally confined to the more expensive types of furniture and cabinetmaking, interior trim, paneling, and similar products. The wood is used extensively in burial caskets, interior work of boats and ships, and turning, and in several types of musical instruments, particularly pianos. Its characteristic low and even shrinkage, stability after manufacture, and ease of working make it particularly valuable for molds, dies, and patternmaking. However, the largest volume is still used for face veneer, often with a core or backing of cedrela or other less valuable woods.

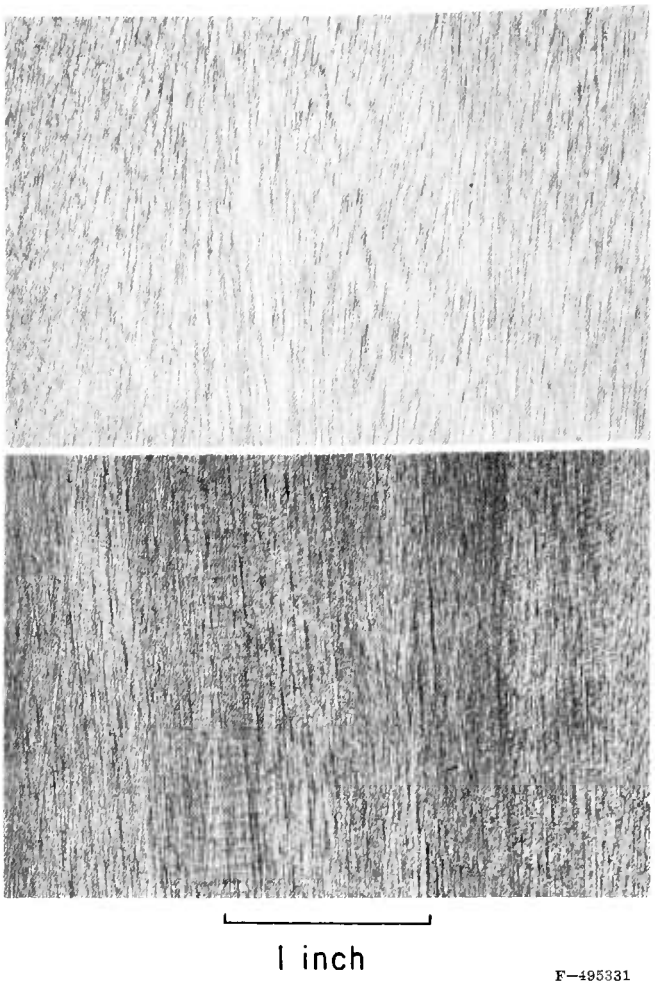

FIGURE 24.—Caoba hondureña: *Top*, flatsawed; *bottom*, quartersawed.

CAPA BLANCO

Petitia domingensis Jacq. (verbena family, Verbenaceae)

Capá blanco is a timber of excellent quality and unusually attractive appearance (fig. 25). The light-brown to medium-brown heartwood is frequently variegated in different brownish hues or is marked by attractive darker colored waxy looking stripes. The sapwood is lighter brown and not clearly separated from the heartwood. The wood possesses rather fine grain, which may be straight, somewhat wavy, or interlocked. Luster is medium to high, growth rings are not visible, and odor and taste are not distinctive. It is a very hard, heavy, tough, and strong wood, weighing about 49 pounds per cubic foot when air-dry and 71 pounds when green.

The wood air-seasons rapidly with only moderate degrade. Green lumber air-dries to slightly below 18 percent moisture content in 4 months or less under cover in the San Juan area, and degrade is limited to a moderate amount of bow and twist and very slight cupping. Other types of seasoning defects are of little importance. Shrinkage is moderate and uniform during seasoning, indicating that the wood should be relatively stable after manufacture. Green lumber shrinks 1/8 inch (1.2 percent) per foot across the growth rings and 1/4 inch (2.2 percent) per foot parallel to the growth rings during seasoning to 15 percent moisture content.

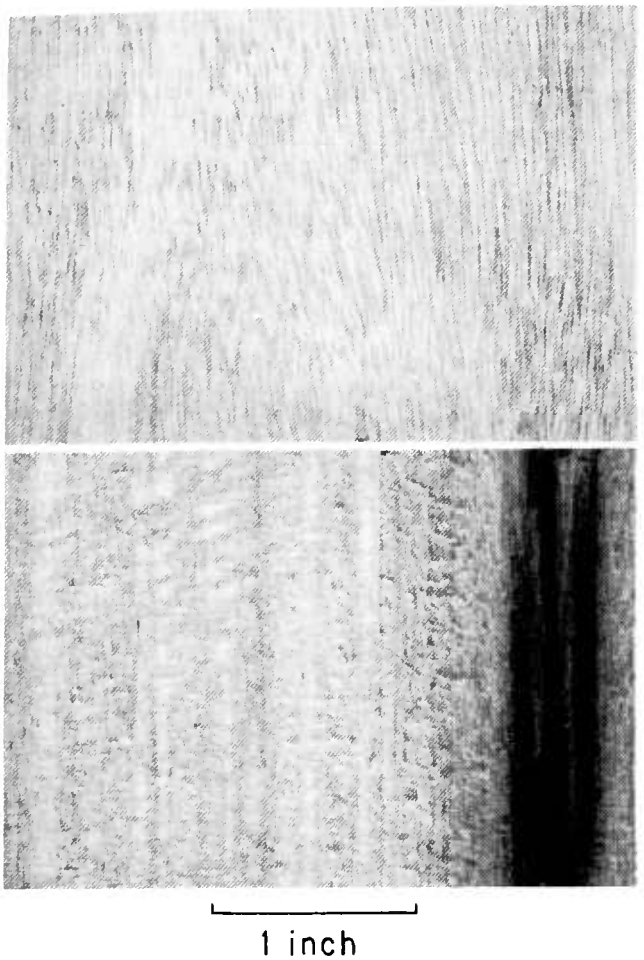

FIGURE 25.—Capá blanco: *Top*, flatsawed; *bottom*, quartersawed.

Capá blanco is moderately easy to work. Good to excellent surfaces are obtained in all machining operations except planing, in which considerable "pickup" or torn grain occurs where interlocked grain is present. The wood otherwise planes and machines in other operations to a glossy smooth surface; it glues well, takes a high polish, and accepts nails or screws with a minimum of splitting.

Capá blanco heartwood is moderately resistant to dry-wood termites and moderately durable in contact with the ground. Sap-staining fungi are not troublesome in the log or during the seasoning of sawed products.

The wood is sufficiently attractive for use in furniture, cabinetmaking, turned articles, novelty items, interior paneling, and similar uses. The finished wood resembles black walnut (*Juglans nigra*) of the United States in color and pleasing appearance. It has been used in the Caribbean area for rollers in coffee-hulling mills, for making carts, and for posts, poles, piling, and props. The wood appears to be suitable for all types of agricultural implements, handles, sporting goods, and other products requiring an attractive, strong, and durable wood. Knotty and low-grade material would be suitable for all types of light and heavy construction, including housing, farm buildings of all types, bridge material, and reinforcing for concrete work. The wood may be somewhat troublesome to peel or slice into veneer, because of the frequent occurrence of wavy and roey grain.

CAPÁ PRIETO

Cordia alliodora (Ruiz & Pav.) Oken (borage family, Boraginaceae)

Capá prieto is an attractive, durable, and much-used wood throughout the American tropics (fig. 26). The freshly cut heartwood is light greenish brown to olive brown in color, frequently with darker streaks. Seasoned wood becomes a pale golden brown to brown, and the darker streaks become more prominent. Growth rings are delineated by narrow dark lines of pores, which show as darker colored streaks on a quartersawed (radial) surface and as wavy undulating lines on a flatsawed (tangential) surface. Small dark rays give the wood a lightly mottled appearance on quartersawed surfaces.

The sapwood is lighter in color than the heartwood and not clearly delineated from it. The grain is generally straight, texture is fine to mostly medium, and luster is medium to high. Odor and taste are generally lacking except for certain darker colored wood from very old, large trees, which may have a distinct spicy odor. Capá prieto is a moderately heavy wood, weighing 42 pounds when air-dry and 68 pounds when green.

The wood seasons at a moderate rate. Green lumber 1⅛ inches thick air-seasons to about 18 percent moisture content in 4 to 5 months under cover in the San Juan area. Degrade during seasoning is limited to a moderate amount of warping. Surface checking and end splitting were not evident in the study.

Shrinkage is moderate and uniform during seasoning. Green wood is reduced about ⅛ inch (1.0 percent) per foot in width across the growth rings

and ¼ inch (2.0 percent) per foot parallel to the growth rings on becoming air-dry.

Capá prieto saws and machines easily, with good to excellent results. The wood's tendency to split when screws and nails are driven can be overcome by preboring and the use of proper size lead holes. It is reported to be an excellent wood to glue and to hold its place well when manufactured. The wood is moderately strong and hard, resembling Mexican mahogany in this respect.

Capá prieto is resistant to dry-wood termites, rating slightly above Mexican mahogany in this respect; it is very durable in the ground, but very susceptible to attack by marine borers. Dark-colored wood is believed to be more durable than the lighter colored wood. Unpainted wood weathers well when exposed without the protection of paint. Only very slight checking occurs after several years' exposure to the elements.

Because of its ease in working, good durability, low shrinkage, and attractiveness, capá prieto is used extensively for furniture, cabinetwork, millwork, general construction, bridge timbers, ship decking, and general indoor and outdoor construction. It should also be useful for veneer, plywood, boat planking and other boat parts, turnings, and instruments. The wood's high durability should qualify it for many of the same uses as cedro hembra and mahogany, but it is probably most valuable for decorative purposes.

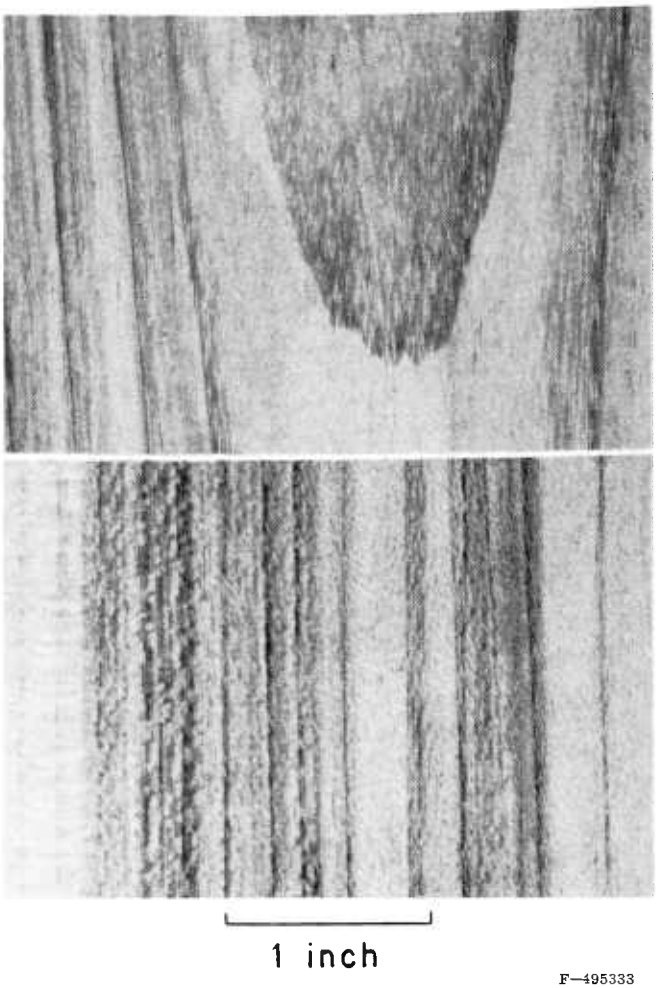

FIGURE 26.—Capá prieto: *Top*, flatsawed; *bottom*, quartersawed.

CARACOLILLO

Homalium racemosum Jacq. (flacourtia family, Flacourtiaceae)

Caracolillo is an exceedingly heavy, hard, strong wood—but is not particularly attractive. The heartwood ranges from grayish brown to reddish brown (fig. 27), frequently with irregular streaks and patches of darker brown. The sapwood is an attractive golden yellow that merges gradually into the darker heartwood. The wood has fine texture, interlocked grain, and is without distinctive odor or taste when seasoned. Air-dry wood weighs 58 pounds per cubic food and green wood about 72 pounds at 50 percent moisture content.

The wood seasons at a moderate rate, reaching an air-dry moisture content of about 18 percent in 6 months under cover in the San Juan area. Moderate degrade occurs during seasoning in the form of very slight cup, end and surface checking, and crook, slight twist, and moderate bow. Directional and volumetric shrinkage is moderate for a wood of caracolillo's density. Green wood undergoes about ⅕ inch (1.8 percent) shrinkage per foot in width across the growth rings and ⅜ inch (3.1 percent) per foot in width parallel to the growth rings in seasoning to 15 percent moisture content. Caracolillo is reported to be stable after manufacture.

Caracolillo is moderately difficult to machine because of its density, but it can be worked to a glossy smooth finish in all machining operations. However, the wood has poor resistance to screw splitting unless adequate-sized lead holes are used. It takes stain, paint, and varnish satisfactorily without a filler and should also glue satisfactorily.

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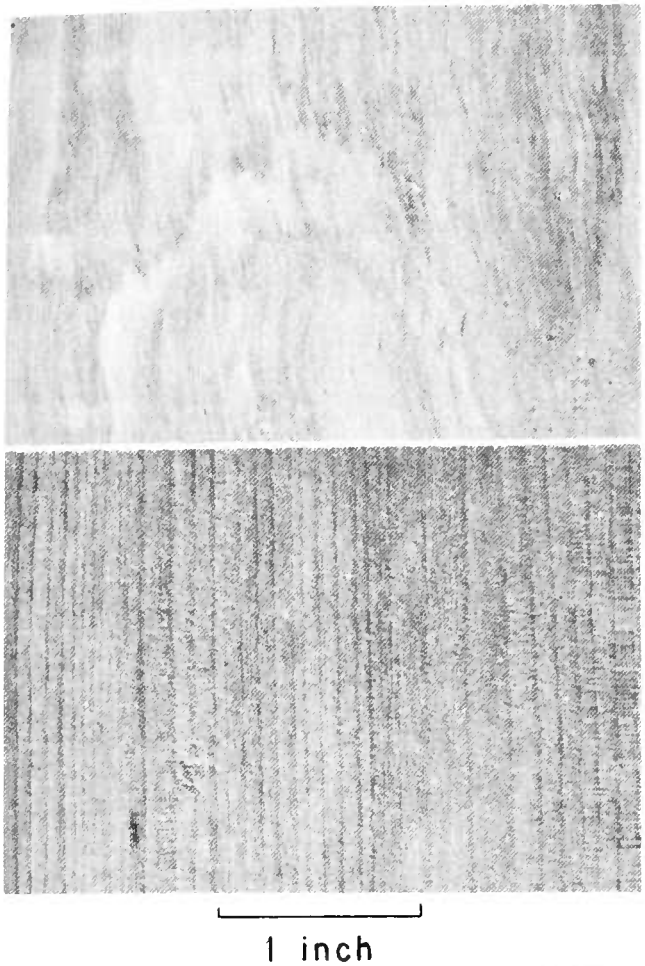

FIGURE 27.—Caracolillo: *Top*, flatsawed; *bottom*, quartersawed.

The heartwood has considerable resistance to dry-wood termites, rating well above Mexican mahogany in this quality. Although the wood's durability rating in the ground or when submerged in teredo-infested waters is not known, it is presumably not high.

Caracolillo is suitable for flooring, furniture, cabinetwork, turning, and other decorative uses. The wood's high strength, hardness, and straight but interlocked grain indicates that it would be suitable for tool handles, sporting and athletic goods, agricultural implements, boat frames, keels and underwater structural members of boats, and similar uses. It is also suitable for heavy construction of all types wherever a heavy, strong material is required.

CASUARINA

Casuarina equisetifolia L. (casuarina family, Casuarinaceae)

Casuarina is commonly called Australian-pine because of its needlelike leaves and its native habitat in Australia. The tree is planted extensively in the lower mountain regions of Puerto Rico, where it makes excellent growth. Trees frequently grow to 15 inches in diameter and 140 feet tall in 15 to 20 years after planting. Clear boles up to 100 feet long are common on the better sites.

The wood is very hard and heavy, and exceptionally strong and tough. Its heartwood is a dull reddish brown, occasionally with dark brown to almost black streaks at irregular intervals (fig. 28), and not easily separated from the pinkish sapwood. The wood has a very fine texture and medium luster, and tightly interlocked grain is characteristic. Growth rings are not easily distinguished. Air-dry wood weighs about 64 pounds per cubic foot and green wood 72 pounds per cubic foot at 42 percent moisture content.

The wood dries at a moderate rate and undergoes considerable degrade during the process. Green lumber 1⅛ inches thick air-dries to about 18 percent moisture content in 5 months under cover in the San Juan area. Seasoning is accompanied by severe cupping and surface checking and lesser amounts of other external defects. Some casehardening may also occur under the usual drying conditions.

Seasoning is accompanied by heavy and relatively uneven shrinkage. Green wood shrinks at the rate of ¼ inch (2.4 percent) per foot in width across the growth rings and ⅔ inch (5.8 percent) per foot across the growth rings in drying to 15 percent moisture content. However, longitudinal shrinkage (0.04 percent) is surprisingly low for a wood with such tightly interlocked grain.

Casuarina logs are very difficult to saw in small circular sawmills. Circular saws tend to heat,

chatter, and veer off course, producing lumber so consistently offsize that it has little, if any, market value. Because of its density and hardness, air-dry casuarina lumber is also difficult to machine. However, machined surfaces are usually of fairly good quality.

Some difficulty is encountered in machining, because of the frequent "pickup" that occurs in planing and the tearing and roughened surfaces that developed in turning under normal operating conditions. Where these defects are not present, the wood machines to a glossy smooth surface. It is rated as a good wood for boring and mortising, and it sands to a very smooth finish. Because of its tightly interlocked grain, it has exceptionally good resistance to screw splitting for a wood of its high density. Well-finished wood is attractive but lacks the distinctive figure preferred in furniture, cabinetwork, and other decorative uses.

Casuarina is very susceptible to damage by dry-wood termites and only slightly durable in the ground. But, on the basis of short-term tests in Puerto Rico, it can be effectively and simply treated with preservatives by the hot and cold bath process.

Casuarina is used principally in Puerto Rico for fence posts and poles, tobacco barns, and other structures. It should be suitable for utility poles and piling in nonteredo areas and for many other uses where an extremely hard, dense, wood is required. Because of extreme difficulty in sawing, casuarina is limited mainly to uses for which round or hewn material is acceptable, although it may be feasible to square logs in the mill for use in heavy construction.

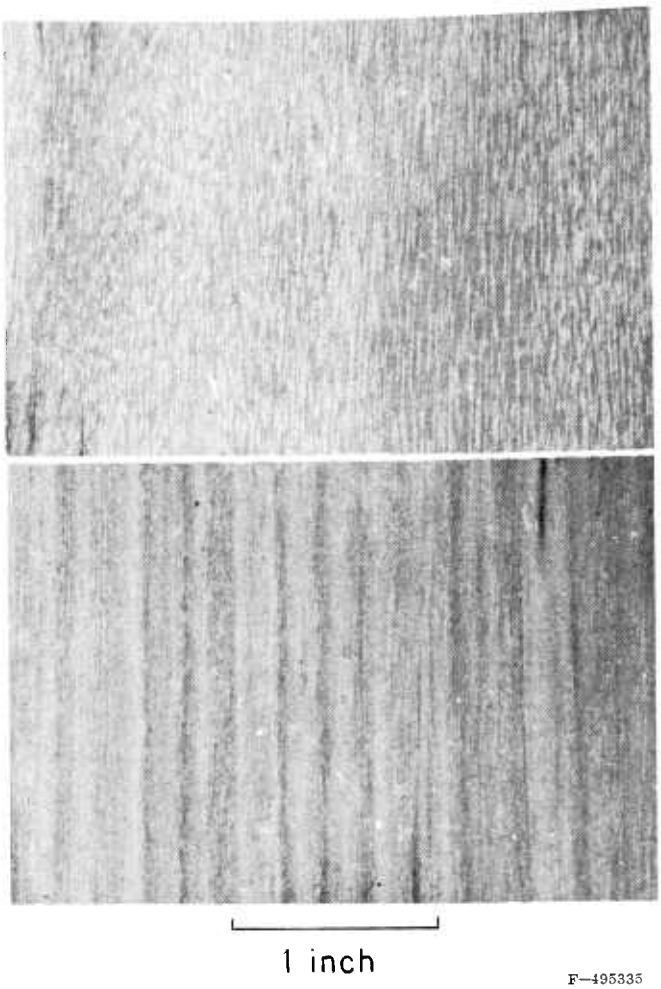

FIGURE 28.—Casuarina: *Top*, flatsawed; *bottom*, quartersawed.

CEDRO HEMBRA (CENTRAL AMERICAN CEDAR)

Cedrela odorata L. (mahogany family, Meliaceae)

Cedro hembra is the most important timber for general domestic use in tropical America, but the supply is very limited in Puerto Rico. Most of the local logs are short and of small diameter. Both the tree and wood are widely known as Spanish cedar or Central American cedar.

The heartwood (fig. 29) is pinkish to reddish brown when freshly cut, becoming a uniform red or dark reddish brown, occasionally with a purplish tinge, after exposure. The darkest colored wood comes from the drier exposures. The sapwood is whitish gray or pinkish and sharply delineated from the heartwood. Growth rings are clearly marked by narrow lines of darker pores, which are visible on both quartersawed and flatsawed surfaces. A pleasing figure is provided by these scattered vessel lines that stand out on an otherwise plain surface. The luster is fairly high, often described as a satiny sheen, and the texture is medium and uniform. The wood is straight grained and easily split. A cedarlike odor is usually apparent, and at times a bitter taste is evident in seasoned wood.

Two distinct types of wood are recognized in some areas and may be represented in Puerto Rico. One is a dark variety that is more straight grained, coarser textured, and has more volatile oil; the other is lighter colored, not so straight grained, and has finer texture, lower luster, and less volatile oil. The weight of the wood varies considerably according to site, age of tree, and rapidity of growth. Wood cut in Puerto Rico averaged 34 pounds per cubic foot when air-dry and 51 pounds in the green condition.

Cedro hembra seasons at a rapid rate with only minor degrade. Green 1⅛-inch lumber air-seasons to 20 percent moisture content in 4 months under cover in the San Juan area. The air-dry moisture content of 20 percent is unusually high for a wood of moderate density. Seasoning degrade is usually limited to a small amount of warping in the form of cup, bow, and twist. Surface checking and

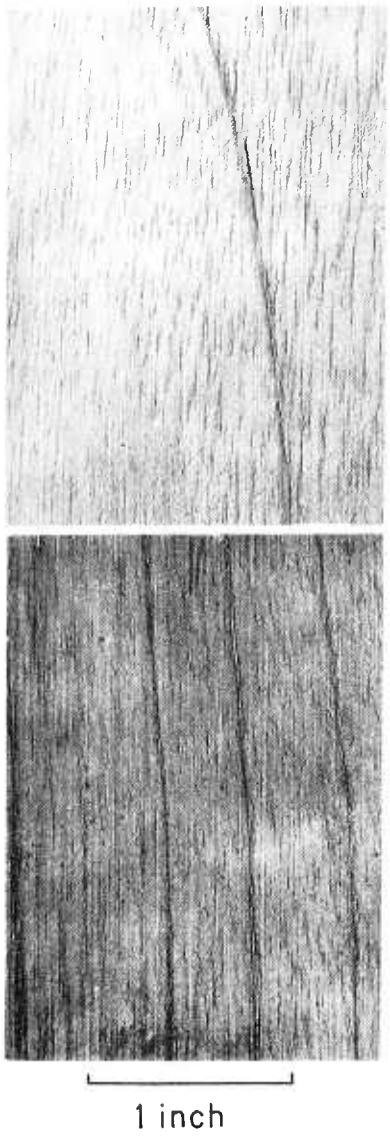

FIGURE 29.—Cedro hembra: *Top*, flatsawed; *bottom*, quartersawed.

other external defects were not observed in the study.

In kiln-seasoning, some pieces are liable to distort or collapse, and splits may occur along knots unless low temperatures are used. Successful kiln schedules for this species have been developed by the Forest Products Research Laboratory, Princess Risborough, England, and by the Indonesian Forest Research Institute.

Cedro hembra undergoes relatively low and uniform shrinkage during seasoning and stays in place very well after manufacture. Green wood shrinks ¼ inch (2.1 percent) per foot in width across the growth rings and ⅓ inch (3.0 percent) per foot width parallel to the growth rings in seasoning to 15 percent moisture content.

The wood works very easily with both hand and power tools, giving good results in planing, shaping, mortising, and sanding. It is a fairly good wood to turn but is difficult to bore; torn and roughened grain occur in these operations. The presence of gum in some material gives trouble in polishing but, in general, the wood stains and polishes beautifully after suitable filling. It has good nail- and screw-holding properties, is easy to glue, and is a fairly good bending wood. Cedro hembra is very popular in the veneer and plywood industry, because it peels cold, dries exceptionally well, and has good glueing properties. A slight tendency for wooly surfaces to occur in veneering is overcome by maintaining sharp edges on all cutting surfaces.

Cedro hembra is slightly inferior to Honduras mahogany in most strength properties but is, in general, a relatively strong wood for its weight. It is considered more resistant to dry-wood termites than Honduras mahogany, rating resistant as compared to moderately resistant for that species. However, the wood is sometimes attacked by pinhole borers and has low resistance to attack by marine borers. It is rated moderately durable to durable in resistance to decay in contact with the ground. Both logs and lumber are subject to sapstaining fungi. The wood possesses excellent weathering properties when exposed to the elements without the protection of paint.

In the countries where it grows, cedro hembra is the most extensively used wood for general construction and carpentry of all types, and for face and core veneer for decorative and utility grades of plywood. The heavier grades are suitable for the same uses as Honduras mahogany. The wood is also particularly well suited for patternmaking, venetian blinds, decking and planking for small boats, musical instruments, doors, paneling, shingles, flooring, and cigar boxes. It is used extensively in the American tropics for furniture, millwork, boat parts, both interior and exterior decoration, and for general and durable construction.

CEIBA

Ceiba pentandra (L.) Gaertn. (bombax family, Bombacaceae)

Ceiba, also known as the silk-cotton tree, is an exceedingly lightweight wood (fig. 30) resembling guano (balsa) in appearance, and at 17 pounds per cubic foot air-dry weighs the same as that species. Green wood weighs 50 pounds per cubic foot at 24 percent moisture content. The dry wood in its natural state is a very light brown, but it is nearly always turned to blue gray by sapstaining fungi. The sapwood is the same color and difficult to distinguish from the heartwood. The wood has coarse texture, straight grain, and low luster; it is without distinctive odor or taste.

Green wood air-seasons to about 18 percent moisture content in 6 months under cover in the San Juan area. This moderately rapid rate of seasoning is accompanied by moderate degrade in the form of a small amount of warping and moderate surface checking.

Shrinkage is low but somewhat uneven during seasoning. Green wood is reduced about $\frac{1}{10}$ inch (0.8 percent) per foot across the growth rings and $\frac{1}{3}$ inch (3.2 percent) along the growth rings in the air-drying process. Its longitudinal shrinkage of 0.22 percent is fairly high for a wood without interlocked grain.

Ceiba machines easily but not satisfactorily. It can be sawed almost without effort but tends to develop fuzziness in both ripping and crosscutting. The wood gives excellent results in planing and sanding, and in resistance to screw splitting, but it is difficult to shape, bore, turn, and mortise because of its tendency to tear in these operations.

Both the logs and lumber are very susceptible to attack by insects and decay. Logs left in the forest for any length of time discolor and decay rapidly and are very quickly riddled by insects. The lumber, as mentioned earlier, is almost always turned blue gray by sap-staining fungi unless dipped in a fungicide solution soon after sawing.

The tree is better known for its kapok than for the soft, nondurable wood it produces. The floss surrounding the seeds of this tree is collected by natives in Central America (rarely in Puerto Rico) and sold on the export market as kapok. This product is used extensively in buoys, life belts, life-saving jackets, and for stuffing pillows, cushions, and similar articles.

Ceiba possesses low strength in proportion to its low density but is still about twice as strong as guano (balsa). The wood is suitable for boxes, slack cooperage, toys, light construction, and numerous other products requiring a light, soft, easily worked wood. Ceiba's similarity to guano may qualify it for many uses where the heavier grades of this wood are acceptable. It should also be acceptable for patternmaking, plywood cores, and utility-grade plywood.

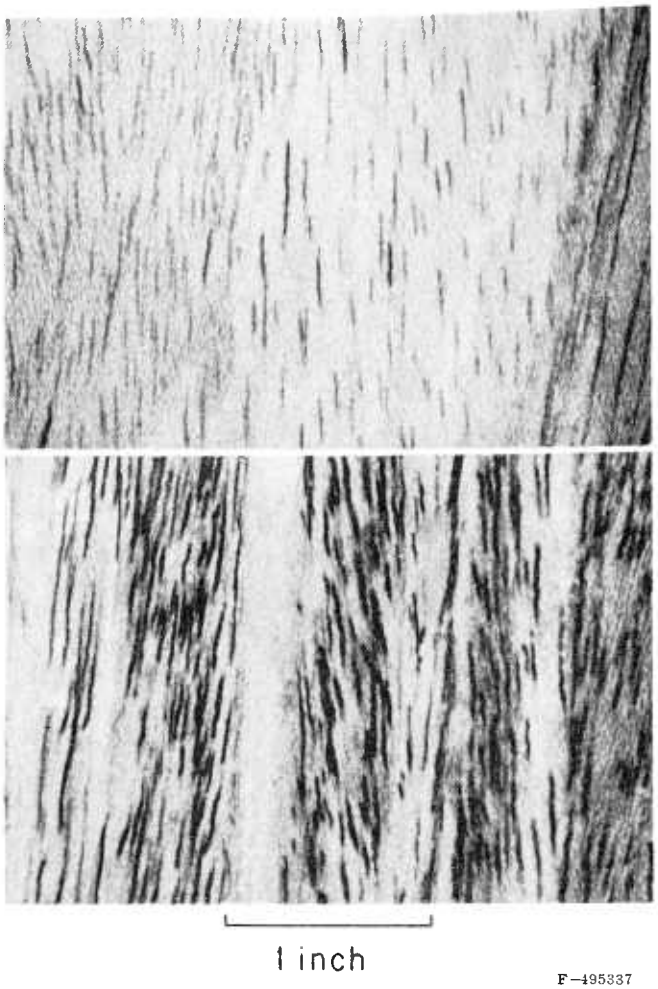

FIGURE 30.—Ceiba: *Top*, flatsawed; *bottom*, quartersawed.

CUCUBANO

Guettarda laevis Urban (madder family, Rubiaceae)

Cucubano is an attractive and useful wood but generally available only in small-diameter logs from the Puerto Rican forests. The heartwood (fig. 31) is an attractive pale yellowish brown to golden brown, often streaked or variegated with a darker brown. The sapwood is cream to very light brown and not clearly delineated from the heartwood. The wood has good luster, fine texture, and generally straight to occasionally interlocked grain. Growth rings are very faintly marked by somewhat darker colored tissue. Odor and taste are not distinctive in seasoned wood.

The wood is moderately hard, strong, and heavy, weighing 50 pounds per cubic foot when air-dry and 69 pounds when green. On the basis of tests of closely related species, cucubano possesses strength properties commensurate with its weight and somewhat higher than those for oak, but it is considered a relatively poor bending wood.

The wood seasons at a moderate rate with a moderate amount of degrade. Green lumber air-dries to about 18 percent moisture content in approximately 6 months under cover in the San Juan area. A moderate amount of surface check-

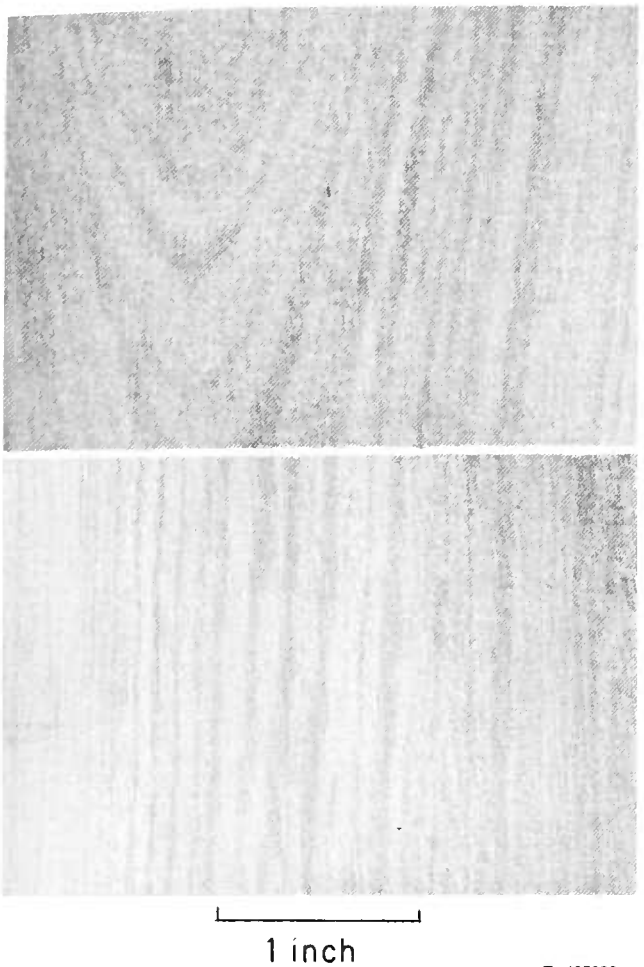

FIGURE 31.—Cucubano: *Top*, flatsawed; *bottom*, quartersawed.

ing and warping occurs during the seasoning process.

Shrinkage is relatively uniform and not excessive for a wood of cucubano's density. Green wood shrinks ¼ inch (2.0 percent) per foot in width across the growth rings and ½ inch (4.0 percent) per foot in width parallel to the growth rings in drying to 15 percent moisture content.

Cucubano works easily with either power or hand tools, with generally satisfactory results in most operations. However, the wood has a tendency to crush and crumble in boring, and it scratches readily in sanding unless fine abrasive paper is used. Because of its generally very straight and uniform grain and high density, it is also easily split by nails or screws unless properly prebored. It takes a good polish without the use of a filler.

Cucubano is very susceptible to dry-wood termites and probably is not durable in the ground or when exposed to marine borers. The wood is seldom used in Puerto Rico, but it appears to be suitable for tool handles, fancy boxes, brush backs, small dimension turnery parts, and other items requiring a dense, close-grained, uniform wood. It should also be equally useful for furniture, cabinetwork, farm implements, interior trim, paneling, and novelty items, and it may be suitable for decorative veneer and plywood. Cucubano is equally well fitted for exterior construction, piling in nonteredo areas, bridgework, and other similar uses requiring a very heavy, hard, and strong wood.

CUPEY

Clusia rosea Jacq. (mangosteen family, Guttiferae)

Cupey is a heavy, hard, strong wood of rather common appearance (fig. 32). The heartwood is reddish brown in contrast to the lighter colored sapwood, which merges gradually into the heartwood. The wood has medium luster, medium to fine texture, and straight grain. Growth rings are not evident, and seasoned wood is without distinctive odor or taste. Air-dry wood weighs 52 pounds per cubic foot and green wood 72 pounds per cubic foot at 71 percent moisture content.

The wood air-seasons at a moderate rate. Green lumber 1⅛ inches thick air-seasons to 17 percent moisture content in about 6 months under cover in the San Juan area. A moderate amount of degrade occurs during seasoning in the form of warp and surface checking. Surface checks are often fairly deep, particularly around knots, and some casehardening and collapse may also occur.

Cupey undergoes moderately high shrinkage during seasoning, compared with other woods of similar density. Green lumber shrinks at the rate of ¼ inch (2.1 percent) per foot in width across the growth rings and 9/16 inch (4.7 percent) per foot in width parallel to the growth rings when seasoned to 15 percent moisture content. Sapstain fungi are not troublesome during seasoning.

Cupey is moderately difficult to saw and machine because of its great density and hardness, yet it produces fair to good surfaces in all operations. However, some trouble is encountered in planing and boring: tearing and crushing occur frequently. The wood takes screws satisfactorily without splitting and should glue and polish well.

Cupey is very susceptible to attack by pinhole borers, dry-wood termites, and other insects. It is

probably poorly resistant to decay and attack by marine borers, although specific information is not available.

Because the wood is not particularly attractive, it is used principally for fuel, fence posts, and rural construction. However, cupey is suitable for both light and heavy construction, cheap grades of furniture, farm implement parts, tool handles, and other uses requiring a heavy, strong wood.

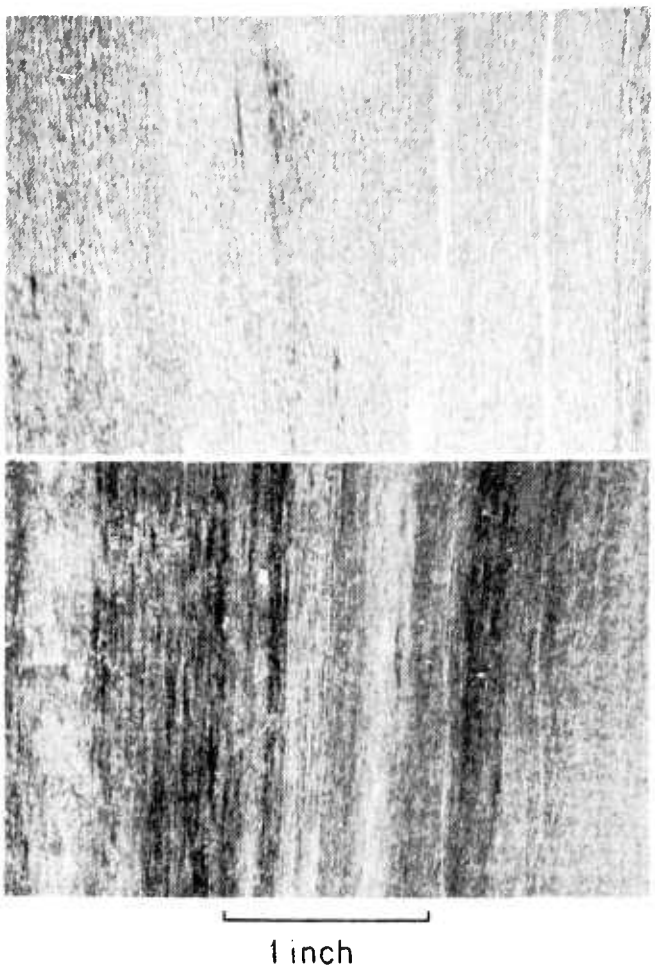

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FIGURE 32.—Cupey: *Top*, flatsawed; *bottom*, quartersawed.

ESPINO RUBIAL

Zanthoxylum martinicense (Lam.) DC. (rue family, Rutaceae)

Espino rubial, also called Martinique prickly-ash, belongs to the satinwood group but lacks the characteristic attractiveness and workability of certain other woods in the genus. The heartwood is creamy to light brown in color (fig. 33), sometimes with a pronounced greenish blue, and it is not readily distinguished from the lighter colored sapwood. Growth rings are clearly marked on the end grain by zones of larger and lighter colored vessels. The wood is without distinctive figure except for an inconspicuous feather pattern on flatsawed surfaces and very fine pencil striping on the quartersawed surfaces, both resulting from the ring-porous nature of the wood. The wood is moderately heavy and hard, has medium to fine texture, straight to irregular grain, good luster, and a rancid odor when freshly worked. Air-dry wood weighs about 35 pounds per cubic foot and green wood 53 pounds.

The wood seasons rapidly but undergoes rather severe degrade during the process. Green 1⅛-inch lumber air-dries to 18 percent moisture content in slightly over 4 months under cover. Moderate amounts of bow, twist, and crook, and very slight cup and surface checking, occur during the seasoning process.

Espino rubial undergoes moderate and uniform shrinkage during seasoning. Green wood shrinks $\frac{5}{32}$ inch (1.5 percent) per foot in width across the growth rings and $\frac{10}{32}$ inch (2.6 percent) per foot in width along the growth rings in seasoning to 15 percent moisture content. Molds and sap-staining fungi are not particularly troublesome during the seasoning process.

The wood works easily with either hand or power tools but produces only fair to poor results in most operations. Torn grain and coarse fuzziness are common in shaping and turning; tearing

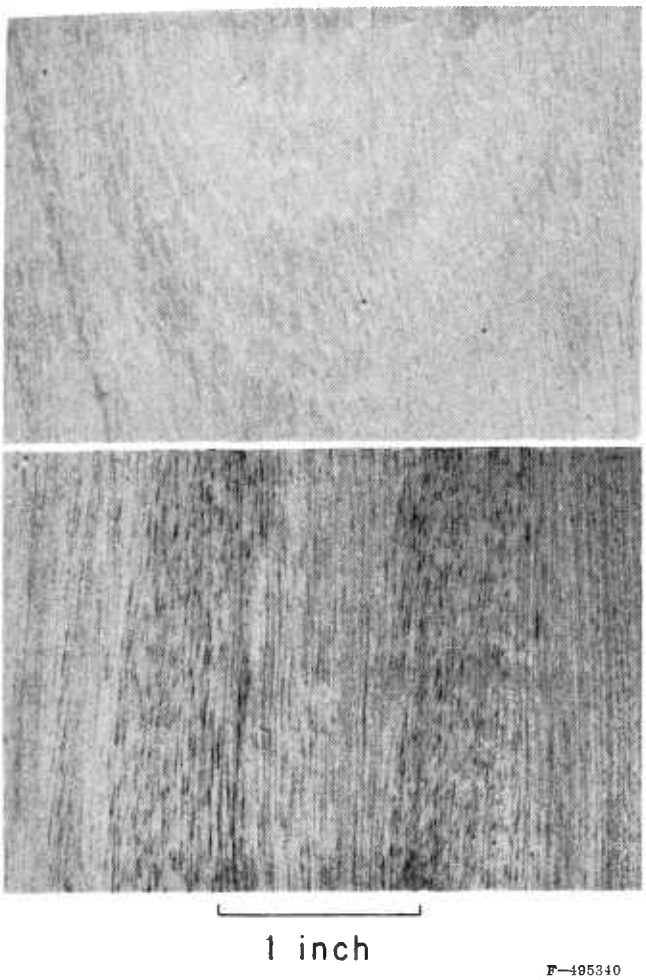

FIGURE 33.—Espino rubial: *Top*, flatsawed; *bottom*, quartersawed.

and crushing are troublesome in boring and mortising; and considerable scratching and fuzziness occur in sanding unless a very fine abrasive paper is used. However, the wood has good resistance to screw splitting. The best machined surfaces are obtained when very sharp and thin cutting edges are used along with an increased spindle speed and a reduced rate of feed.

Espino rubial is very susceptible to dry-wood termites, pinhole borers, and other insects. It is not believed to be durable in contact with the ground, although specific information as to its vulnerability to decay is not available.

Because of its plain appearance, difficulties in seasoning, and only fair working qualities, espino rubial is best suited for boxes, crates, general carpentry, low-grade furniture, light construction, concrete forms, and similar uses. However, with considerable care in seasoning and machining, the better grades of this species could be used for interior trim, doors, window frames, and other types of interior construction. It might also be suitable for utility veneer and core stock.

EUCALIPTO

Eucalyptus robusta J. E. Smith (myrtle family, Myrtaceae)

Small to occasionally medium-size logs of eucalipto, known as swamp mahogany or swamp messmate in its native Australian habitat, are available from the extensive plantings of this species in the high mountainous rain forests of Puerto Rico. The tree is also known as beakpod eucalyptus in some areas. Logs of other *Eucalyptus* species growing on the island may occasionally be marketed in combination with *E. robusta*, and they have the same general properties and uses as that species.

The heartwood of eucalipto is salmon to light reddish brown when seasoned (fig. 34), often mottled with brown streaks and patches, and is indistinct from the light-brown sapwood. Faint growth rings are evident on the end grain. The wood is coarse in texture, quite lustrous, and fairly straight grained, although some interlocked grain may occur. The timber is hard, strong, stiff, and elastic, weighing 42 pounds per cubic foot when air-dry. Green wood weighs 69 pounds per cubic foot at 115 percent moisture content.

Like most other eucalypts, this wood is difficult to season. Carefully stacked 1¼-inch lumber requires about 6 months to reach an air-dry moisture content of 19 percent under cover in the San Juan area. Considerable degrade develops during seasoning, mostly from warp, although a small amount of surface and end checking may occur.

The wood undergoes unusually great and uneven shrinkage during seasoning for a wood of its density. Green wood shrinks more than ⅜ inch (3.5 percent) per foot in width across the growth rings and slightly over 1⅛ inches (9.7 percent) per foot in width parallel to the growth rings in seasoning to an air-dry moisture content of 15 percent.

The wood works easily with both hand and machine tools and gives fairly good results in most operations. There is, however, a tendency for the wood to crush and tear in boring and for scratches to show clearly in sanding unless fine abrasives are used. Eucalipto possesses unusual resistance to splitting when screws are driven, and it should take nails equally well. After appropriate fillers are used, the wood can be finished to a smooth, satiny appearance.

The wood is considered durable in the ground, but it is very susceptible to attack by dry-wood termites in Puerto Rico. On the basis of experience with other closely related species, this wood is probably highly resistant to the penetration of preservatives.

This species is used in Australia for general construction work, especially in contact with the ground. It should be useful in Puerto Rico for all types of posts, utility poles, and light and heavy construction, and for other purposes requiring a strong, durable wood. The difficulty of seasoning sawed material and its lack of attractiveness indicate that the wood is most usable in the round or squared form. Yet it appears to be suitable for flooring, boxes, crates, and cheap furniture if satisfactory methods of seasoning can be developed. The wood is sufficiently strong and durable for piling in nonteredo areas, but it requires the use of caps during driving operations. Round or squared timbers would also be very serviceable for supports and bracing in concrete construction work.

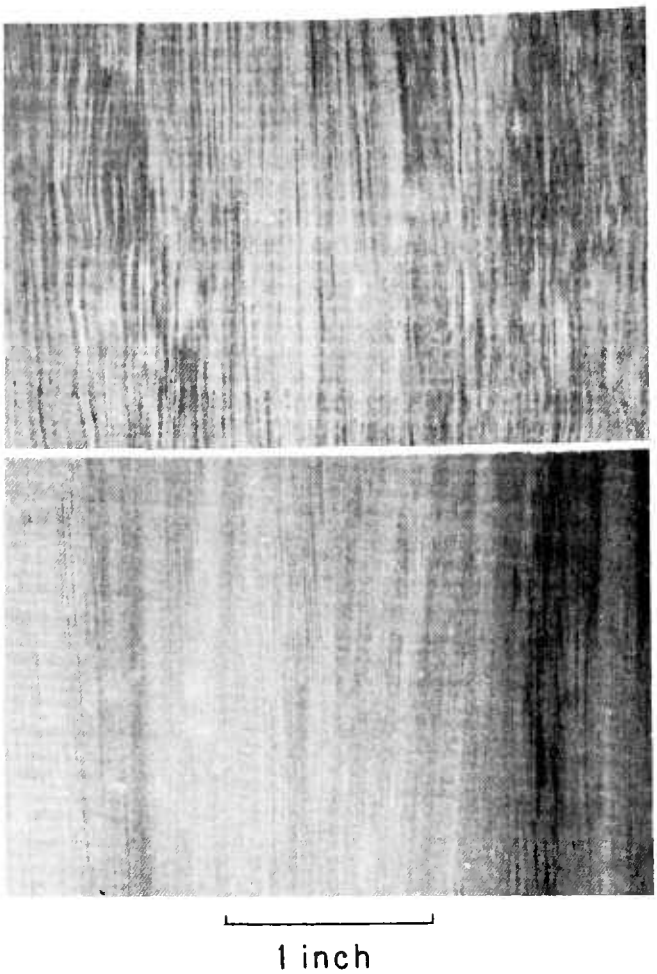

FIGURE 34.—Eucalipto: *Top*, flatsawed; *bottom*, quartersawed.

GRANADILLO

Buchenavia capitata (Vahl) Eichl. (combretum family, Combretaceae)

Granadillo is a very attractive timber of good quality and many potential uses. The heartwood (fig. 35) is light yellow to golden brown and distinct but not clearly separated from the pale-yellow sapwood. The wood has high luster, straight to more frequently roey grain, medium texture, and a faint odor and mildly astringent taste when green. Dry wood is without distinctive odor or taste. Growth rings are marked by narrow bands of darker pores, showing as an attractive ribbon stripe on quartersawed surfaces. It is moderately hard and strong, weighing 46 pounds per cubic foot when air-dry and 68 pounds when green. Air-dry granadillo weighs about the same as white oak and is similar to it in most strength properties.

Green lumber air-seasons rapidly with only a very small amount of degrade in the form of slight bow and twist. Green lumber seasons to an air-dry moisture content of 18 percent in slightly less than 4 months under cover in the San Juan area.

Granadillo shrinks very little during seasoning. Green lumber loses $\frac{1}{8}$ inch (1.1 percent) per foot in width across the growth rings and $\frac{5}{16}$ inch (2.5 percent) per foot along the growth rings in drying to an air-dry moisture content of 15 percent.

The wood machines with moderate difficulty because of its hardness, but it produces good surfaces in all operations even though some tearing

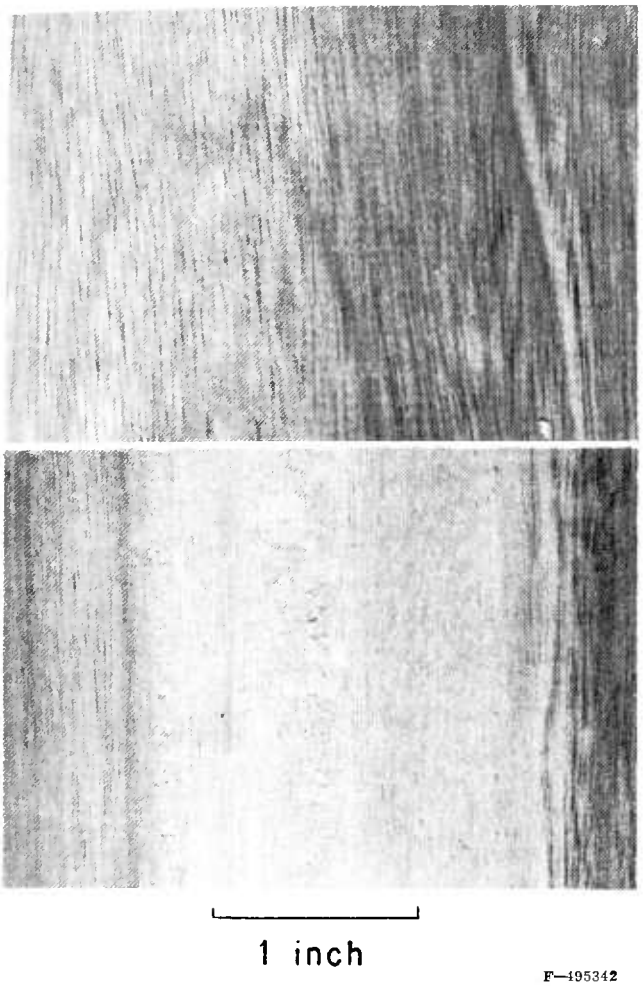

FIGURE 35.—Granadillo: *Top*, flatsawed; *bottom*, quartersawed.

may result from irregular grain. It is reported to finish well and to take a beautiful high satiny polish.

The wood is rated more resistant to dry-wood termites than Honduras mahogany or cedro hembra and is fairly durable in the ground. Sap-stain fungi or insects are not troublesome during seasoning.

Granadillo's uniform color, attractiveness, and good machining properties make it highly acceptable for all types of furniture and cabinetwork. It is also recommended for house framing, flooring, construction work of all kinds, plywood, and railway sleepers after preservative treatment. Because of its attractiveness, it is recommended for decorative veneer and plywood. The wood should also be suited for interior trim, boat building, boxes and crates of all types, turnery, and many other uses requiring a strong, attractive wood with good durability.

GUABA

Inga vera Willd. (legume family, Leguminosae)

Guaba is a wide spreading, low branching tree that is planted extensively for shade and protection on coffee plantations. It produces short logs of small to medium diameter. The wood is seldom used except for charcoal and fuel, but it has sufficient strength for many other uses. Also, it is moderately attractive (fig. 36) and machines well.

The heartwood is pale brown to golden brown with longitudinal streaks or patches of darker brown that in turn are frequently shaded with hues of green or yellow. The indistinct sapwood is whitish in color. The wood is coarse in texture, fairly lustrous, straight to frequently roey grained, and without distinctive odor or taste. Guaba is comparable to Douglas-fir in density, weighing 44 pounds per cubic foot when air-dry and 62 pounds in the green condition. Compared to woods of similar density, guaba is considered a moderately hard, strong, tough wood with good resistance to splitting and good bending properties.

Guaba air-seasons rapidly with a moderate amount of degrade, mostly in the form of bow. Careful piling might eliminate most of this degrade. Green lumber air-seasons to about 19 percent moisture content in 3 months under cover in the San Juan area, undergoing moderate and uniform shrinkage during the process. Green wood shrinks at the rate of $\frac{1}{8}$ inch (1.0 percent) per foot in width across the growth rings and $\frac{1}{4}$ inch (2.0 percent) per foot parallel to the growth rings in seasoning to 15 percent moisture content.

The wood saws and machines easily and with good results in all operations except shaping.

Torn and raised grain is particularly troublesome in this operation.

Guaba is very susceptible to damage by termites and other insects and to decay when in contact with the ground. Sap-staining fungi are apt to be troublesome in the log or freshly sawed lumber.

Because of its good strength properties, generally good machining characteristics, and moderate attractiveness, guaba is suitable for utility furniture, boxes, crates, light construction of all types, and general carpentry. After preservative treatment, it should also be useful for railway ties, posts, poles, bridge timbers, and other miscellaneous exterior uses.

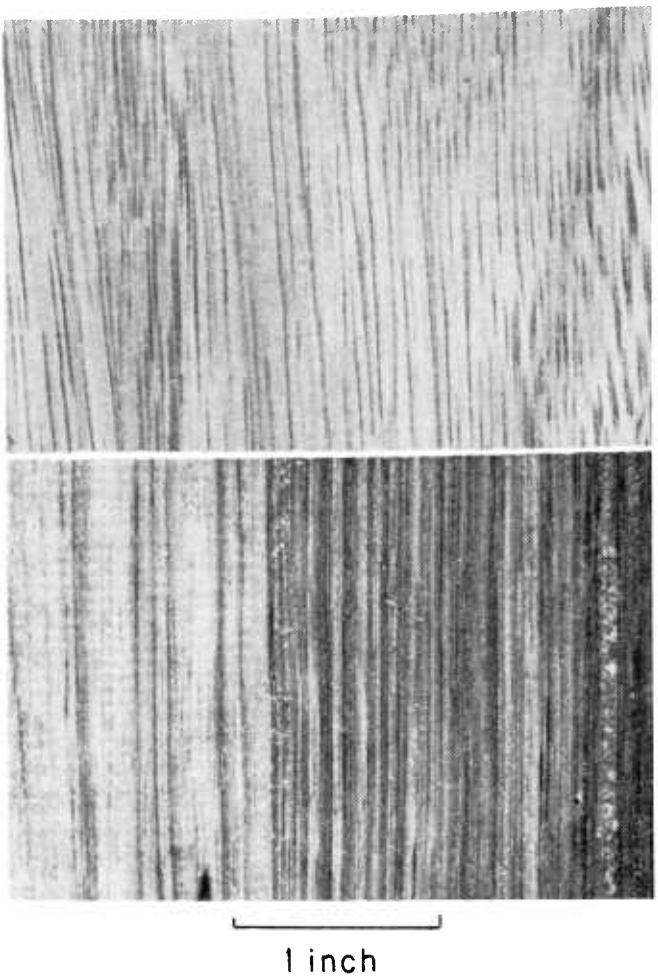

FIGURE 36.—Guaba: *Top*, flatsawed; *bottom*, quartersawed.

GUAJÓN

Beilschmiedia pendula (Sw.) Benth. & Hook. f. (laurel family, Lauraceae)

The heartwood of guajón is a pinkish brown, often with widely spaced blackish lines at irregular intervals (fig. 37), and it is readily distinguished from the pale-brown sapwood. Numerous pores are visible as fine scratches on flat surfaces, giving the wood a somewhat attractive appearance. The wood has medium texture, straight grain, medium luster, and is without distinctive odor or taste. Growth rings are not clearly defined. Guajón is moderately hard, strong, and heavy, weighing 41 pounds per cubic foot when air-dry and 64 pounds when green.

The wood air-seasons slowly with only a minor amount of warping and no visible surface checking. In the tests, green lumber 1⅛ inches thick required 10 months or longer to reach an air-dry moisture content of 20 percent. Guajón is accordingly the slowest to air-dry but one of the least refractory of the commercial hardwoods growing in Puerto Rico.

Shrinkage during seasoning is moderate and uniform. Green wood shrinks at the rate of ¼ inch (2.0 percent) per foot of width across the growth rings and 7/16 inch (3.6 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Guajón works easily, but with varying results. It is rated "good" in planing and shaping; "fair" in turning, mortising, and sanding; and "poor" in boring. Rough surfaces result from torn grain in turning; tearing and crushing occur along the sides of the holes in boring and mortising; and scratches are clearly visible in sanding unless a fine abrasive paper is used. However, surfaces well sanded with fine abrasives are very smooth and take a good polish. The wood has good resist-

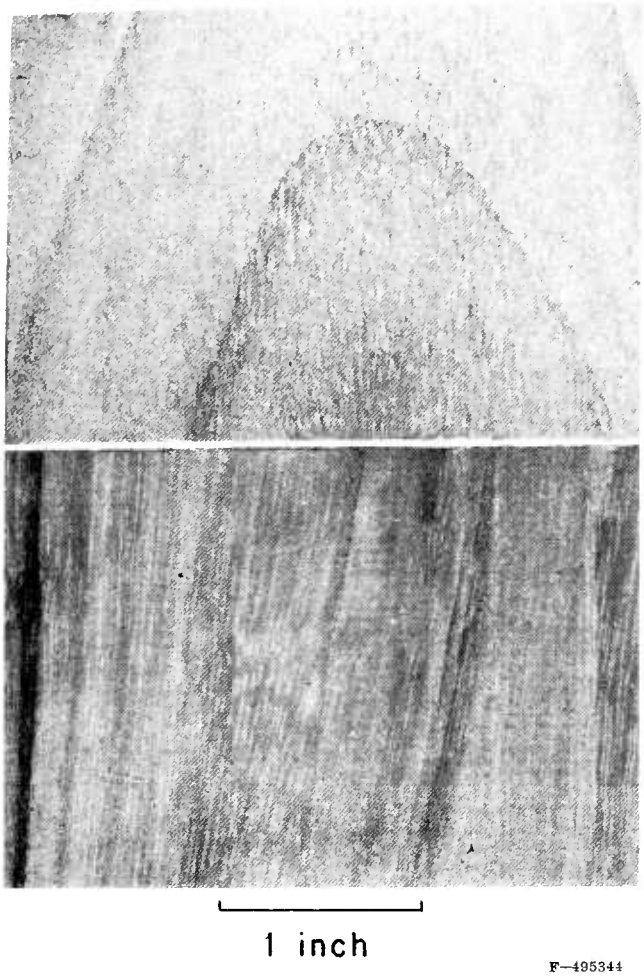

FIGURE 37.—Guajón: *Top*, flatsawed; *bottom*, quartersawed.

ance to splitting when screws are driven and presumably will take and hold nails satisfactorily.

Guajón is very susceptible to damage by drywood termites. Although it is generally considered to be highly durable when in contact with the ground, authentic tests proving this point are lacking.

The wood is used for shipbuilding, general construction, flooring, furniture, cabinetmaking, and carpentry. It is also recommended for decorative plywood, handles, interior trim and paneling, agricultural implements, and other uses for which maple and birch are used.

GUAMÁ

Inga laurina (Sw.) Willd. (legume family, Leguminosae)

Guamá is one of the trees planted extensively in Puerto Rico and other Caribbean areas to shade and protect coffee plantations. Because of its characteristic low branching and the coffee-growers' preference for young thrifty trees, only short, small- to medium-size logs are available. The wood is seldom used except for fuel and charcoal, yet it is as attractive and serviceable as many recognized furniture woods.

The heartwood (fig. 38) is a pale reddish brown, often streaked with a darker brown, and not clearly distinguished from the lighter colored sapwood. Luster is medium to high, and the texture is coarse. The grain is straight to more frequently roey, showing as ribbon stripes on flatsawed surfaces. Odor and taste are lacking in seasoned wood. The wood is medium in density, weighing 46 pounds when air-dry as compared with 48 pounds for white oak and 44 pounds for sugar maple. Green wood weighs 67 pounds per cubic foot. It is moderately hard, strong, and tough, comparing favorably in strength properties with other woods of similar density.

Guamá seasons rapidly with moderate degrade in the form of very slight twist and crook and moderate bow. Green lumber air-seasons to about 18 percent moisture content in approximately 4 months under cover in the San Juan area. The wood undergoes low and uniform shrinkage during seasoning and is stable after manufacture. Green wood shrinks at the rate of about 1/5 inch (1.6 percent) per foot in width across the growth rings and 1/3 inch (2.7 percent) per foot in width parallel to the growth rings in seasoning to 15 percent moisture content.

The wood works easily and with generally good results except that some torn grain occurs in pieces with roey grain, particularly in planing and shaping, where only fair results are obtained. The wood finishes satisfactorily and takes lacquer, varnish, or paint very well after a grain filler is applied. It also has good resistance to screw splitting, and it glues satisfactorily but is somewhat difficult to nail unless prebored.

Guamá is very susceptible to termite damage and decay. Logs are also quickly attacked by pinhole borers if not converted into lumber soon after felling. Sap-staining fungi are not troublesome in either the logs or green lumber.

Guamá is suitable for many of the same purposes as oak, such as furniture, cabinetwork, tool handles, interior trim, general construction, crates, boxes, and flooring. After treatment with preservatives, it should be useful for posts, railway crossties, bridge timbers, and other exterior work. It has also been recommended for both decorative and utility-grade veneer and plywood.

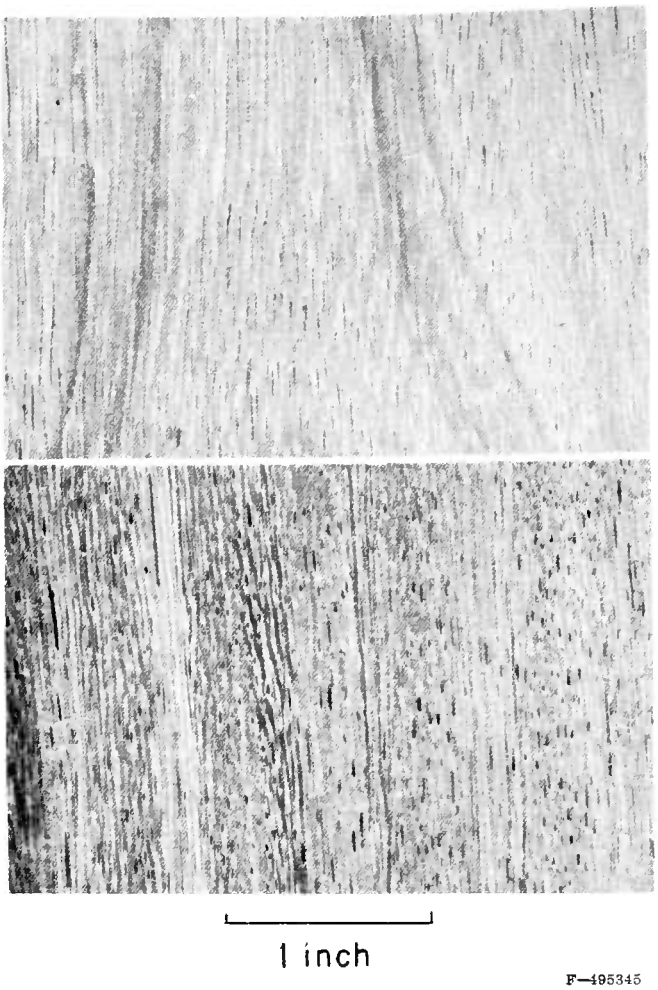

FIGURE 38.—Guamá: *Top*, flatsawed; *bottom*, quartersawed.

GUANO (BALSA)

Ochroma pyramidale (Cav.) Urban (bombax family, Bombacaceae)

Guano, also called balsa, is the lightest commercial wood used today. Good-quality lightweight wood of this species is increasingly more difficult to obtain and correspondingly higher in cost as the Central American supply is depleted. Unfortunately the wood growing in Puerto Rico is generally somewhat heavier than the export grade accepted by importers; it is somewhat less buoyant and not so efficient for insulation against heat and sound as the export grade.

The heartwood is pale brown or slightly tinged with red. The sapwood, which provides most of the commercial wood, is nearly white or oatmeal colored, often with a yellowish or pinkish hue. The grain is very coarse (fig. 39), straight, and uniform. The wood is odorless, tasteless, and has a rather high, silky luster and velvety feel. In the tests, wood from trees grown in Puerto Rico averaged 17 pounds per cubic foot when air-dry and 27 pounds when green as compared with 27 pounds for air-dry western white pine of the United States. The commercial grade of guano used by industry weighs 8 to 14 pounds, with an average of about 10 pounds per cubic foot.

The Puerto Rican guano air-seasoned at a moderate rate when closely piled, reaching a moisture content of about 17 percent in 5 to 6 months under cover in the San Juan area. Moderate degrade occurs during seasoning in the form of slight to moderate cup, slight bow and twist, and a very slight amount of crook, surface checking, and end checking. Casehardening was not evident in the study.

The wood is reported to air-season satisfactorily by end-racking in Ecuador where 4½-inch thick stock seasons below 20 percent moisture content in 14 to 21 days. Guano is reported to be somewhat difficult to kiln-dry; is has a tendency to split, warp, and caseharden; and to be practically toasted, in the kiln-drying process.

Guano undergoes considerable shrinkage during seasoning for a wood of its density; afterwards it loses or gains moisture quickly with changes in

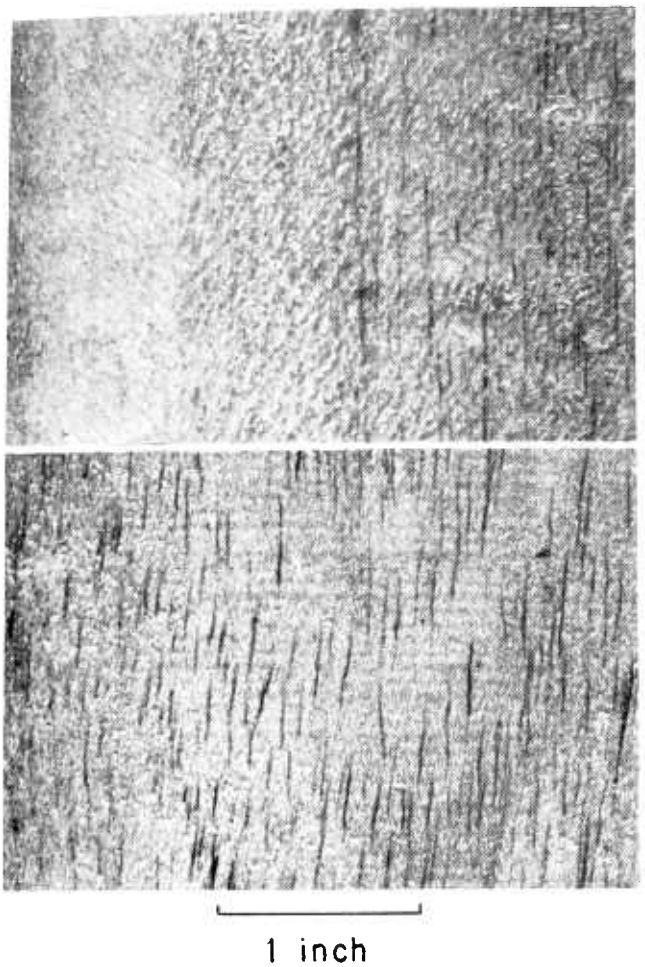

FIGURE 39.—Guano (balsa): *Top*, flatsawed; *bottom*, quartersawed.

atmospheric conditions, but fortunately undergoes relatively small dimensional changes. Waterproofing treatments with paraffin, commercial water repellents, varnish, or glossy paint are effective in reducing the hygroscopicity of the wood. The ratio of tangential to radial shrinkage is high, indicating that considerable stress may occur during seasoning, leading to the development of seasoning defects. Green wood shrinks at the rate of 1/6 inch (1.3 percent) per foot in width across the growth rings and 9/16 inch (4.7 percent) per foot in width parallel to the growth rings in seasoning to 15 percent moisture content. The longitudinal shrinkage of 0.11 percent is also moderately high for wood of guano's low density.

Guano is easy to work with sharp, thin-edged power or hand tools, with practically no dulling effect on cutting edges. Thin-gage saws are recommended because thick-edged tools produce wooly surfaces and cause the wood to crumble, particularly in planing. In most machining operations the wood is fairly difficult to work without the occurrence of fuzziness and crumbling. Guano takes nails and screws readily but is too soft to hold them.

Inasmuch as the wood glues satisfactorily, this is the most satisfactory method of fastening or holding it in place. Guano can be stained satisfactorily and polished fairly well, but it absorbs much of the material during the process. The use of a filler is necessary if a good surface coating is desired.

Termites, marine borers, and decay organisms readily attack the wood and cause severe damage. Despite its softness and porosity, guano is fairly resistant to impregnation with preservatives, although both heartwood and sapwood can be satisfactorily treated by either pressure or nonpressure methods. However, pressure treatment often causes collapse of the cell walls.

The strength of guano varies directly with its density. In general, the wood is stronger for its weight than other timbers. The slow-growing and consequently heavier grade of guano growing in Puerto Rico is suitable for certain types of fruit and vegetable containers, novelties, toys, and temporary boarding or cement forms. Material treated against termite attack should also be adequate for cores of flush doors and other light construction. In general, guano can be used for many purposes for which the heavier grades of commercial balsa are commonly acceptable, and as a substitute for white pine where high strength and stability are not essential.

GUARAGUAO

Guarea trichilioides L. (mahogany family, Meliaceae)

Guaraguao, also called American muskwood, is frequently planted for shade and protection in coffee plantations, producing short logs of medium to large diameter. The very attractive heartwood (fig. 40) is pinkish to red when first cut, turning a light reddish brown after seasoning and exposure. The whitish to brownish sapwood is distinct but not clearly demarcated from the heartwood. The luster is rather low, texture is medium, and grain is straight. Green wood is aromatic, but no distinctive odor or taste is evident in seasoned wood. It is a moderately heavy wood, weighing 38 pounds per cubic foot air-dry and 71 pounds green. Guaraguao is strong and tough for its weight in comparison with other woods of similar density.

Lumber of this species seasons slowly, requiring about 8 months under cover in the San Juan area to air-season 1⅛-inch material to 19 percent moisture content. Seasoning is accompanied by

a moderate amount of warping, and sapwood pieces tend to distort more than heartwood pieces. No surface checking was evident in the tests.

The wood undergoes moderately and fairly uniform shrinkage during seasoning. Green wood shrinks 1/16 inch (1.4 percent) per foot in width across the growth rings and 7/16 inch (3.7 percent) per foot in width parallel to the growth rings in seasoning to 15 percent moisture content. The wood is reputed to be stable after manufacture.

Guaraguao saws and machines easily and well in all operations except boring. In this operation it has a tendency to tear and crumble. Silica is present in the wood but has no detrimental effects on its machining properties. The wood takes a high lustrous finish with either varnish or lacquer.

Guaraguao has good resistance to dry-wood termites and is durable in the ground. The heartwood is considerably more resistant to dry-wood termites than Honduras (Mexican) mahogany but rates somewhat below West Indies mahogany in this characteristic. The heartwood is highly resistant to impregnation with preservatives but the sapwood responds well to pressure treatment.

Because of its attractiveness, good strength, durability, and favorable working properties, guaraguao is well suited for furniture and cabinetwork, turnery, interior trim, and general construction and carpentry. Guaraguao has strength and working properties similar to those of white oak and is suitable for most of the same purposes. For veneer, the wood may be similar to other related species that are suitable but require considerable steaming for either rotary or slicing operations.

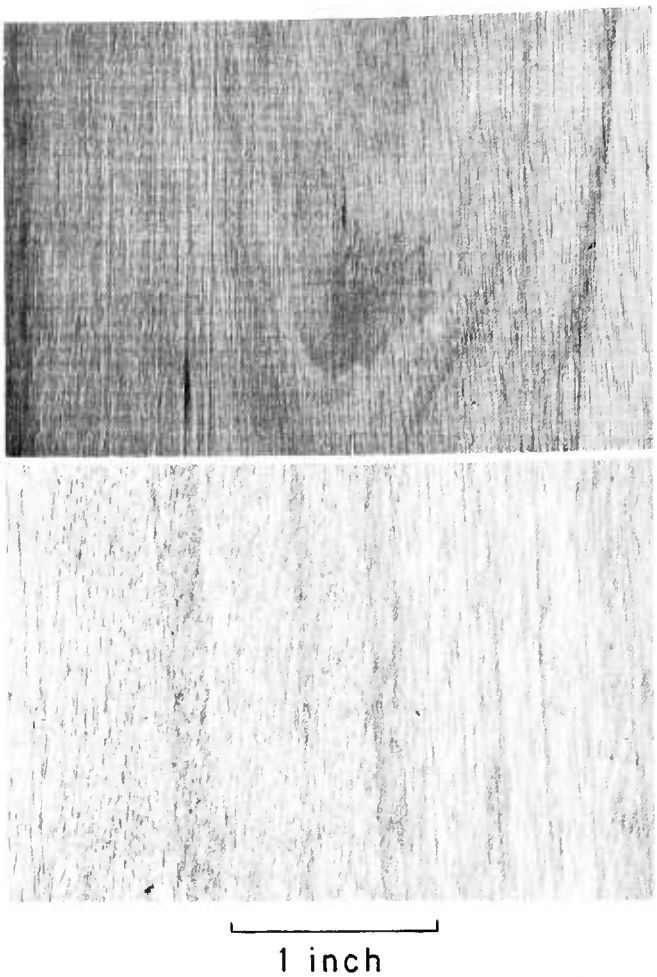

FIGURE 40.—Guaraguao: *Top*, flatsawed; *bottom*, quartersawed.

GUAYABOTA

Eugenia stahlii (Kiaersk.) Krug & Urban (myrtle family, Myrtaceae)

Guayabota is an attractive grayish-brown wood with a very mild and pleasant scent but without distinctive taste. Growth rings are marked by narrow bands of darker colored wood (fig. 41), which shows on the quartersawed surface as closely spaced, darker colored lines. The pinkish-brown sapwood is clearly distinct from the heartwood. The wood has fine texture, irregular grain, and medium to low luster. It is very hard, heavy, tough, and strong, weighing 57 pounds per cubic foot air-dry and 72 pounds green.

The wood is moderately difficult to season. Green lumber air-dries at a moderate rate, reaching 18 to 19 percent moisture content in 5 to 6 months under cover in the San Juan area. A moderate amount of warping and a small amount of surface checking occur during seasoning.

High but uniform shrinkage occurs during seasoning. Green wood shrinks at the rate of 1/3 inch (2.8 percent) per foot in width across the growth rings and 2/3 inch (5.8 percent) per foot in width parallel to the growth rings in seasoning to 15 percent moisture content. However, its longitudinal shrinkage of 0.06 percent is low for a wood with irregular grain.

Guayabota is moderately difficult to work because of its hardness, but it machines to a very smooth surface in all operations except sanding. The wood is rated "poor" in sanding on the basis that scratches show clearly unless very fine abrasive paper is used. Yet a glossy-smooth surface can be obtained when 4/0 or 5/0 grit paper is used. Guayabota is extremely susceptible to screw splitting, rating lowest of the woods tested. Preboring

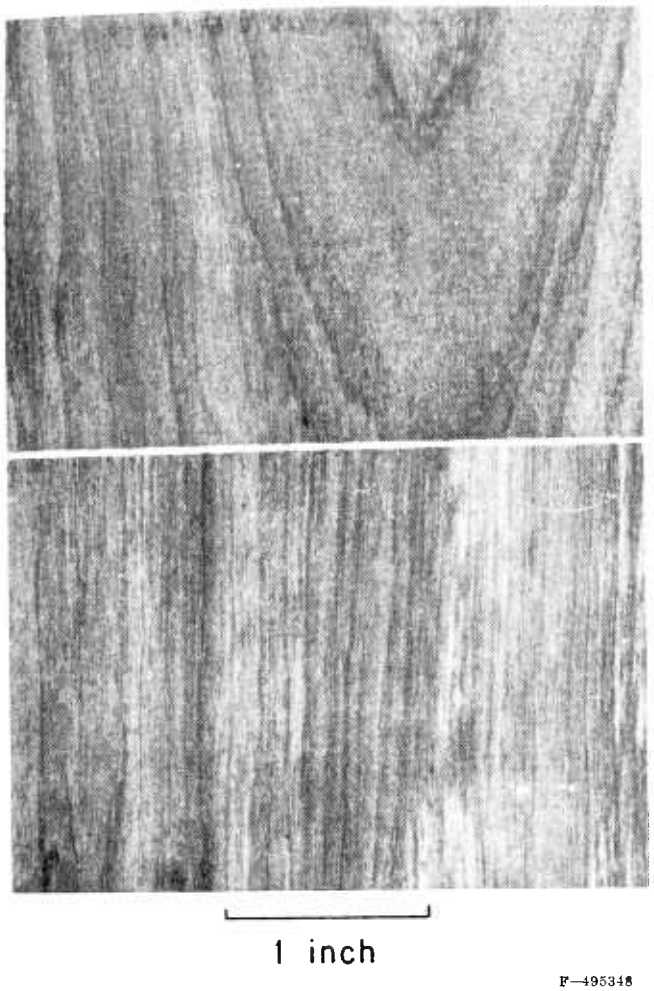

FIGURE 41.—Guayabota: *Top*, flatsawed; *bottom*, quartersawed.

proper size lead holes for screws or nails is very essential in this wood. The smooth surfaces obtained in machining should finish and polish satisfactorily.

Guayabota is very susceptible to dry-wood termites and is reported to be variable in decay resistance, with the darker colored specimens being the most durable.

This wood is suitable for furniture, cabinetwork, turnery, carving, interior trim, tool handles, agricultural implements, boat building, and both light and heavy construction. Quartersawed material is the most attractive and should be used where appearance is important. After proper preservative treatment, guayabota would be acceptable for posts, poles, piling, and other exterior uses above and below ground.

HIGÜERILLO

Vitex divaricata Sw. (verbena family, Verbenaceae)

Higüerillo, or white fiddlewood, is closely related to teca and possesses many of the good features of that wood. The heartwood (fig. 42) is tan to brown colored when freshly cut and generally variegated with darker shades of tan or brown. After seasoning and exposure, the heartwood becomes gray brown to deep brown, often with indistinct alternating narrow bands of lighter or darker wood. The fairly distinct sapwood is grayish colored when green, turning a light brown upon drying.

The wood has medium luster, fine texture, and fairly well defined growth layers. The grain is irregular and interlocked, making it unusually strong in resistance to splitting. Odor and taste are not distinctive in seasoned wood. Higüerillo is a heavy wood, weighing 47 pounds per cubic foot air-dry and 72 pounds green.

Green lumber dries so slowly that it is impractical to air-season the wood on a commercial scale. In the study, higüerillo was not completely air-dry after more than 1 year under cover in the San Juan area. Degrade, which occurred during the 1-year seasoning period, was confined to a small amount of warping; there was no apparent surface checking, end splitting, or casehardening.

Higüerillo undergoes moderately low and uniform shrinkage for a wood of its high density, being considerably better in this respect than many other woods of similar weight. Green wood shrinks at the rate of $\frac{3}{16}$ inch (1.6 percent) per foot in width across the growth rings and $\frac{7}{16}$ inch (3.5 percent) per foot parallel to the growth rings in seasoning to 15 percent moisture content. Its longitudinal shrinkage of 0.21 percent is nominal for a wood with interlocked grain.

Higüerillo saws and machines easily with fairly good results. It is an excellent wood to turn but planes poorly because of the tearing and roughness that develop in the numerous pieces having irregular grain. The wood gives good results in shaping, boring, and mortising, but fine abrasives are necessary in sanding to obtain good results. It finishes satisfactorily and takes a high polish but, judging by related species, it may be somewhat difficult to glue.

The wood is moderately resistant to dry-wood termites. Although specific information is lacking for higüerillo, closely related species are reported to have some resistance to marine borers and fair resistance to fungal attack. Higüerillo is a strong, hard, tough wood, comparable to white oak in all strength properties.

A closely related species, *Vitex gaumeri*, of British Honduras, has been used successfully for polo-stick heads because of its high resistance to splitting and denting. Higüerillo may be equally useful for this purpose and for other purposes such as golf-club heads, croquet mallets, other sporting goods, and tool handles. It should also be suitable for boat decking and planking, flooring, and general construction. In Central America, several other species of *Vitex* are used for heavy and durable construction.

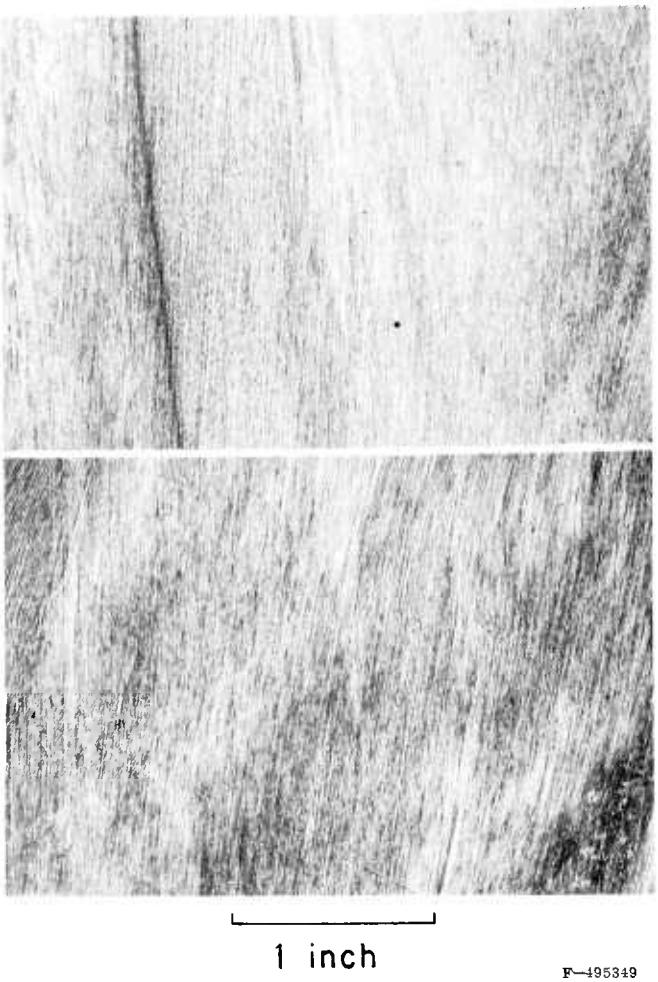

FIGURE 42.—Higüerillo: *Top*, flatsawed; *bottom*, quartersawed.

JÁCANA

Pouteria multiflora (A. DC.) Eyma (sapodilla family, Sapotaceae)

The heartwood (fig. 43) of jácana is reddish brown and not readily distinguished from the dull, light-brown sapwood. The wood has uniformly fine texture, generally straight grain, and medium to low luster. Growth rings are not evident, and odor and taste are absent in seasoned wood. It is very hard, firm, strong, and very heavy, weighing 59 pounds per cubic foot air-dry and 74 pounds green.

Jácana is a difficult wood to air-season; it dries slowly, with considerable degrade. About 7 months is required to air-season the wood to 17 percent moisture content under cover in the San Juan area. Moderate cup, bow, twist and surface checking occur during the seasoning process, along with very slight crook and slight end checking. Surface checks and end splits are apt to be deep whenever they occur and to widen and extend as drying progresses. None of the defects is particularly serious individually, but in the aggregate they cause a considerable loss during seasoning.

High but uniform shrinkage occurs during seasoning. Green wood loses $\frac{7}{16}$ inch (3.6 percent) per foot in width across the growth rings and $\frac{2}{3}$ inch (5.4 percent) per foot along the growth rings in drying to 15 percent moisture content.

The wood is fairly difficult to work because of its high density, hardness, and silica. Yet it is considered a good working wood except in planing. Considerable torn grain occurs in this operation when wavy or irregular grain is present and to some extent in straight-grained pieces. Because of its high density and straight, even grain, the wood splits rather easily with screws or nails but should finish and glue satisfactorily.

Jácana is moderately resistant to dry-wood termites and other insects, and it probably is slightly to moderately resistant to decay when in contact

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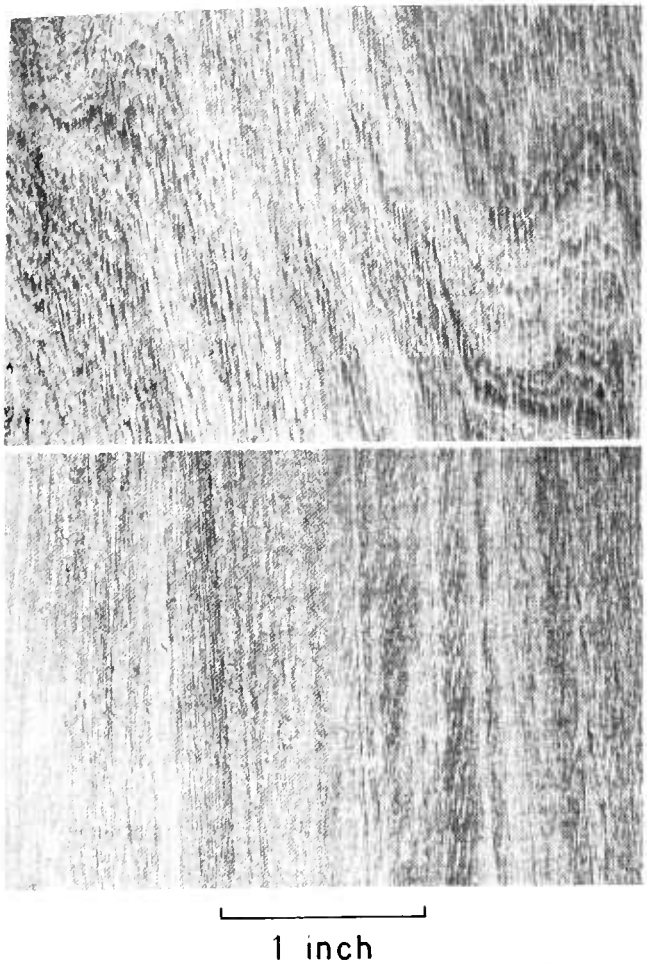

FIGURE 43.—Jácana: *Top*, flatsawed; *bottom*, quartersawed.

with the ground. Molds and sap-staining fungi are not troublesome in the log or during seasoning.

The difficulty in seasoning jácana, plus its common appearance and only fair planing qualities, restricts its use to some extent. It is currently used in other Caribbean areas for heavy construction, house framing, bridgework, posts, and other uses requiring a heavy, hard, strong wood. It should also be suitable for furniture, agricultural implements, some types of sporting goods, heavy flooring, piling in nonteredo areas, and boat timbers.

JAGUA

Genipa americana L. (madder family, Rubiaceae)

Jagua, or genipa, is an attractive timber suitable for many of the same uses as ash, maple, and birch. The heartwood (fig. 44) is a very light yellowish brown, occasionally with a slight pinkish- or purplish-blue overcast, merging gradually into the cream-colored sapwood. Growth rings are indistinctly marked by narrow bands of darker colored wood which at times show on the quartersawed surface as faint lines, giving the wood an attractive striped figure. Flatsawed surfaces frequently have a ribbon stripe.

The wood has medium luster, rather fine texture, and straight to irregular grain. Distinctive odor and taste are not apparent in seasoned wood. The wood is hard, heavy, strong, and resilient, weighing 51 pounds when air-dry and 64 pounds green.

Jagua air-seasons slowly, green 1⅛-inch lumber requiring 7 to 8 months to reach 20 percent moisture content. However, only a minor amount of warping occurs during seasoning, and virtually no surface checking.

The wood undergoes moderate and fairly uniform shrinkage during seasoning and should stay in place well after manufacture. Green wood shrinks at the rate of about 1/5 inch (1.7 percent) per foot in width across the growth rings and ½ inch (4.1 percent) per foot parallel to the growth rings in drying to 15 percent moisture content.

Jagua works easily and with excellent results, machining better than most other Puerto Rican woods, and ranking well above mahogany, teca, and other well-liked cabinetwoods. It has good resistance to screw splitting, glues satisfactorily,

and should take all types of stains and finishes without difficulty. The heartwood is very susceptible to pinhole borers, dry-wood termites, and decay. Sap-staining fungi are seldom troublesome during seasoning.

Jagua is used for shoe lasts, plow beams, tool handles, barrel hoops, chests, and many other products requiring fine and uniform texture combined with high strength and resilience. The wood is especially good for all types of bent work and should be a very satisfactory substitute for ash. Its excellent machining qualities, attractiveness, and uniform texture make it an excellent material for furniture, cabinetwork, and turnery of all types. It should also work well as flooring, interior trim, and decorative veneer, and for most purposes for which maple, birch, or ash are cnr rently preferred.

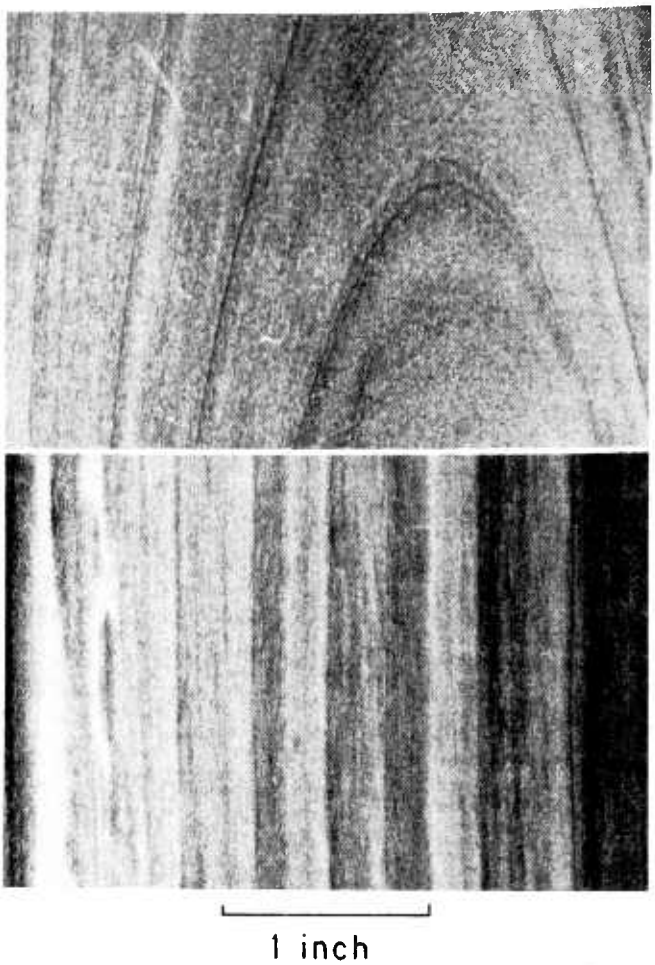

FIGURE 44.—Jagua: *Top*, flatsawed; *bottom*, quartersawed.

JAGÜEY BLANCO

Ficus laevigata Vahl (mulberry family, Moraceae)

This species is related to the common cultivated fig, *Ficus carica* L., and the rubber plant of the florists, *F. elastica* Roxb., from the Far East. The tree and wood are known in Puerto Rico as jagüey blanco. The English name is shortleaf fig. The tree does not produce edible fruit.

Both the heartwood (fig. 45) and sapwood are a uniform light brown. The wood is composed of alternating bands of wood fibers and soft parenchyma, which shows on the flatsawed surface as an irregular darker brown pattern and on the quartersawed surface as a very fine, closely spaced striping. Surfaces having an appreciable amount of the soft, darker colored parenchyma tissue are correspondingly more difficult to machine.

The wood has low luster, coarse texture, and straight grain. It is fairly light and soft, but tough and strong for its weight. Air-dry wood weighs 30 pounds per cubic foot and green wood about 55 pounds.

The wood is heavily saturated with moisture (119 percent) when first cut. It seasons slowly, requiring 6 to 7 months to reach an air-dry moisture content of 17 percent in the San Juan area. However, very little degrade occurs and even the widest boards dry with a minimum of distortion. Degrade is confined to slight bow and twist and very slight cup and crook. Discoloration of the sapwood by fungi is common during the early stages of seasoning, and it is difficult to control unless the lumber is immersed or sprayed with a fungicide solution immediately after sawing.

Shrinkage is low and fairly uniform during seasoning. Green wood shrinks at the rate of 1/8 inch (1.0 percent) per foot in width across the growth rings and 1/3 inch (2.8 percent) per foot along the growth rings in drying to 15 percent moisture content.

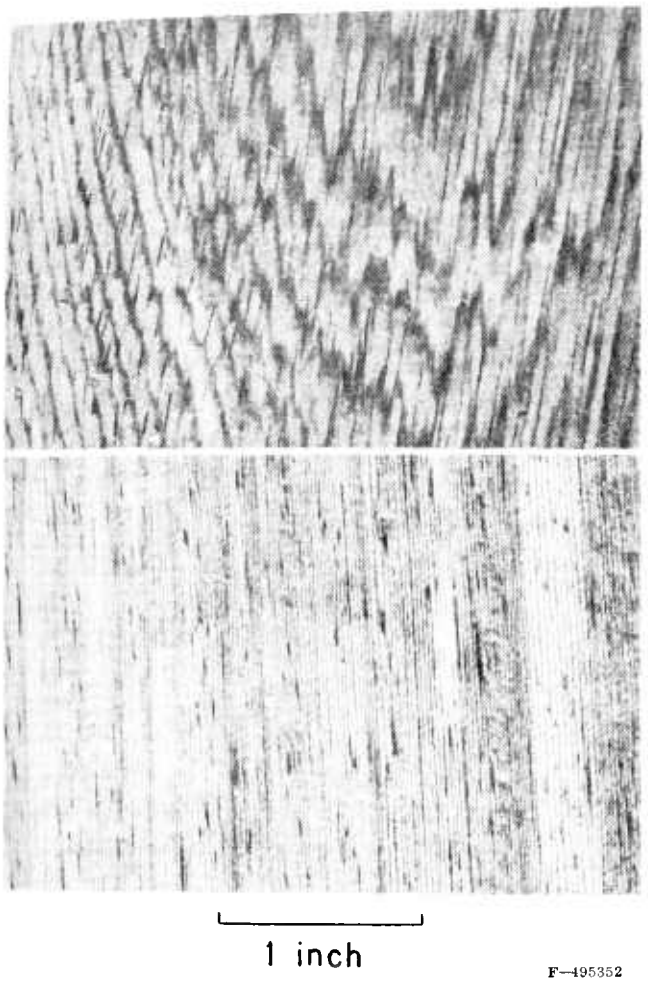

FIGURE 45.—Jagüey blanco: *Top*, flatsawed; *bottom*, quartersawed.

Jagüey blanco works easily but with poor results, except in planing and sanding, in which satisfactory surfaces are obtained. The wood tends to pickup and fuzz in shaping and turning and to crush and crumble in boring and mortising. The preponderance of soft parenchyma tissue is responsible for most of the machining difficulties. It is also responsible for all surfaces being somewhat rough to the touch and requiring careful sanding before polishing. Jagüey blanco has excellent resistance to screw splitting, and it is reported to take and hold nails firmly and finish smoothly with paint or varnish.

The wood is very susceptible to damage by termites and other insects, decay-causing fungi, and probably marine borers. But, judged by its appearance and structure, jagüey blanco should be easily impregnated with preservatives to combat these destructive agencies.

The various *Ficus* woods are generally considered to have limited commercial value on the export market, though they are suitable for many everyday purposes if seasoned before they can decay. Air-dry jagüey blanco can be used for boxes, crates, interior construction, general light carpentry, and temporary concrete forms. After proper preservative treatment, it would also be suitable for numerous outdoor uses where a light, easily nailed, moderately strong wood is acceptable.

JOBO

Spondias mombin L. (cashew family, Anacardiaceae)

Jobo, or yellow mombin, is a soft, lightweight wood of common appearance (fig. 46). When first cut, the heartwood is buff colored and indistinguishable from the sapwood, but when seasoned it turns a golden brown and is readily distingnished from the cream-colored sapwood. Both heartwood and sapwood are often turned to a blue-gray color by sap-staining fungi during the early stages of seasoning. Jobo weighs about 30 pounds when air-dry and 60 pounds when green at 133 percent moisture content.

The wood has straight to slightly interlocked grain and coarse texture. Numerous pores, barely visible on end surfaces, appear on the longitudinal surfaces as distinct grooves or as somewhat darker lines or scratches against the lighter backgrounnd. The wood possesses no characteristic odor or taste.

Jobo is moderately easy to season. Green wood 1⅛ inches thick air-dries to a moisture content of about 16 percent in 6 months under cover in the San Juan area. Moderate degrade occurs during seasoning in the form of very slight cup, moderate bow, slight twist and crook, and very slight end and surface checking. Heavy mold occurs on both sapwood and heartwood unless the wood is immersed in a fungicide soon after it is sawed.

Low and uniform shrinkage occurs during the seasoning process. Green wood shrinks at the rate of $\frac{1}{10}$ inch (0.9 percent) per foot in width across the growth rings and $\frac{7}{32}$ inch (1.8 percent) per foot parallel to the growth rings in drying to a moisture content of 15 percent.

The wood is easy to work but has rather poor machining properties unless handled carefully.

It is an excellent wood to plane but develops rough and torn surfaces in other machining operations that use conventional hobby-shop size machines and tools. However, the wood sands fairly well and has good resistance to screw splitting. Jobo is very susceptible to decay, termites, and other insects; logs left in the woods are soon attacked by pinhole borers.

Jobo possesses moderate strength properties, being somewhat harder on the end and sides than many woods of comparable density; in general, it is tough and strong for its weight. Jobo is used for soft-drink cases, packing boxes of all types, interior construction, and match splints. It has been recommended for utility plywood. It will produce a good yield of pulp that is suitable for making a strong, white printing paper. With special care in machining, the wood could also be utilized in the cheaper grades of furniture and cabinetwork, and it is quite suitable for light construction of all types when protected from insects and decay. Because large cuttings take root readily, sections of young stems and limbs of large trees are used extensively for live fence posts.

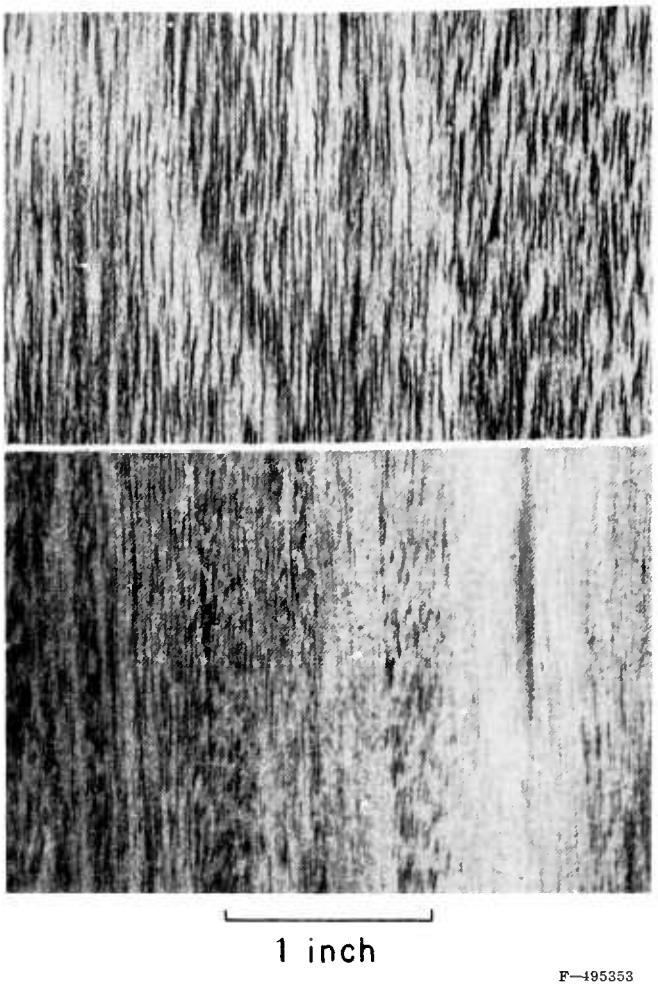

FIGURE 46.—Jobo: *Top*, flatsawed; *bottom*, quartersawed.

JUSILLO

Calycogonium squamulosum Cogn. (melastome family, Melastomataceae)

Jusillo, also commonly known as camasey negro, is one of several species of the genus *Calycogonium* that are endemic to Puerto Rico. The pinkish-brown to pale-brown heartwood is characterized by irregular, widely spaced black streaks of varying widths, giving the wood an unusual and somewhat attractive appearance (fig. 47). The sapwood is bright yellow and fairly well distinguished from the heartwood. The wood has fine texture, generally straight grain, and good lustre, and it is odorless and tastless and without distinctive growth rings. It is hard, heavy, and strong, weighing about 56 pounds per cubic foot when air-dry and 76 pounds when green.

The wood seasons at a moderate rate with a moderate amount of degrade. Green lumber air-dries to about 18 percent moisture centent in 6 months under cover in the San Juan area. Degrade is limited to a moderate amount of warp and some very light surface and end checking. A small amount of casehardening may also occur at times.

Shrinkage is moderate and uniform during seasoning despite the wood's high density. Freshly sawed lumber shrinks ¼ inch (2.2 percent) per foot across the growth rings and nearly ½ inch (3.9 percent) per foot along the growth rings in seasoning from the green condition to 15 percent moisture content. Longitudinal shrinkage is also moderate.

The wood's hardness and density make it moderately difficult to saw and machine, but it can be worked to a glasslike surface in all operations except planing. The frequent occurrence of torn grain makes this operation difficult. In sanding, the wood will show scratches unless a very fine

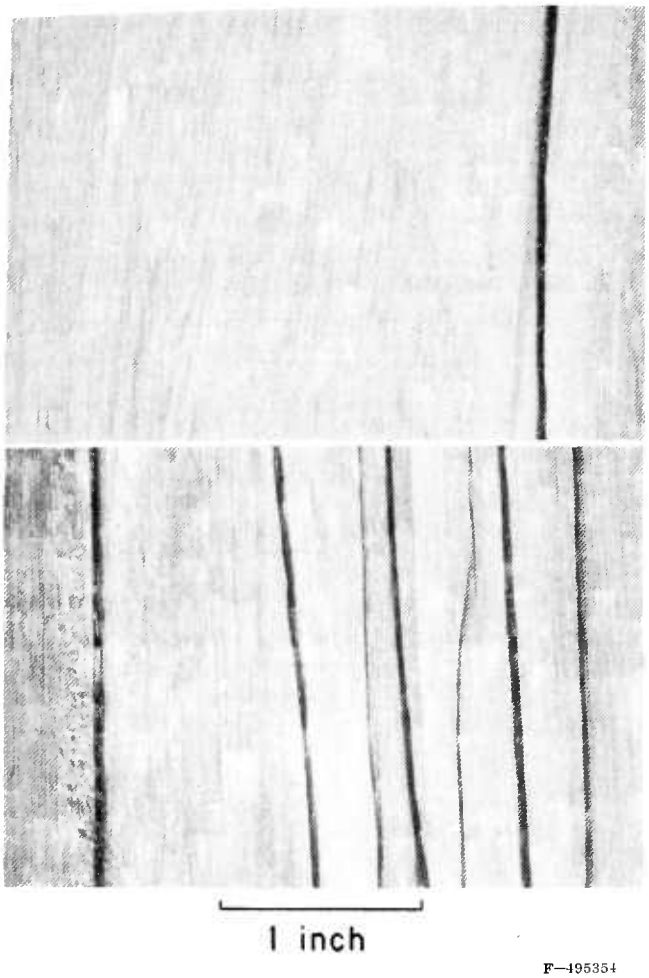

FIGURE 47.—Jusillo: *Top*, flatsawed; *bottom*, quartersawed.

abrasive is used. Jusillo is also very susceptible to splitting by nails or screws unless it is prebored or adequate-sized lead holes are employed. It should glue satisfactorily and finish exceptionally well with all types of coatings.

The heartwood is very susceptible to dry-wood termites and of doubtful durability in contact with the ground or in teredo-infested waters. Pinhole borers will also attack the wood before and after it is sawed.

The wood is considerably heavier, harder, and probably stronger than sugar maple or yellow birch. It is suitable for the same purposes as these woods, except where the pinkish to pale-brown color or the unusual and characteristic pattern of black lines would be objectionable. The figure is of a type that might be quite acceptable for some purposes and quite objectionable in others.

Judged by its physical properties, the wood is suitable for furniture, patternmaking, veneer and plywood, agricultural implements, tool handles, heavy-duty flooring, turnery, boat parts, and vehicle frames. It would also give good service for heavy construction, bridge timbers, and piling in nonteredo areas. After preservative treatment, it should also serve well for railway ties, posts, poles, and other products that would be in contact with the ground.

LAUREL AMARILLO

Nectandra sintenisii Mez (laurel family, Lauraceae)

Laurel amarillo is a rather light, moderately soft wood resembling yellow-poplar (*Liriodendron tulipifera*) of the United States in superficial appearance (fig. 48). The heartwood is a pale greenish yellow, merging gradually into a slightly lighter colored sapwood. The luster is satiny, the texture medium, and the grain straight to more frequently interlocked. Odor and taste are not distinctive in seasoned wood. Air-dry wood weighs about 41 pounds per cubic foot and green wood 54 pounds per cubic foot.

The wood air-seasons satisfactorily without excessive degrade. It air-dries at a moderate rate, reaching about 17 percent moisture content in 6 to 7 months under cover in the San Juan area. Moderate degrade occurs during seasoning in the form of very slight cup, end checking, and crook, and slight twist and moderate bow. Surface checking was not evident in the tests.

Laurel amarillo is easy to work and produces good surfaces in all operations except planing, where the frequent roey grain causes considerable torn and fuzzy surfaces. The species of *Nectandra*, as a group, are considered to glue and paint well and hold nails satisfactorily. Laurel amarillo is probably similar to other members of the genus in these properties.

Low to moderate shrinkage occurs during seasoning. Green wood of this species shrinks at the rate of ⅛ inch (1.1 percent) per foot across the growth rings and ¼ inch (2.0 percent) per foot along the growth rings in drying to 15 percent moisture content. The wood is extremely resistant to moisture absorption and holds its place exceptionally well after manufacture.

Laurel amarillo is very susceptible to attack by dry-wood termites, marine borers, and sap-staining fungi. Like other closely related species, it may

be moderately durable in the ground. The heartwood is extremely resistant to impregnation with preservatives, though the sapwood is easily treated.

The wood is somewhat lighter than white oak, but tests of other species of the genus indicate that it should be comparable to white oak in most mechanical properties except resistance to splitting, in which it is only 60 percent as strong as oak. It is a moderately good bending wood.

The wood of laurel amarillo is suitable for general construction, boxes, crates, carpentry, millwork, flooring, and interior trim. Although it is not particularly attractive, it should be suitable for some types of furniture and cabinetwork; however, the wood's poor planing qualities would necessitate considerable sanding of exposed surfaces prior to finishing. Other similar species of *Nectandra* have been recommended for tool handles, instruments, crossties, and boat construction.

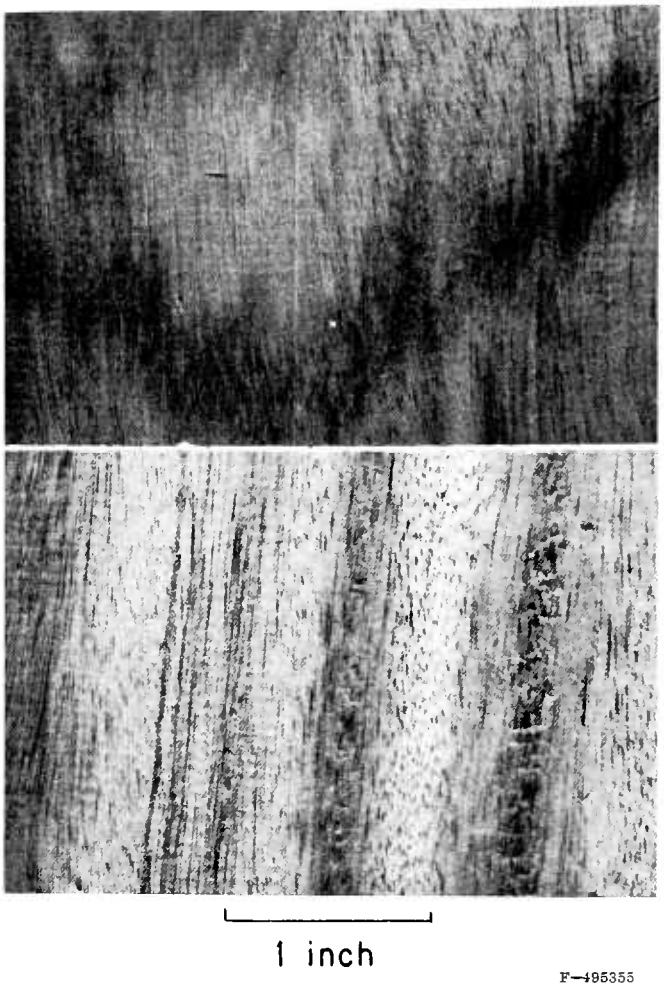

FIGURE 48.—Laurel amarillo; *Top*, flatsawed, *bottom*, quartersawed.

LAUREL AVISPILLO

Nectandra coriacea (Sw.) Griseb. (laurel family, Lauraceae)

Laurel avispillo, or Jamaica nectandra, has pinkish-colored heartwood (fig. 49), which merges gradually into light-brown sapwood. The wood appears to have zones of tension wood composed of soft gelatinous fibers that are similar to those occurring in Mexican mahogany; they appear as slightly darker colored bands or stripes on flatsawed surfaces. These areas give the wood an attractive configuration but present trouble in most machining operations because they develop considerable fuzziness.

The grain is straight to irregular and tightly interlocked, the texture is medium, and the luster is medium to high. The wood is moderately soft and light, weighing 36 pounds air-dry and 51 pounds green per cubic foot.

The wood air-seasons easily and satisfactorily except for a moderate amount of warping. Surface and end checking are not troublesome. Green lumber air-seasons to about 17 percent moisture content in 6 months under cover in the San Juan area. Shrinkage is moderate and uniform during seasoning. Green wood shrinks $\frac{1}{6}$ inch (1.4 percent) per foot across the growth rings and $\frac{4}{10}$ inch (3.3 percent) per foot parallel to the growth rings in drying to a moisture content of 15 percent. All species of *Nectandra* are reported to be stable after manufacture.

The wood is easily machined with good results in all operations except turning and sanding. Torn and fuzzy grain develop in turning and severe fuzzing during sanding wherever there is a

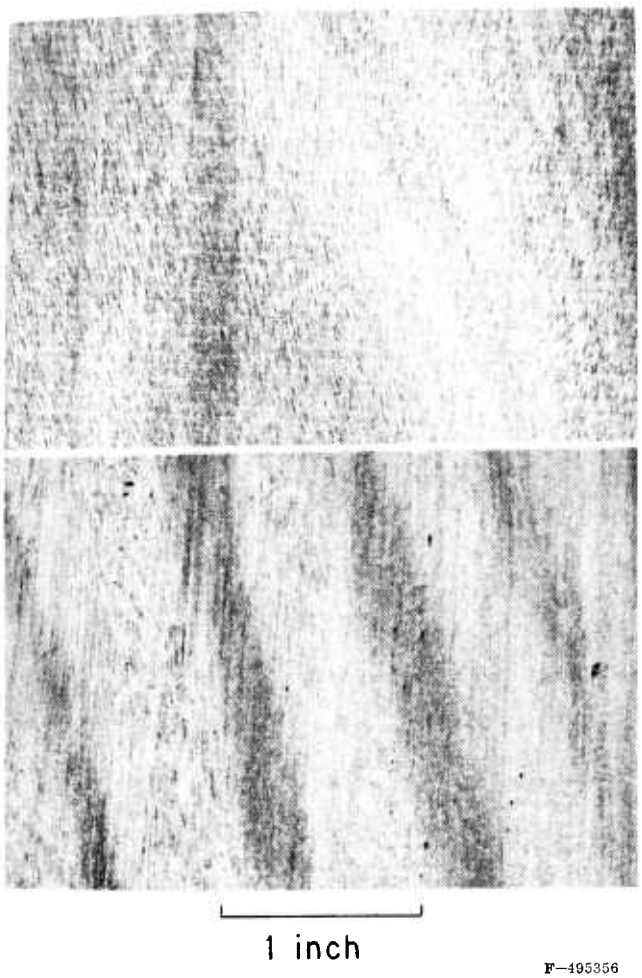

FIGURE 49.—Laurel avispillo: *Top*, flatsawed; *bottom*, quartersawed.

tension-wood zone. However, with extra care the wood can be finished to a very smooth, paintable surface and when properly sanded is equal or superior to Mexican mahogany in attractiveness. Laurel avispillo takes and holds screws and nails satisfactorily, glues well, and can be painted or varnished with good results. Grain fillers are not required as in laurel prieto.

The heartwood of laurel avispillo is very susceptible to dry-wood termites and other insects, and the logs are readily attacked by pinhole borers. Both logs and green lumber are fairly resistant to sap-staining fungi. The heartwood of other species of *Nectandra* is moderately durable in the ground but is very resistant to impregnation with preservatives while the sapwood is not durable and is easily treated. Laurel avispillo may have similar characteristics in these respects.

The wood is suitable, with considerable care in machining, for furniture, cabinetwork, interior trim, paneling, toys, novelties, turning, and other uses requiring an attractive wood of moderate strength and durability. It is also well qualified for general carpentry, interior and exterior construction, and possibly for decorative veneer and plywood. The wood is also satisfactory for boxes, crates, toys, boatbuilding, and other miscellaneous uses.

LAUREL GEO

Ocotea leucoxylon (Sw.) Maza (laurel family, Lauraceae)

Laurel geo is a moderately soft, light wood. The heartwood (fig. 50) is uniform light golden brown with medium luster, and generally it is not sharply delineated from the pale yellowish-brown or cream-colored sapwood. The wood has medium texture, straight to more frequently interlocked grain, and lacks distinctive odor or taste when seasoned. The lack of figure and the wood's dull-brown color give it a rather common appearance. Air-dry wood weighs 34 pounds per cubic foot and green wood 50 pounds per cubic foot.

Laurel geo is difficult to air-season. The wood dries at a moderate rate, reaching an air-dry moisture content of 16 percent in about 5 months under cover in the San Juan area. There is severe degrade during air-seasoning in the form of cup, bow, twist, and crook, but no appreciable end or surface checking.

Moderate and uniform shrinkage occurs during air-drying. Green wood shrinks $\frac{5}{32}$ inch (1.2 percent) per foot in width across the growth rings and $\frac{1}{16}$ inch (2.4 percent) per foot along the growth rings in drying to an air-dry moisture content of 15 percent. As judged from tests of other species of *Ocotea*, laurel geo should be stable after manufacture and should withstand exposure well without the protection of paint.

Laurel geo saws and machines easily with little dulling effect on cutting edges. Machined surfaces are acceptably smooth, except for a tendency toward fuzziness in sanding and frequent crushing and tearing of the wood in boring. Other similar species of *Ocotea* are known to take good finish with paint, stain, or varnish, to glue well, and to hold nails satisfactorily except on the end grain.

The wood is moderately resistant to dry-wood termites, and observation of closely related species indicates that it may be moderately resistant to decay. The heartwood of other species is highly resistant to impregnation with preservatives while the sapwood is easily treated. Sap-staining fungi are troublesome in freshly cut logs and lumber, and pinhole borers often attack logs soon after felling.

Laurel geo is suitable for inexpensive grades of furniture and cabinetwork and for interior trim, general capentry, and light interior and exterior construction. It may be one of the better local woods for boxes and crates, plywood, sheathing, concrete forms, and other products where a moderately light, easily worked, yet moderately strong wood is required. It does not possess sufficient attractiveness for decorative purposes to compete with a number of other local woods.

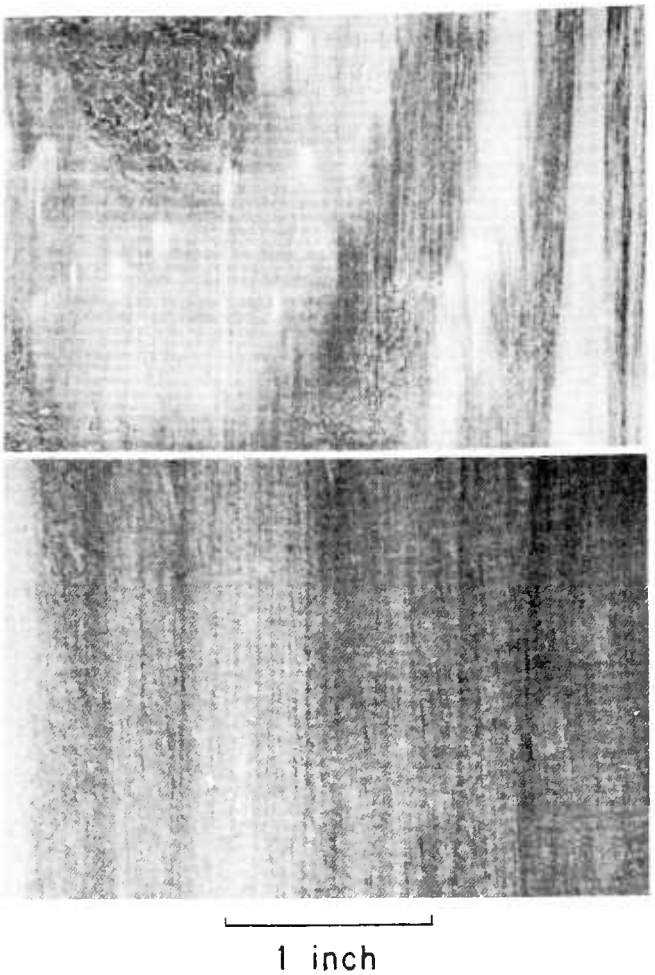

FIGURE 50.—Laurel geo: *Top*, flatsawed; *bottom*, quartersawed.

LAUREL PRIETO

Nectandra membranacea (Sw.) Griseb. (laurel family, Lauraceae)

Laurel prieto logs are generally small in diameter but of good quality. The heartwood is yellowish brown to golden brown in contrast to the fairly distinct grayish-colored sapwood. The wood lacks attractive figure except for the presence of faint ribbonlike stripes (fig. 51) in those pieces having fairly distinct growth rings. Open pores on the end grain appear as elongated scratches on flatsawed surfaces, giving the wood a somewhat rough texture. The wood has straight to occasionally wavy grain, medium texture, and medium luster. Air-dry wood weighs 34 pounds per cubic foot and green wood 46 pounds per cubic foot.

This timber air-seasons at a moderate rate and satisfactorily, reaching an air-dry moisture content of about 16 percent in 6 months under cover in the San Juan area. A minor amount of degrade occurs in the form of slight bow and very slight cup, twist, and crook. Surface checking and casehardening are not a problem.

Shrinkage is moderate and uniform during seasoning, amounting to $\frac{5}{32}$ inch (1.3 percent) per foot in width across the growth rings and $\frac{12}{32}$ inch (3.0 percent) per foot parallel to the growth rings from green to an air-dry moisture content of 15 percent. Seasoned wood holds its place well after manufacture.

Laurel prieto saws and machines easily, but it has a tendency to tear and develop fuzziness during sawing. Good results are obtained in planing, shaping, and mortising; torn grain is quite troublesome in turning and boring; and fine scratches are evident in sanding. If fine abrasives are used, the

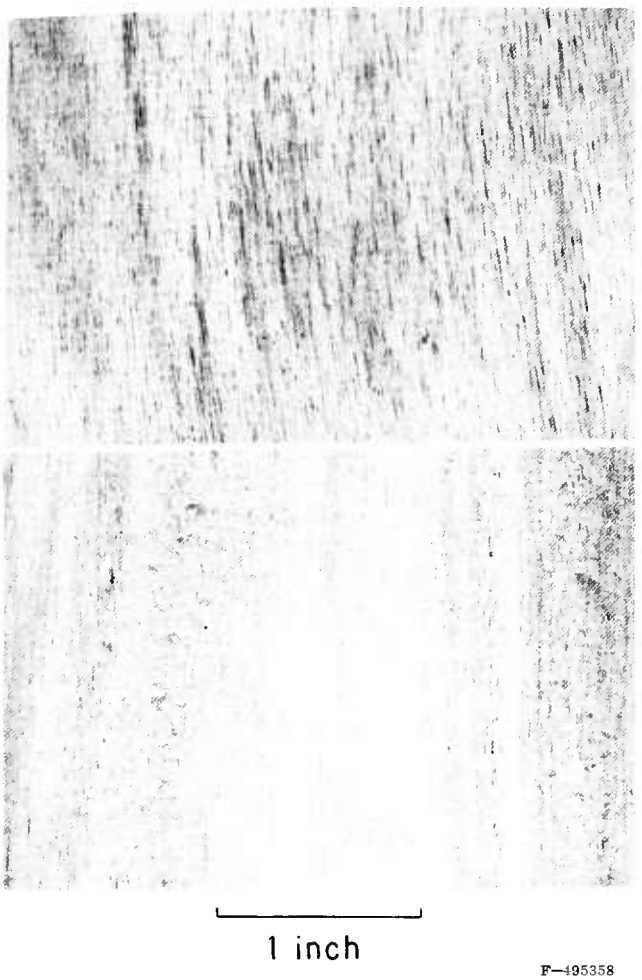

FIGURE 51.—Laurel prieto: *Top*, flatsawed; *bottom*, quartersawed.

wood can be finished to a smooth, uniform surface. The wood takes all types of finishes satisfactorily after its characteristic open grain has been properly filled. It should nail and glue without difficulty.

The heartwood of laurel prieto is considered very susceptible to dry-wood termites and may be vulnerable to decay-causing organisms. Logs and lumber are both subject to sap-staining fungi. The heartwood of other species of *Nectandra* is reported to be very resistant to impregnation with preservatives. This species may be similarly resistant.

Laurel prieto's wood is moderately soft and light but, if similar to other closely related species, should possess good strength properties. It lacks attractiveness and good working properties for use in furniture and cabinetwork, but it is suitable for boxes, crates, interior trim, and possibly plywood. The wood is sufficiently strong for general carpentry and light construction of all types, particularly for studding, sheathing, wall partitions, and similar uses.

LAUREL SABINO

Magnolia splendens Urban (magnolia family, Magnoliaceae)

Laurel sabino is limited to Puerto Rico, where it is one of the most highly regarded woods for furniture and cabinetwork. Short logs of medium to frequently large diameter are obtained from the very old crooked-growing trees found scattered in the high rain forests of the eastern mountains.

Freshly cut heartwood (fig. 52) is an unusual and very attractive olive green, turning medium to dark brown upon seasoning and exposure. Growth rings are marked by fairly distinct lines of lighter colored wood which appear on the quartersawed surfaces as longitudinal stripes and on flatsawed surfaces as wavy lines, giving the wood a very attractive figure. Frequent dark streaks give the wood additional figuration. The sapwood is whitish when freshly cut, becoming somewhat darker upon seasoning and exposure. The grain is straight to more frequently wavy, texture is fine and uniform, and odor and taste are not evident. The wood is moderately heavy, weighing 44 pounds per cubic foot air-dry and 72 pounds green.

This wood is easy to air-season, drying rapidly with only minor degrade in the form of very slight bow and slight twist. Other forms of warp and surface checking were not apparent in the Puerto Rican tests. Green lumber 1⅛ inches thick air-seasons to about 17 percent moisture content in 3 to 4 months under cover in the San Juan area.

Shrinkage is moderate in all directions and somewhat below that of other woods of similar density. Green wood shrinks at the rate of 3/16 inch (1.5 percent) per foot in width across the

growth rings and 5/16 inch (2.6 percent) per foot along the growth rings in drying to 15 percent moisture content. Molds and sap-staining fungi seldom develop during seasoning. The wood stays in place well after manufacture.

Laurel sabino saws and machines easily. However, in planning, considerable tearing occurs as a result of the irregular grain. In the Puerto Rican tests, the wood gave fair results in planing; good results in shaping, turning, boring, mortising, and screw splitting; and fair results in sanding. A fine abrasive paper should be used to overcome scatching. The wood is moderately resistant to dry-wood termites but very susceptible to decay when in contact with the ground.

Laurel sabino is moderately strong, comparing favorably with other woods of similar density. It is used extensively in Puerto Rico for furniture and cabinetwork. The wood has a number of desirable qualities and should be suitable for utility and decorative veneer and plywood, millwork, turnings of many types, durable construction, boat planking, and general interior and exterior construction and carpentry. Unfortunately, the exceptionally attractive bright olive-green color in freshly worked wood disappears through an oxidation process that leaves the wood a pleasing but less attractive brown.

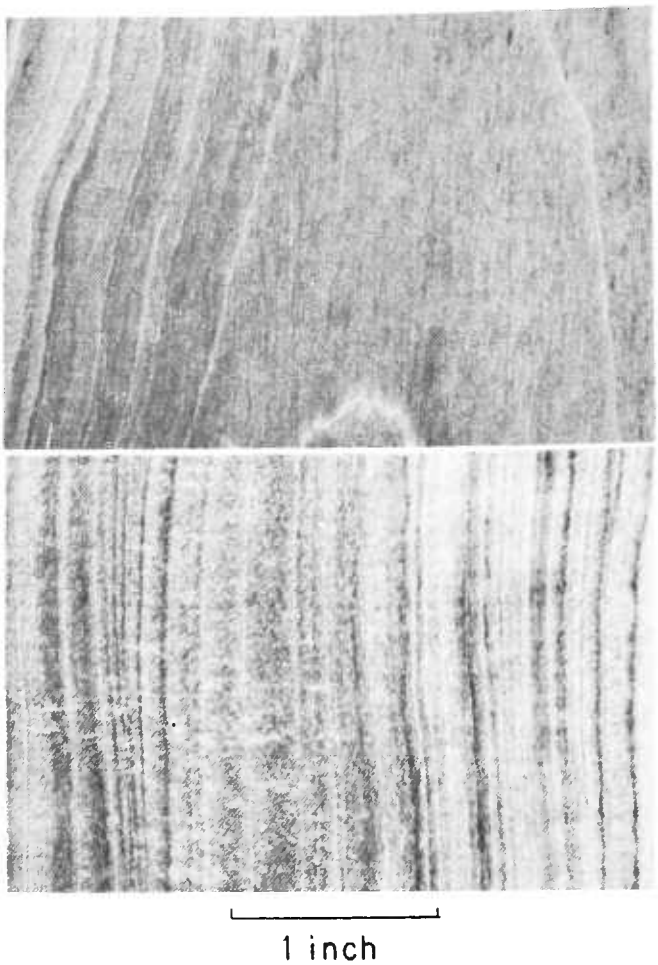

FIGURE 52.—Laurel sabino: *Top,* flatsawed; *bottom;* quartersawed.

MAGO

Hernandia sonora L. (hernandia family, Hernandiaceae)

Mago is a firm, soft, lightweight wood resembling the heavist grades of guano (balsa). The heartwood (fig. 53) and sapwood are indistinguishable, both grayish white in color with occasional faint olive-colored streaks. Numerous large darker colored pores are visible on the end grain and appear on longitudinal surfaces as numerous brown dots or scratches, giving the wood a characteristic but not particularly attractive appearance. The wood has low luster, medium to coarse texture, and straight grain. Air-dry wood weighs about 21 pounds per cubic foot and green wood 35 pounds per cubic foot as compared with 9 to 12 pounds for the commerical grade of air-dry guano.

The wood air-seasons satisfactorily. It dries at a rapid rate with only minor degrade in the form of very slight cup and crook, slight bow and twist, and without any apparent surface or end checking. Green 1⅛-inch lumber air-seasons to about 17 percent moisture content in slightly over 4 months under cover in the San Juan area.

Shrinkage is moderate and uniform. Green wood shrinks 1/16 inch (1.4 percent) per foot in width across the growth rings and 9/32 inch (2.4 percent) per foot parallel to the growth rings in drying to an air-dry moisture content of 15 percent.

Mago works easily with either hand or power tools but develops fuzziness in most operations and is reported to dull saws and knives rather quickly. The use of very sharp and thin cutting edges is recommended. Mago is rated poor to very poor in all machining qualities but, because of its softness and straight grain, takes both nails and screws without splitting. Finishing and polishing is difficult; this is due to the soft, porous nature of the wood.

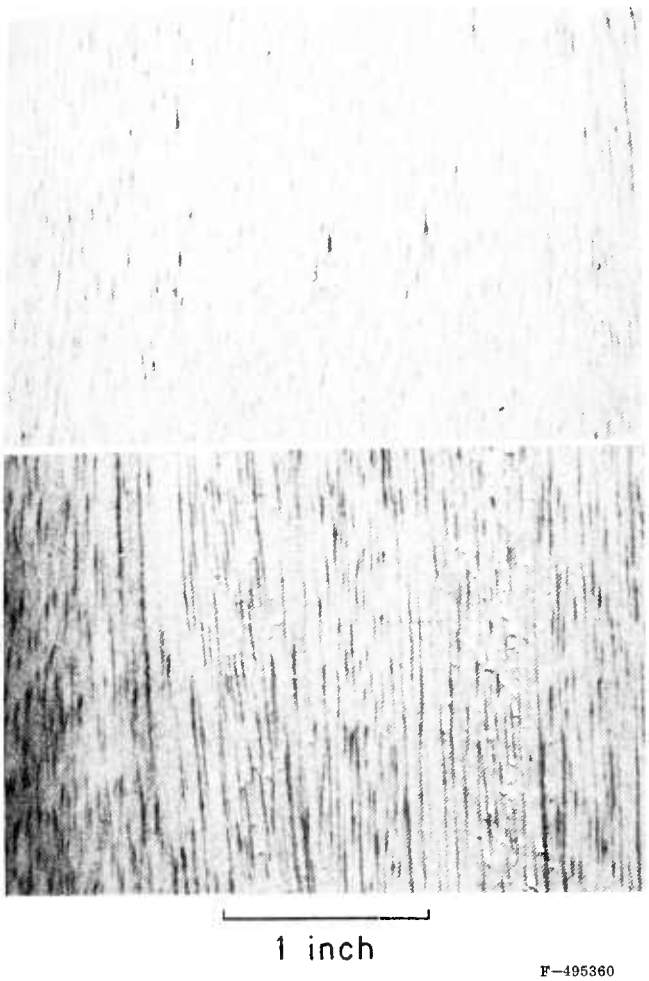

FIGURE 53.—Mago: *Top*, flatsawed; *bottom*, quartersawed.

Mago is very susceptible to termites and other insects, marine borers, and decay-producing organisms. It probably is penetrated readily by preservatives and could be made acceptable for many uses by preservative treatment.

Because of its light weight, softness, and low strength properties, mago is restricted to such uses as light boxes, crates, fishing floats, temporary boarding, and interior construction. It has been recommended for utility plywood and could be used as a substitute for the heavier grades of guano (balsa). The wood is also used in British Guiana for flooring and native canoes in addition to most of the above uses.

MAMEY

Mammea americana L. (mangosteen family, Guttiferae)

Mamey wood is obtained from trees better known for their fruit, the mammee apple, than for their wood. The wood is not plentiful and is very difficult to season, but it is quite attractive and works very well.

Seasoned heartwood (fig. 54) is a reddish brown, merging gradually into the dull, slightly lighter colored sapwood. The surface of both heartwood and sapwood are often flecked with small, dark-colored oily exudations. The grain is straight to more frequently irregular and interlocked, and the texture and luster are medium. Odor and taste are not distinctive in seasoned wood. Mamey wood is hard, heavy, and strong, weighing 54 pounds per cubic foot air-dry and 71 pounds green.

The wood is difficult to season, requiring about 5 months to air-dry to 22 percent moisture content and undergoing considerable degrade during the process. Severe cup, twist, and surface checking, and moderate bow, crook, and end checking develop during seasoning. Moderate to severe collapse and casehardening were also noted in the Puerto Rican study in which at least 50 percent of the volume was lost through seasoning defects.

Mamey undergoes exceptionally high shrinkage during seasoning and is quite unstable after manufacture. Green wood shrinks ⅔ inch (5.4 percent) per foot in width across the growth rings and nearly 1½ inches (12.1 percent) per foot parallel to the growth rings in drying to 15 percent moisture content. A longitudinal shrinkage of 0.38 percent is also high for the wood's density, usually indicating unfavorable seasoning characteristics.

Mamey is moderately easy to saw and machine and produces satisfactory results in most operations. The wood gives some trouble in sanding, because of the small scratches that occur when ordinary sanding belts are used. A sanding grit of 4/0 grade or finer is required to obtain scratch-free surfaces. The numerous small "resin" ducts may also cause trouble when certain types of finishes are desired. For a wood of its density, mamey is unusually resistant to splitting by screws or nails. It is very susceptible to damage by dry-wood termites but is moderately durable in the ground.

Because of its poor seasoning characteristics, heavy shrinkage, and lack of stability after manufacture, mamey is not suitable for furniture and similar uses. It is used principally for fence posts, fuel, and miscellaneous domestic purposes. But it may be useful for turning and novelty items in which its attractive and somewhat unusual appearance would be of value. The wood could also be utilized for some types of general construction and carpentry.

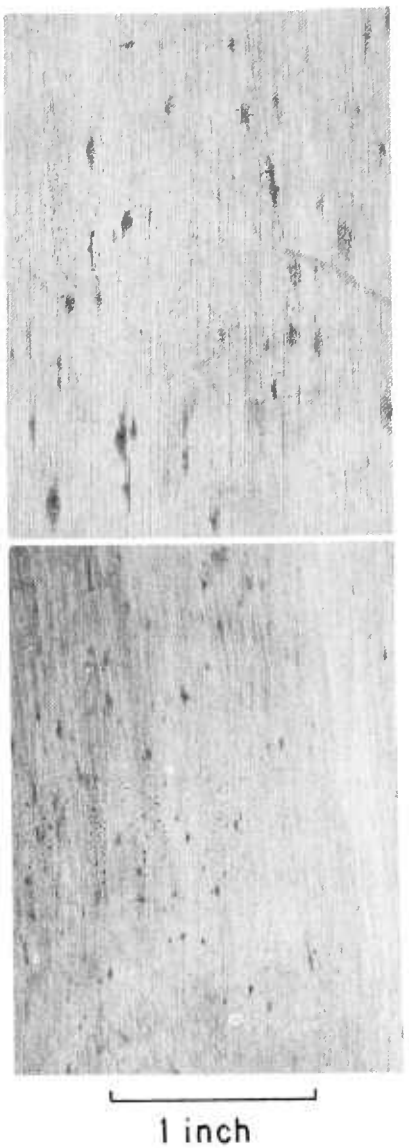

FIGURE 54.—Mamey: *Top*, flatsawed; *bottom*, quartersawed.

MANGO

Mangifera indica L. (cashew family, Anacardiaceae)

The mango tree is better known for its savory fruit than for its wood, which is moderately attractive but quite difficult to work.

Seasoned heartwood (fig. 55) is a pale yellowish color and not clearly distinct from the cream-colored sapwood. The wood is characterized by numerous large open pores, which are readily visible on the end grain and show as straight to frequently wavy light-brown scratches on the longitudinal surfaces, giving the wood a somewhat stippled appearance. Growth rings are fairly well marked by narrow bands of darker colored wood. The wood is lustrous, medium in texture, has straight to wavy grain, and is without pronounced odor or taste after seasoning. Air-dry wood weighs 41 pounds per cubic foot and green wood about 59 pounds per cubic foot.

Mango is fairly easy to air-dry. The wood seasons at a moderate rate with only minor degrade, drying to below 19 percent moisture content in about 5 months under cover in the San Juan area. Green 1⅛-inch lumber air-dries without any appreciable surface checking and only a minor amount of warping. Discoloration from sap-staining fungi is not apt to occur when lumber is stacked soon after sawing.

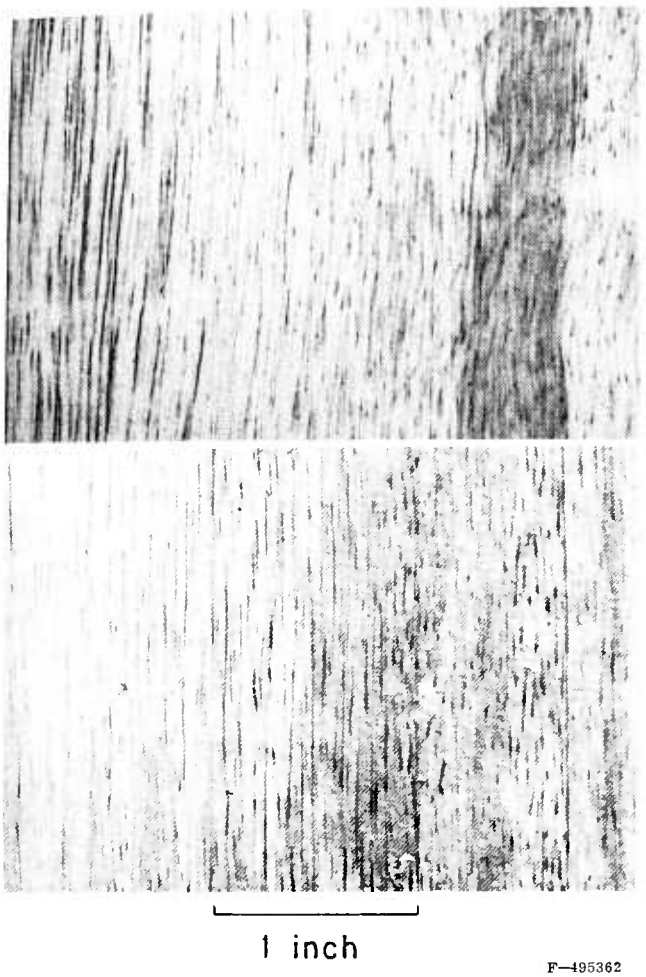

FIGURE 55.—Mango: *Top*, flatsawed; *bottom*, quartersawed.

The wood undergoes fairly low and uniform shrinkage. Green wood loses 1/10 inch (0.8 percent) per foot in width across the growth rings and 9/32 inch (2.3 percent) per foot parallel to the growth rings in seasoning to 15 percent moisture content.

Mango works easily but with only fair results. Torn grain and fuzziness are common in planing, shaping, and turning. In sanding there is a tendency for scratches to show unless very fined abrasives are used. Only occasional roughness and torn grain develop in boring and mortising.

The wood is moderately resistant to dry-wood termites. It probably is rather low in resistance to decay and to attack by marine borers.

Mango lacks the attractiveness and workability for furniture and similar products, but it appears to be well adapted for most types of construction and other uses where a moderately heavy, strong wood of low to moderate durability and fair machining quality is acceptable.

MARÍA (SANTA MARÍA)

Calophyllum brasiliense Camb. (mangosteen family, Guttiferae)

This wood is known in Puerto Rico as both maría and santa maría. The heartwood (fig. 56) is variable in color, ranging from light pinkish to reddish brown, often with fine darker colored striping. The sapwood is light brown, usually distinct from the heartwood. The grain may be straight, but it is more frequently interlocked, the latter type producing an attractive ribbon figure on the quartersawed surface. The luster is medium and the texture moderately coarse. The wood is without distinctive odor and taste. Growth rings are not evident to the naked eye. María is sometimes mistaken for Honduras mahogany, being somewhat similar in color and often showing good figure. It is heavier and stronger than mahogany and is more durable for some uses. Air-dry wood weighs 43 pounds per cubic foot and green wood 66 pounds at 92 percent moisture content.

María is very difficult to air-season. Green lumber 1⅛ inches thick requires 6 months or more to reach 18 percent moisture content in the San Juan area. Seasoning is accompanied by severe bow, twist, and crook, a moderate amount of cup, and slight end checking. Although end checks and splits are extended during seasoning, surface checking was not evident in the Puerto Rican study. Except for a tendency for moisture to remain in the center of heavy planks, quartersawed material is reported to kiln-dry satisfactorily when low-temperature/high-humidity kiln schedules are used.

María undergoes above-average shrinkage for a wood of its density but stays in place well after manufacture. Green wood loses 3/8 inch (3.0 percent) per foot in width across the growth rings and 9/16 inch (4.6 percent) per foot along the growth rings in seasoning to 15 percent moisture

content. A longitudinal shrinkage of 0.03 percent is low for a wood having interlocked grain.

In the green condition, maría is stronger than white oak in most strength properties and equal or superior to most other woods of similar density. When air-dry, the wood is comparable to the appreciably heavier white oak in all strength properties except modulus of rupture, crushing strength, hardness, and cleavage. Except for a slight deficiency in strength parallel to the grain, maría possesses average or better strength properties for tropical woods in its density class.

The wood is fairly easy to work and, except for occasional dark-streaked material that contains deposits of calcium carbonate, has little dulling effect on cutting edges. The machined surfaces are generally good in shaping, mortising, and sanding but rather rough in boring and turning. Chipping and tearing is fairly common on surfaces with interlocked grain, especially in planing and shaping. Cutting edges of 20° or less have been recommended to reduce such tearing to a minimum. Crushed and torn surfaces are also fairly common in boring. María has good resistance to screw splitting. It glues, stains, and finishes satisfactorily, requiring about the same amount of filler as Mexican mahogany.

The heartwood is very susceptible to attack by marine borers and dry-wood termites, but it has been reported moderately resistant to subterranean termites. Generally, it is moderately durable in contact with the ground. The sapwood is easily impregnated with preservatives by either pressure or open-tank bath methods, but the heartwood is extremely resistant under pressures up to 140 pounds per square inch.

María is as attractive as Mexican mahogany and can be used for many of the same purposes, but it is considerably more difficult to season and work. It is used for furniture, cabinetmaking, flooring, shingles, interior construction, shipbuilding, house framing, agricultural implements, handles, and many other purposes where a fairly strong, moderately durable wood is required. It gives fair service as railway ties and other products that must contact the soil. The wood makes an attractive veneer, but it is seldom used for this product because it tends to flake during the cutting operation.

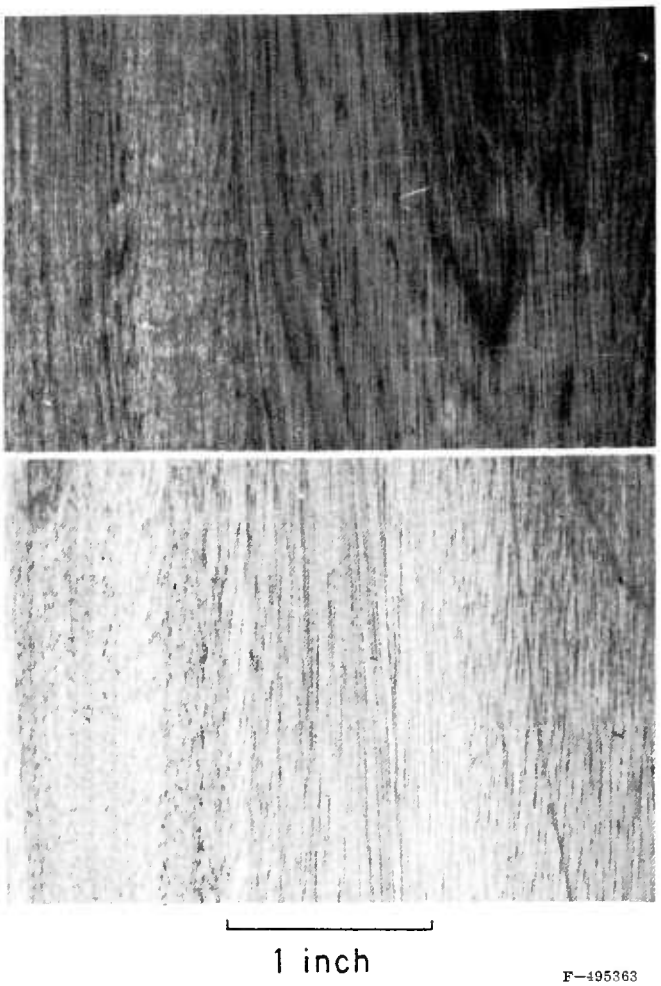

FIGURE 56.—María: *Top*, flatsawed; *bottom*, quartersawed.

MARICAO

Byrsonima coriaceum (Sw.) DC. (malpighia family, Malpighiaceae)

Maricao is a moderately hard, heavy wood, resembling redgum (*Liquidambar styraciflua*) of the United States in appearance and physical properties. The heartwood (fig. 57) is reddish brown with a purplish cast and is generally marked by darker colored stripes, which impart a stippled effect on the lighter colored background. The gray to reddish-brown sapwood is distinct from the heartwood. The luster is medium, the grain straight to slightly roey, and the texture fine. Growth rings are not distinct. Distinctive odor and taste are not evident in seasoned wood. Air-dry wood weighs 48 pounds per cubic foot and green wood 67 pounds per cubic foot.

The wood air-seasons fairly well, drying at a moderate rate with moderate degrade: very slight cup, moderate bow, and slight crook and twist. End and surface checking are minor. Green lumber air-seasons to 16 percent in approximately 6 months under cover in the San Juan area.

Shrinkage is moderate for the wood's density. Green wood shrinks at the rate of $\frac{1}{16}$ inch (1.5

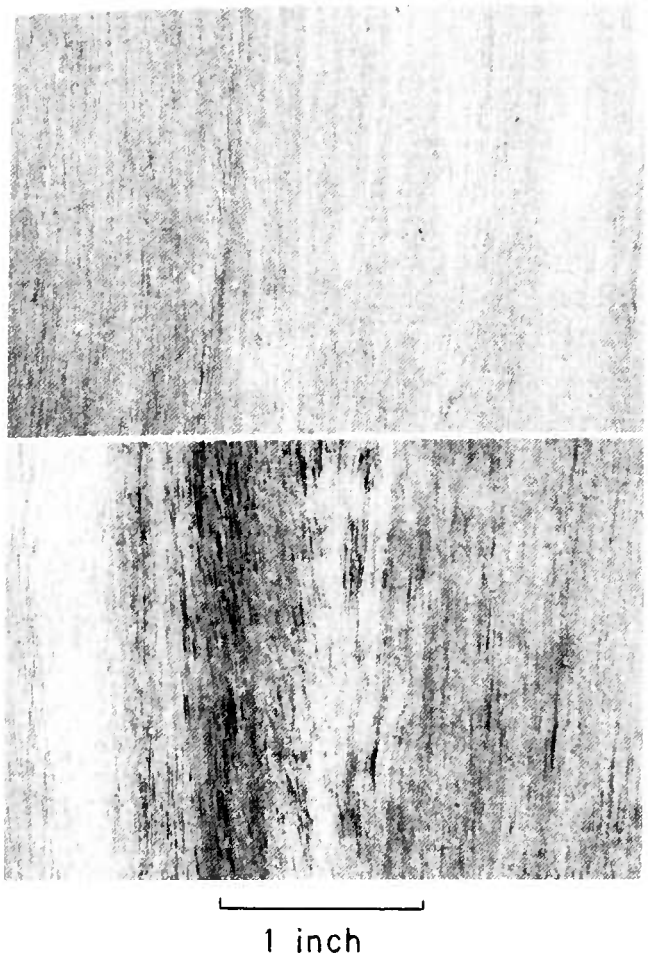

FIGURE 57.—Maricao: *Top*, flatsawed; *bottom*, quartersawed.

percent) per foot across the growth rings and 7/16 inch (3.5 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Maricao works fairly easily with both hand and power tools. Good to excellent surfaces are produced in all operations. Proper size lead holes must be prebored before screws are driven or the wood splits rather badly. The wood requires some filling before finishing.

Maricao is very susceptible to dry-wood termites and other wood-destroying insects, only slightly resistant to decay, and fairly immune to sap-staining fungi. However, it seems to be more immune than most other local woods to pinhole borers. The wood is not regarded as having any appreciable resistance to marine borers.

Both the heartwood and sapwood of Maricao are recommended for fancy furniture and cabinetwork, turning, flooring, interior trim, and other decorative uses. The wood is also suitable for general carpentry, house framing, and heavy construction. It has been recommended for plywood and veneer.

MASA

Tetragastris balsamifera (Sw.) Kuntze (bursera family, Burseraceae)

Masa is a high-quality wood resembling yellow birch of the United States, and it is suitable for the same uses. The heartwood (fig. 58) is a light reddish brown when first cut, becoming orange brown upon seasoning and exposure. The sapwood is sharply demarcated, white when first cut and later becoming a yellowish brown upon drying and exposure. The grain is irregular to very roey, luster medium, texture uniformly fine, and growth layers indistinct. Seasoned wood is mildly fragrant but has no distinctive taste. The wood is quite heavy, weighing about 48 pounds per cubic foot air-dry and 60 pounds green.

Masa is very easy to air-season, losing its moisture rapidly with only a very minor amount of degrade. Green lumber 1⅛ inches thick seasons to about 17 percent moisture content in less than 4 months under cover in the San Juan area. Degrade occurring during seasoning is limited to very slight bow and twist. Other forms of warp, surface checking, and interior defects did not develop in the Puerto Rican tests.

Masa undergoes moderate shrinkage for a wood of its density and should be reasonably stable in use. Green wood shrinks at the rate of ¼ inch (2.1 percent) per foot in width across the growth rings and ⅖ inch (3.4 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

The wood is moderately easy to saw and machine, producing clean, smooth surfaces in all operations except planing, in which considerable tearing develops in pieces having roey grain. Masa takes both nails and screws poorly unless it is properly prebored; it sands to a smooth surface, and it is reported to polish very well with all types of finishes.

The heartwood is very susceptible to damage by dry-wood termites and marine borers, but it

is generally durable to very durable in contact with the ground. The lumber is seldom discolored by mold during seasoning.

Masa is a hard, compact, tough wood with strength properties commensurate with its high density. It exceeds strong woods like yellow birch and shagbark hickory (*Carya ovata*) in most strength properties, and it is exceptionally strong in resistance to splitting.

The wood has no distinctive figure, but it finishes much like sugar maple and yellow birch and is suitable for many of the same uses as these very popular woods. It is used for high-grade furniture, cabinetwork, paneling, interior construction, and oars. Other recommended uses include millwork, light and heavy construction of all types, house and factory flooring, and outdoor uses where decay resistance is required.

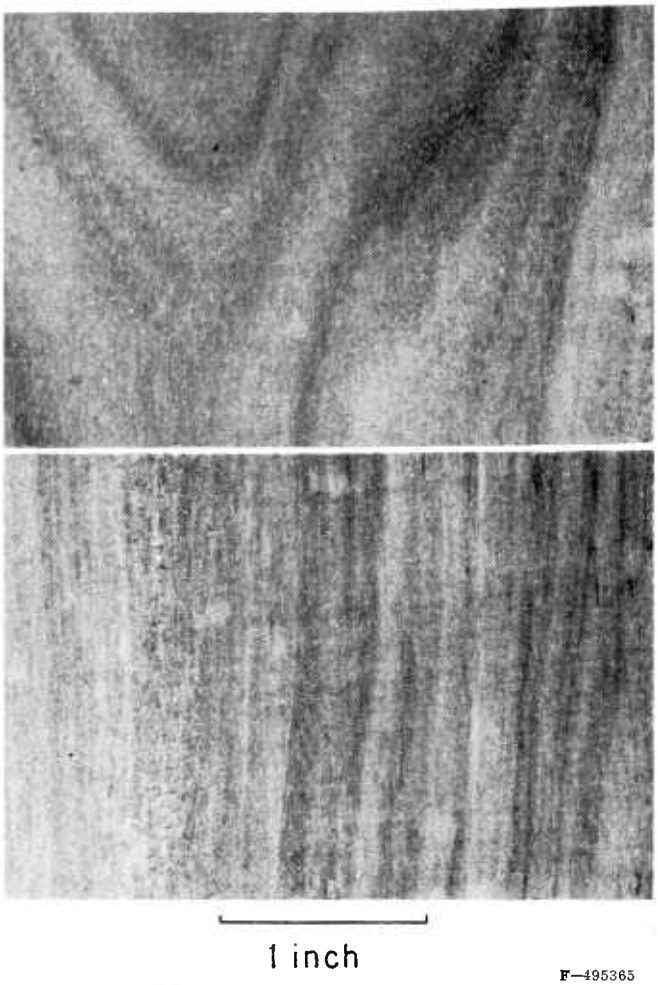

FIGURE 58.—Masa: *Top*, flatsawed; *bottom*, quartersawed.

MOCA (ANGELIN)

Andira inermis (W. Wright) H.B.K. (legume family, Leguminosae)

Moca is a hard, heavy, coarse-textured wood that resembles palm or pitch pine (*Pinus rigida*) in superficial appearance. Other names for the tree and wood are angelin and cabbage angelin. The heartwood (fig. 59) is yellowish brown to dark reddish brown and clearly delineated from the pale-brown to grayish-yellow sapwood. Soft lighter colored tissue appears on the end grain as wavy bands and on flatsawed surfaces as feather-like wavy bands of light-colored tissue. These alternate bands of dark and light fibers give the wood its unusual and decorative appearance. The grain is straight to slightly irregular, and the luster is rather low. Air-dry wood weighs about 47 pounds per cubic foot and green wood 74 pounds per cubic foot.

Moca air-seasons at a moderate rate without serious degrade. Most seasoning defects occur as very slight cup and a moderate amount of bow. Other types of seasoning defects are slight. Green lumber 1⅛ inches thick air-seasons to about 17 percent in 5 months under cover in the San Juan area.

Moca undergoes low to moderate shrinkage during seasoning and is moderately stable after manufacture. Green wood shrinks about 1/6 inch (1.2 percent) per foot in width across the growth rings and 1/3 inch (2.5 percent) per foot along the growth rings in seasoning to an air-dry moisture content of 15 percent.

The wood works easily with both hand and machine tools. Good to excellent surfaces are obtained in all operations except shaping, in which raised and torn grain are common because of the bands of soft parenchyma tissue. A fine, ridgy appearance—raised grain—is also likely to occur in planing when dull knives are used. The wood

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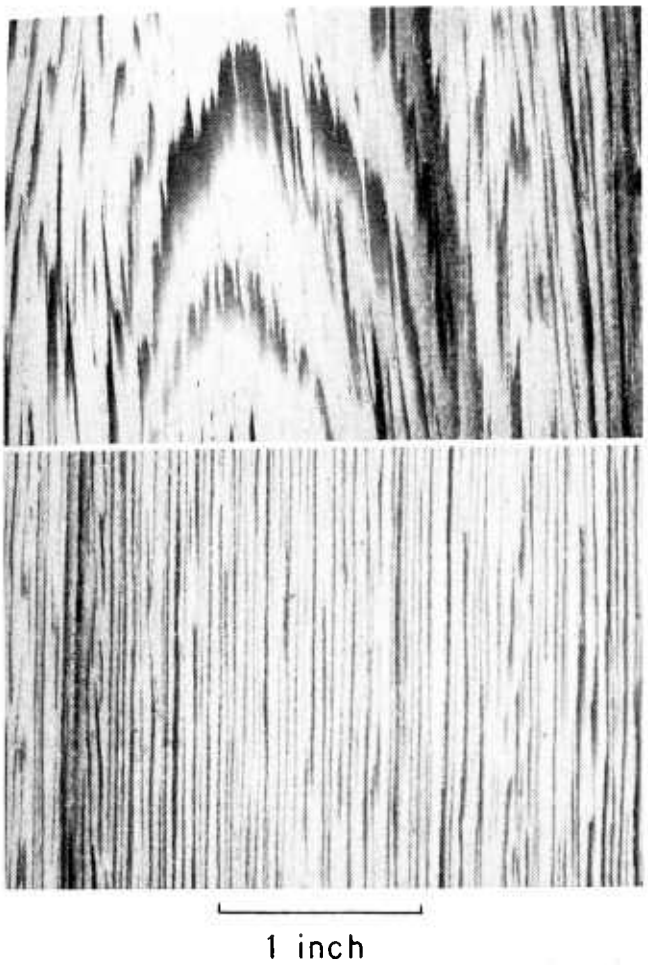

FIGURE 59.—Moca: *Top*, flatsawed; *bottom*, quartersawed.

takes nails well, glues satisfactorily, and finishes well, but lacks luster. Moca compares favorably with woods of similar weight in most strength properties except for a tendency to be somewhat fissile. Some difficulty is encountered in French polishing, because the soft tissue absorbs polish much more readily than the hard tissue.

The sapwood parts of logs and freshly cut lumber are highly susceptible to discoloration by sapstaining fungi. The wood is moderately resistant to attack by dry-wood termites and is durable in contact with the ground. It is also moderately resistant to marine borers but contains no appreciable amount of silica, which is often associated with resistance to this marine animal.

Moca's high figure and attractive coloration causes it to be used extensively for high-grade furniture and cabinetwork and for many fancy turned articles, such as billiard-cue butts, umbrella handles, walking sticks, and police truncheons. The wood has virtually no resonance, making it particularly suitable for radio and television cabinets. It is also utilized in the Caribbean area for heavy construction, bridge timbers, house framing, and sheathing. Its good resistance to decay and dry-wood termites should make it useful for poles, posts, and other similar uses where durability is important.

MOTILLO

Sloanea berteriana Choisy (elaeocarpus family, Elaeocarpaceae)

Motillo (fig. 60) is a very hard, heavy, strong multicolored wood. The heartwood may be grayish, grayish yellow brown, yellowish brown, or a uniform pinkish brown to chocolate brown. Heartwood is usually distinct from the yellowish-colored sapwood. Indistinct darker brown stripes occur at irregular intervals in some specimens.

The wood has medium texture, low luster, irregular grain and it is without distinctive odor or taste. It is not particularly attractive and would be difficult to use for furniture because of its many colors. However, the wood of a uniform brown color would be suitable for many decorative purposes. Air-dry wood weighs 61 pounds per cubic foot and green wood 75 pounds per cubic foot at 51 percent moisture content.

The wood air-seasons moderately well, drying at a moderate rate with a moderate amount of degrade. Green lumber 1⅛ inches thick air-seasons to 16 percent moisture content in 4 to 5 months under cover in the San Juan area. A slight to moderate amount of warp and surface checking occurs during the seasoning process. Shrinkage is moderate and uniform during seasoning. Green wood shrinks about $\frac{3}{10}$ inch (2.4 percent) per foot across the growth rings and $\frac{9}{16}$ inch (4.5 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Motillo works fairly well and produces good to excellent surfaces in all machining operations. But it takes screws and nails poorly, requiring lead holes when screws are used and preboring before nailing.

The wood is moderately resistant to dry-wood termites, rating slightly below Honduras mahogany in this respect. It is probably not durable in the ground nor resistant to marine borers, although definite information is lacking.

While the wood lacks the attractiveness for furniture and cabinetwork, it is sufficiently hard, heavy, and strong for all types of heavy construction, farm implement parts, handles, heavy-duty flooring, boat parts, and piling in areas free of the wood-eating teredos.

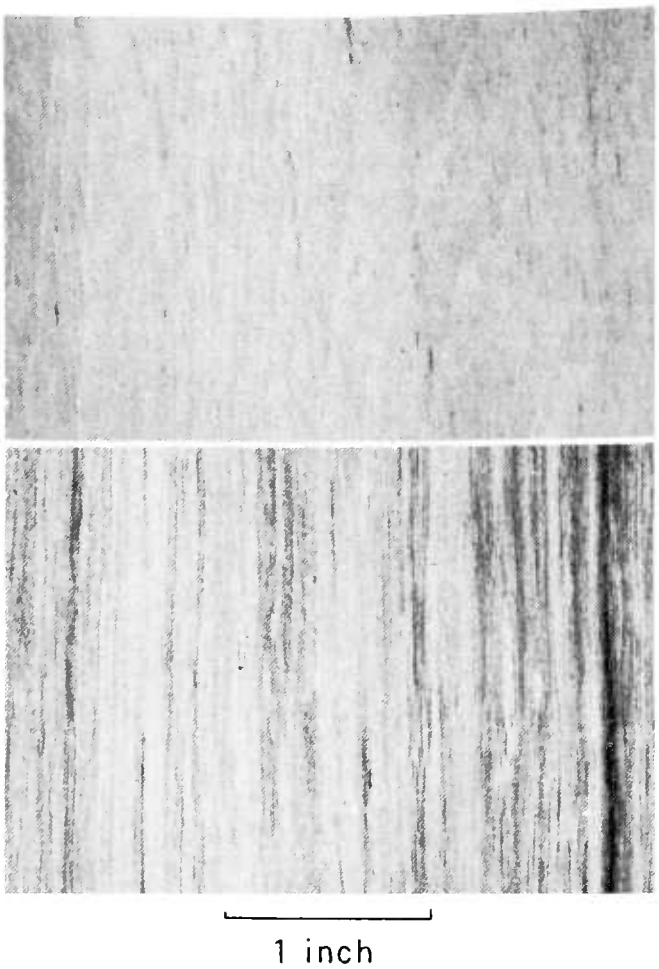

FIGURE 60.—Motillo: *Top*, flatsawed; *bottom*, quartersawed.

NEGRA LORA

Matayba domingensis (DC.) Radlk. (soapberry family, Sapindaceae)

Negra lora is an attractive, very hard, strong wood. The heartwood (fig. 61) is a uniform pinkish brown and not easily distinguished from the lighter colored sapwood. The wood is fine-textured and moderately lustrous. It has a distinctive foul odor. The grain is usually irregular and interlocked. Growth rings are not easily distinguished. It is a heavy wood, weighing 54 pounds per cubic foot air-dry and 72 pounds in the green condition.

The wood seasons slowly but fairly well. Green 1⅛-inch lumber air-dries to 19 percent moisture content in about 7 months under cover in the San Juan area. Slight cup, bow, and crook, and moderate twist, surface checking, and end defects develop during the slow seasoning process.

Shrinkage is uniform but greater than the average for woods of similar density. Green wood shrinks ⅓ inch (2.7 percent) per foot in width across the growth rings and 9/16 inch (4.8 percent) per foot along the growth rings in seasoning to the air-dry condition. Sap-staining fungi are seldom a problem in seasoning this wood.

Negra lora is moderately difficult to saw and machine and has an appreciable dulling effect on cutting edges. Machined surfaces are of good quality in all operations except planing, in which the irregular grain causes considerable coarse fuzziness and tearing. Despite its roey grain, negra lora splits rather easily when screws are driven. It should glue well and take all stains and polishes satisfactorily. The wood is very susceptible

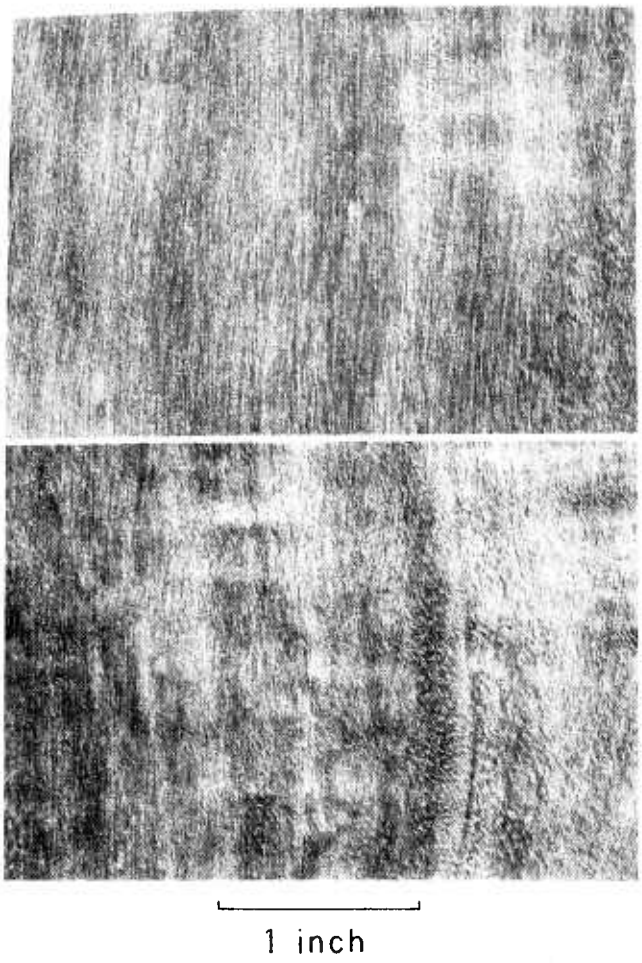

FIGURE 61.—Negra lora: *Top*, flatsawed; *bottom*, quartersawed.

to damage by dry-wood termintes and other insects.

Negra lora is well suited for furniture, cabinetwork, turnery, interior trim, flooring, and other products which require an attractive wood that works well but that need not be durable. The wood should also be useful for handles, agricultural implements, cartwrights' work of all types, cart and vehicle bodies, and other uses where its hardness and strength are a consideration. It would also be suitable for both light and heavy construction of all types where durability is not a factor and, after preservative treatment, for posts and poles.

NEMOCÁ

Ocotea spathulata Mez (laurel family, Lauraceae)

Nemocá is characterized by an unusual array of coloration and figure and is easily the most unusual and perhaps the most attractively figured commercial wood that grows in Puerto Rico (fig. 62). Color of the heartwood may be light pinkish brown, yellowish brown, or greenish brown, interspersed with areas of dark brown to black stripes, scratches, spots, or wavy irregular lines. This intermingling of darker and lighter areas is so complete that no two pieces of heartwood are exactly alike.

The clearly defined sapwood varies from a yellowish brown on the outer edge to a pinkish brown towards the interior; it lacks the dark markings and variegated characteristics of the heartwood. The wood has fine texture, medium luster, and generally interlocked grain. Growth rings are not distinct. The wood has no odor or taste. Nemocá is hard, heavy, and strong, weighing 47 pounds per cubic foot when air-dry and 62 pounds green.

The wood is moderately difficult to air-season. Green lumber air-seasons at a moderate rate, reaching 17 percent moisture content in 5 to 6 months under cover in the San Juan area. Moderate degrade occurs during drying in the form of very slight cup and surface checking, slight to moderate twist, and moderate bow and crook. Degrade is more severe in the darkest colored wood coming from the heart of the tree. Shrinkage, particularly for a wood of nemocá's density, is moderate and fairly uniform. Green wood shrinks at the rate of $\frac{2}{10}$ inch (1.8 percent) per foot in width across the growth rings and $\frac{4}{10}$ inch (3.4 percent) per foot along the growth

rings in drying to 15 percent moisture content.

Nemocá is moderately difficult to work because of its hardness and interlocked grain, but it gives good to excellent results in all machining properties except planing, in which there is considerable pickup and tearing. The roey grain, which is responsible for the difficulty in planing is, however, what gives the wood good resistance to screw splitting. Nemocá can be sanded to a very smooth surface; it will take all types of finishes and polishes satisfactorily.

Certain other species of *Ocotea* are highly resistant to insects and decay, but on the basis of recent tests nemocá is very susceptible to dry-wood termites. Its durability in the ground and in teredo-infested waters is unknown. Pinhole borers are not a serious problem in the logs, and sap-staining fungi are not troublesome during seasoning.

The heartwood possesses the attractiveness, good working properties, and favorable technical properties for furniture, cabinetmaking, paneling, turnery, boat planking, farm implements, handles, heavy construction of all types, bridge building, and piling in nonteredo areas. The rather wide uniform-colored sapwood could be used for flooring, interior trim, millwork, and other products for which a light-colored uniform wood is preferred. The heavily variegated wood should make unusually attractive turnings and novelty items.

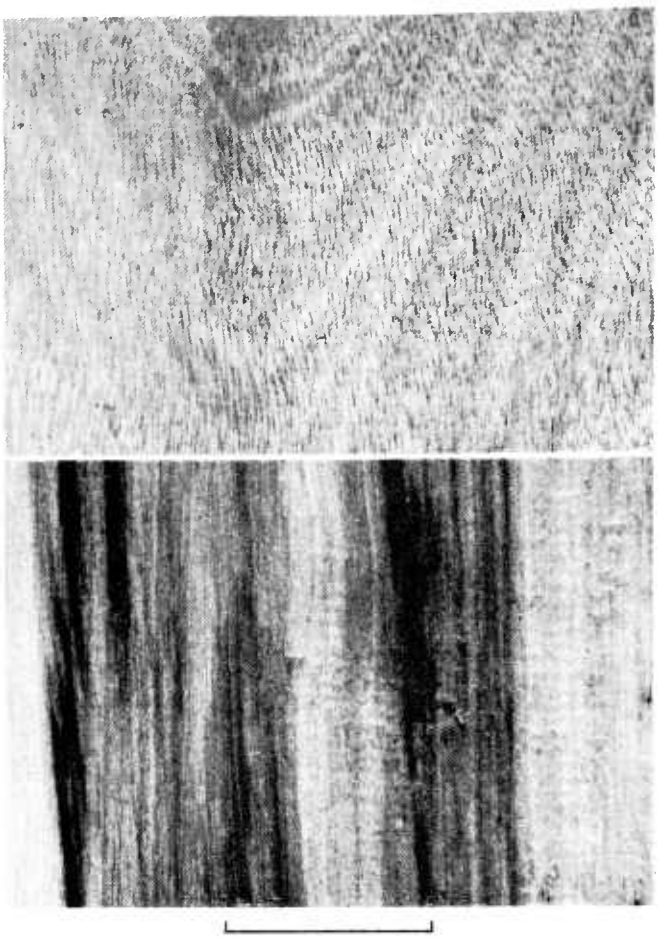

FIGURE 62.—Nemocá: *Top*, flatsawed; *bottom*, quartersawed.

NUEZ MOSCADA

Ocotea moschata (Meisn.) Mez (laurel family, Lauraceae)

Nuez moscada logs are of medium to large size, good length, and exceptionally free from knots and other defects. The wood (fig. 63) resembles nemocá in general appearance and density. The heartwood is extremely variable in color and figuration, ranging from a medium brown to dark brown with irregular darker brown to black streaks or patches. The sapwood is yellowish to light brown and fairly distinct from the heartwood. The unusual appearance of the heartwood gives the wood an attractiveness that should make it highly acceptable for certain decorative purposes.

The wood has medium to fine texture, interlocked grain, medium luster, and is without distinctive odor or taste when dry. Growth rings are distinct. Air-dry wood weighs about 44 pounds per cubic foot and green wood 60 pounds per cubic foot.

Nuez moscada air-seasons satisfactorily. Green 1⅛-inch lumber dries rapidly under cover in the San Juan area, reaching 18 percent moisture content in about 4 months after piling. A small amount of warping develops during seasoning, but no surface checking. The heavy, dark-colored wood from the center of the tree appears to be most susceptible to degrade.

Shrinkage is moderate and uniform during seasoning, but after manufacture the wood tends to twist if not held securely in place. Green wood shrinks at the rate of $\frac{7}{32}$ inch (1.8 percent) per foot in width across the growth rings and $\frac{3}{8}$ inch (3.1 percent) per foot along the growth rings in seasoning to 15 percent moisture content.

Nuez moscada is moderately easy to saw and machine, with good to excellent results in all operations except planing, in which considerable pickup occurs because of interlocked grain. It takes

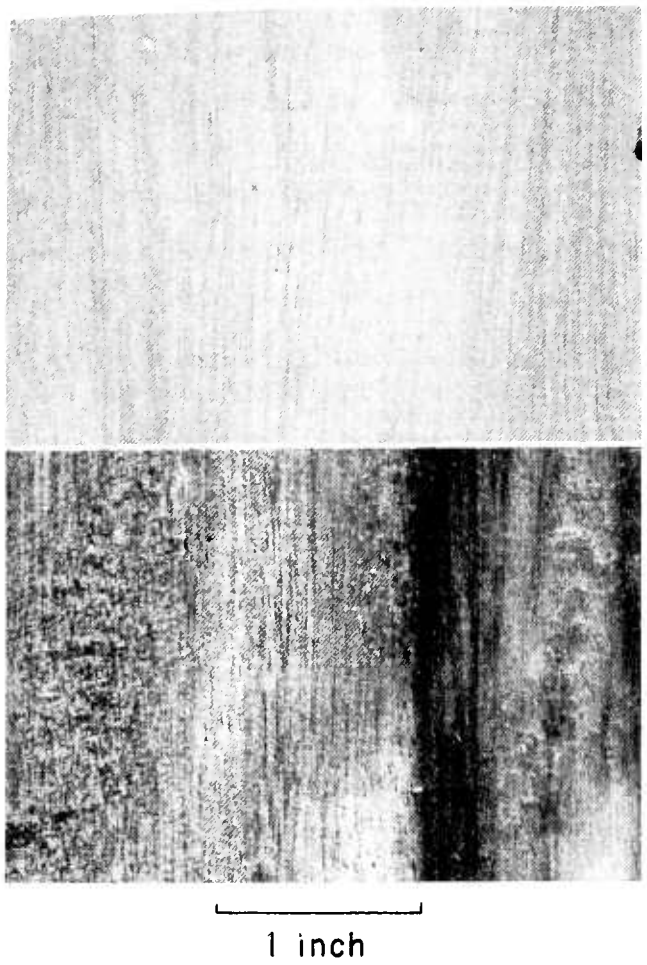

FIGURE 63.—Nuez moscada: *Top*, flatsawed; *bottom*, quartersawed.

screws and nails well without splitting, sands to a smooth, even surface, and can be painted or varnished satisfactorily without the need of fillers.

Dry-wood termites readily attack this wood, and it is presumably very susceptible to other insects, decay-causing fungi, and marine borers. Sap-staining fungi are not troublesome during seasoning or in the logs.

Nuez moscada is recommended for turning, furniture, cabinetmaking, novelty items, and other uses requiring an attractive wood that has good strength and satisfactory working qualities. It should also be satisfactory for both light and heavy construction, bridge timbers, heavy crating, and packing boxes. The highly figured heartwood should be acceptable for interior trim, paneling, and similar products where an unusual and highly figured wood is desired. Wood that is uniform in color may be useful for the same purposes and possibly for flooring.

PALO COLORADO

Cyrilla racemiflora L. (cyrilla family, Cyrillaceae)

The huge, centuries-old palo colorado trees of the upper mountain rain forests provide a limited volume of short but exceedingly large and generally hollow logs. The hollow trees are favorite nesting places of the native Puerto Rican parrot. The wood is very attractive but develops exceedingly severe degrade during seasoning, which limits its utility as a commercial wood. The most common English name for this wood is swamp cyrilla.

Seasoned heartwood (fig. 64) is an attractive dark reddish brown, with the most deeply colored specimens being somewhat oily. The sapwood is lighter brown and not clearly demarcated from the heartwood. The wood has fine and uniform texture, heavily interlocked grain, and moderate to low luster. Growth rings, which are formed annually, are distinct. Distinctive odor and taste are lacking in seasoned wood. On the basis of rough determinations, air-dry wood weighs about 59 pounds per cubic foot and green wood 72 pounds per cubic foot at 118 percent moisture content.

Palo colorado seasons very slowly and undergoes exceptionally severe degrade. In the San Juan area, green lumber 1⅛ inches thick requires 10 months or longer under cover to reach an air-dry moisture content of 19 percent. Even with slow seasoning, exceedingly severe warp, surface checking, end splitting, casehardening, collapse, and honey combing develop in each piece during the process. Degrade is so severe that air-dry lumber is unfit for most commercial uses.

The wood also undergoes exceptionally high shrinkage during seasoning. Measurements made on a large number of severely distorted samples indicate that green lumber shrinks $\frac{6}{10}$ inch (5.0 percent) per foot in width across the annual rings

and 1¼ inches (10.3 percent) per foot in width parallel to the annual rings in drying to 15 percent moisture content. Its longitudinal shrinkage of 0.31 percent is also unusually high, even for a wood with interlocked grain, which is an indication of poor seasoning.

Palo colorado is relatively easy to saw and machine unless severe casehardening or other internal defects are present. Except for scratches that show in sanding unless fine abrasive paper is used, the wood gives good to excellent results in all machining properties. It is also very resistant to screw splitting, because of its fine and tightly interlocked grain. Machined surfaces are glossy smooth, and the darker pieces often have a somewhat waxy or oily feel.

Palo colorado is very susceptible to dry-wood termites and presumably other insects. It is considered durable in the ground, although specific data are lacking. Because of the wood's extremely poor seasoning characteristics and its heavy and uneven shrinkage, its most satisfactory use is in the green condition, and then only in submerged places or other locations where drying will not take place. This includes such uses as submerged or buried piling, underwater parts of docks and wharves, posts, and heavy construction on or beneath the ground. However, if some satisfactory seasoning method could be found, this species would be useful for many purposes requiring a decorative wood that has good machining characteristics.

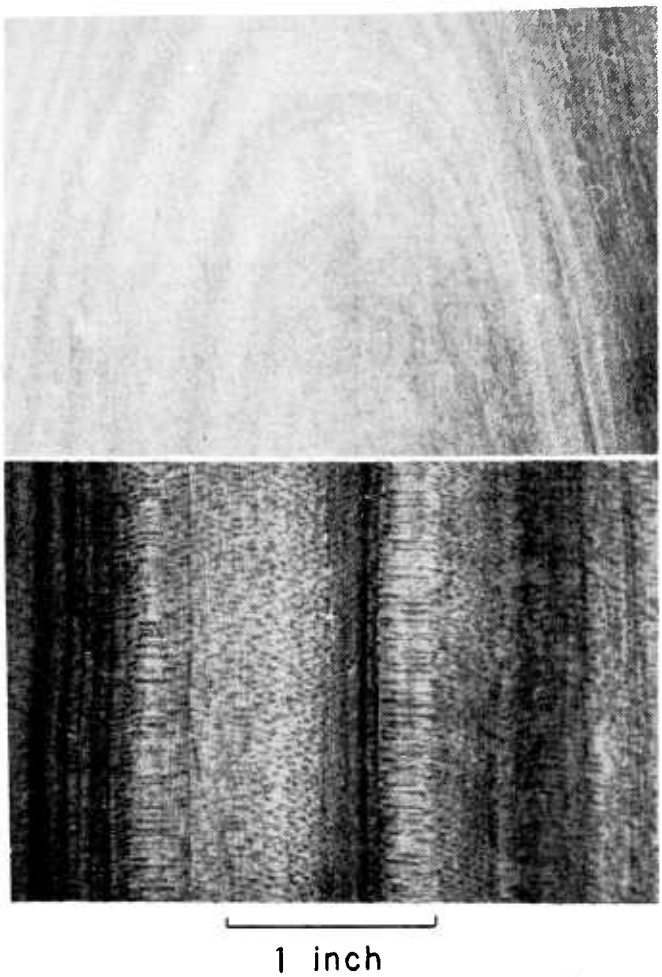

FIGURE 64.—Palo colorado: *Top*, flatsawed; *bottom*, quartersawed.

PALO DE HUESO

Haenianthus salicifolius Griseb. (olive family, Oleaceae)

Palo de hueso (formerly known as *Haenianthus obovatus* Krug & Urban) belongs to a small genus of two or three species limited to the Greater Antilles of the Caribbean area. It is an extremely hard, heavy, strong wood, and somewhat bizarre in appearance (fig. 65).

The heartwood is golden brown to chocolate brown, with wide alternate light and dark colored stripes showing on quartersawed surfaces. The sapwood is lighter in color and merges gradually into the heartwood. The wood has fine texture, fairly high luster, and usually interlocked grain. Growth rings are not distinct. Seasoned wood has no characteristic odor or taste. Air-dry wood weighs 61 pounds per cubic foot and green wood about 77 pounds per cubic foot at 52 percent moisture content.

The wood seasons at a moderate rate. Green lumber air-dries to about 17 percent moisture content in 6 months under cover in the San Juan area. Very slight cup and crook, slight twist, and moderate bow occur during the air-seasoning process. A minor amount of surface and end checking also develops.

Palo de hueso undergoes moderate and unusually uniform shrinkage during seasoning for a wood of its density. The shrinkage of ¼ inch (2.2 percent) per foot in width across the growth rings and ⅞ inch (3.5 percent) per foot in width parallel to the growth rings in seasoning from green to air-dry is considerably below the values for many other commercial woods of similar density. Its longitudinal shrinkage of 0.096 percent is also nominal for a wood having interlocked grain.

Palo de hueso is rather difficult to work because of its density and hardness. Results in the different machining operations vary. The wood is difficult to plane; frequent long, continuous strips of torn fibers and coarse fuzziness develop in many

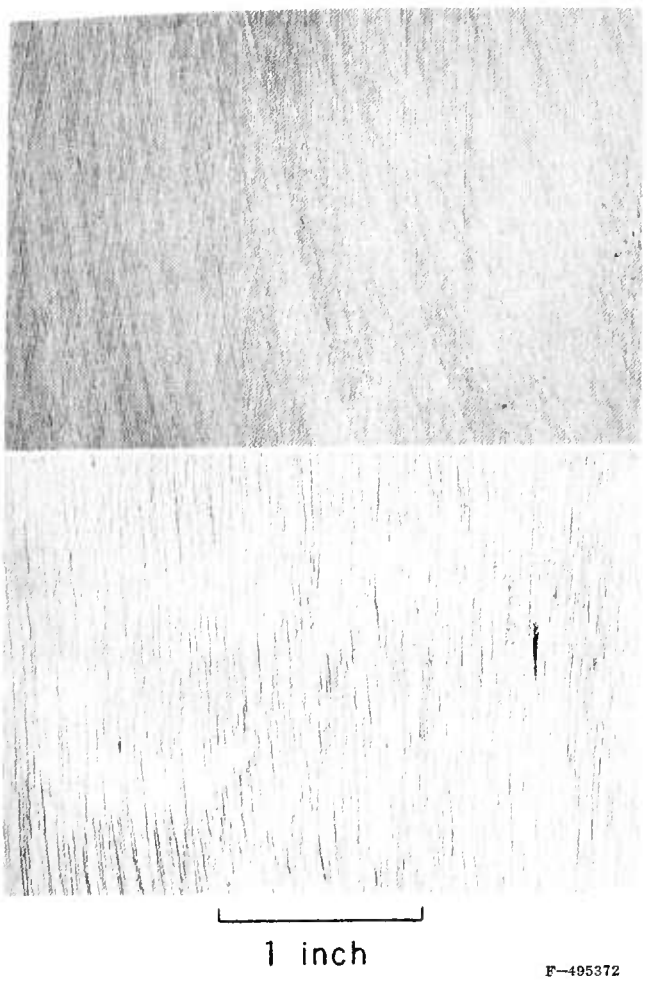

FIGURE 65.—Palo de hueso: *Top*, flatsawed; *bottom*, quartersawed.

pieces. The presence of tension wood and its gelatinous fibers, much like the condition found in Honduras mahogany, accounts for the difficulty in planing. For the same reason, the wood gives only fair results in shaping, but it is a good turning wood, and produces excellent results in boring and mortising. It is a fairly good wood to sand and has fair resistance to screw splitting. Wherever defects are not present, the machined surfaces are exceptionally smooth and can be sanded to a glass-like finish.

Dry-wood termites attack and destroy palo de hueso without difficulty, and pinhole borers attack the sapwood of logs but are not apt to damage the heartwood. Neither logs nor freshly cut lumber are subject to discoloration by sap-staining fungi. Judging from closely related species, the wood probably is fairly resistant to decay in the ground.

Palo de hueso is well suited for uses where an exceptionally heavy, strong, hard wood is required. It should be most suitable for turnings, novelty items, handles, machine parts, heavy construction, boat frames, heavy-duty flooring, work benches, bridge timbers, and piling in nonteredo areas. It is not particularly good for furniture and cabinetwork because of its heaviness, poor working qualities, and rather unattractive appearance.

PALO DE MATOS

Ormosia krugii Urban (legume family, Leguminosae)

Palo de matos is a medium-weight, somewhat coarse-textured wood. The heartwood (fig. 66) is a uniform salmon color with occasional darker colored streaks, and it is not distinct from the yellowish sapwood. Unfinished wood has moderate luster, and feels somewhat coarse or rough to the touch. The wood has moderately coarse texture, generally coarse and irregular grain, indistinct growth rings, and is without distinctive odor and taste. Large open pores that occur in rows, groups, and singly are visible to the naked eye on the end grain. Air-dry wood weighs 37 pounds per cubic foot and green wood 70 pounds at 124 percent moisture content.

The wood air-seasoned slowly, requiring about 6 months to reach an air-dry moisture content of 16 percent in the San Juan area. Seasoning is accompanied by moderate degrade in the form of moderate bow, slight cup and twist, and very slight crook, surface checking, and end splitting. Directional shrinkage is moderate but relatively uneven. Green wood shrinks at the rate of 1/8 inch (1.1 percent) per foot in width across the growth rings and 3/8 inch (3.0 percent) per foot parallel to the growth rings in seasoning to 15 percent moisture content.

Palo de matos saws and works easily in machining operations, with fair to good results. Although the wood is rated good in planing, shaping, and sanding on the basis of smoothness of cut, the machined surfaces are somewhat rough and difficult to finish. It is only a fair wood to turn, bore, and mortise because of its tendency to tear and crush in these operations. It has good resistance to screw splitting and probably takes and holds nails well. It finishes and polishes satisfactorily

but requires considerable sanding and the use of a filter before application of varnish or other finishes.

The wood is very susceptible to damage by dry-wood termites, and it probably is also quite susceptible to decay and marine borers. Sap-staining fungi are not particularly troublesome during seasoning.

On the basis of limited tests of a closely related species growing in Brazil, palo de matos is considered fairly strong, hard, and tough for its density and may possess good bending properties. The Puerto Rican species is quite attractive after finishing and should be suitable for furniture, millwork, interior and exterior construction, boxes, crates, concrete work, general carpentry, and possibly for bent items and utility veneer.

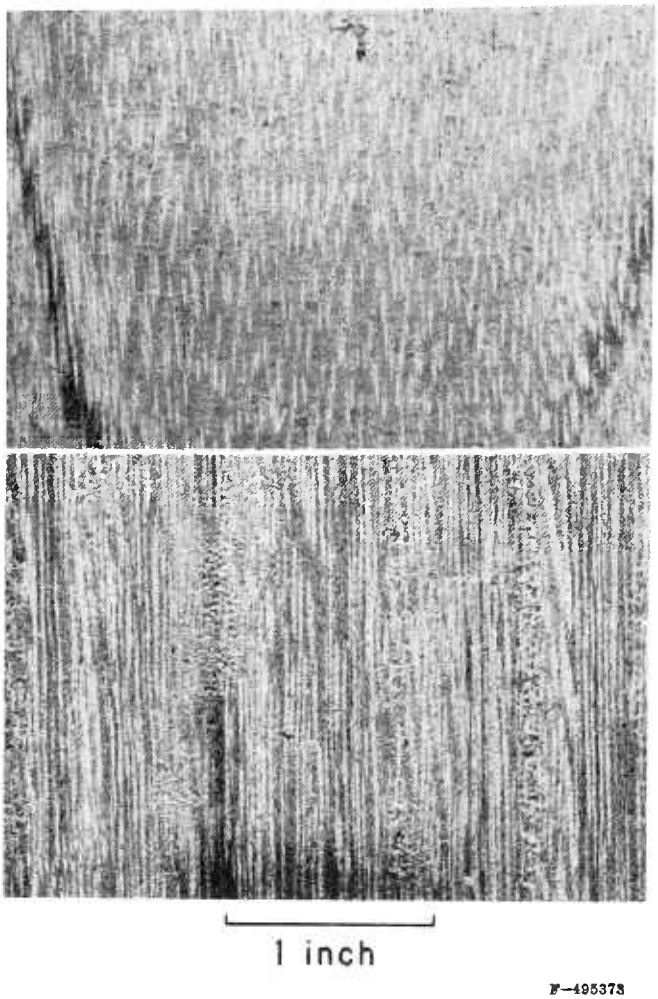

FIGURE 66.—Palo de matos: *Top*, flatsawed; *bottom*, quartersawed.

PANAPÉN

Artocarpus altilis (Parkinson) Fosberg (mulberry family, Moraceae)

Panapén, or breadfruit, is a very soft, lightweight wood, yet quite firm and strong for its weight. The seasoned heartwood (fig. 67) is golden colored, sometimes flecked with orange, and clearly distinguished from the light-yellow to yellowish-brown sapwood. Numerous large, open pores are visible on the end grain and show on the side surfaces as closely spaced lines or scratches, giving the wood a coarse, uneven appearance. Although the wood's luster is low, well-sanded surfaces are fairly smooth, resembling oak in texture, and they are quite attractive because of their pleasing golden color. The grain is irregular and at times interlocked. Growth rings are not apparent. There is no characteristic odor or taste.

Air-dry wood weighs 20 pounds per cubic foot. The amount of moisture in green wood increases from the sapwood towards the center of the tree. Material averaging 124 percent moisture content in the Puerto Rican tests weighed 38 pounds per cubic foot.

The high moisture content of the green wood makes it moderately difficult to season. Freshly cut wood air-seasons at a moderate rate, reaching 19 percent moisture content in 5 months under cover in the San Juan area. Well-seasoned material frequently contains pockets of moisture well above the moisture content of the surrounding wood. A moderate amount of warping occurs during air-drying, but no noticeable surface or end checking. Shrinkage is moderate and somewhat uneven. Green wood shrinks at the rate of $\frac{1}{8}$ inch (1.0 percent) per foot in width across the grain and $\frac{1}{3}$ inch (2.7 percent) per foot parallel to the grain in drying to 15 percent moisture content.

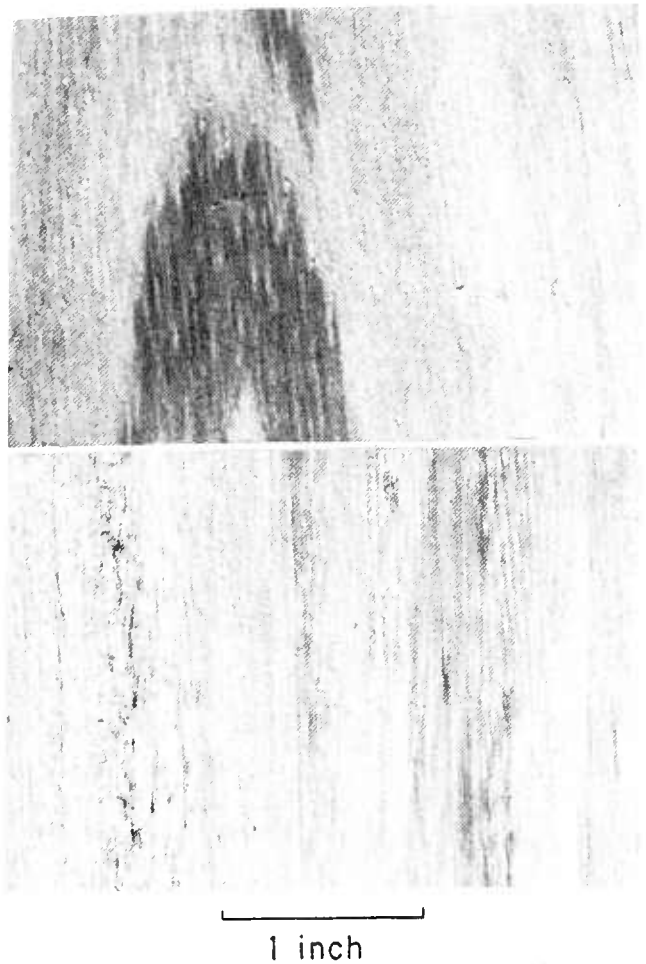

FIGURE 67.—Panapén: *Top*, flatsawed; *bottom*, quartersawed.

Panapén works easily with either power or hand tools, but with generally poor results. Sawed surfaces are inclined to be fuzzy, particularly in ripping, although seasoned wood saws more easily and with less fuzziness than green wood. In the Puerto Rican tests, panapén gave only fair results in planing, because of frequent torn grain and fuzzy surfaces; poor results in sanding because of the visible scratches and fuzziness that occur; and very poor results in shaping, turning, boring, and mortising because of the extreme ease with which the wood crushes, tears, and fuzzes in these operations. However, with special care and using thin cutting edges and reduced spindle speed, the wood should work satisfactorily. Moisture pockets probably are responsible for some of the machining defects.

Panapén's resistance to attack by dry-wood termites is very low. It probably is also very susceptible to decay and to attack by marine borers. Logs should be removed from the forest soon after felling to avoid damage by pinhole borers and sapstain. Fungi will also quickly discolor the sapwood of lumber unless it is either surface-dried immediately after sawing or treated with a fungicide.

The wood lacks the strength, hardness, and attractiveness necessary for cabinetmaking, furniture, and similar uses. However, it is suitable for boxes, crates, interior sheathing, light construction, toys, and similar products. After preservative treatment, the wood could be used for sheathing, siding, and other exterior uses for which a light, easily nailed wood of moderate strength is acceptable. It might also be suitable as a substitute for the heavier grades of guano (balsa) if special techniques were developed to improve its machining characteristics.

ROBLE BLANCO (ROBLE)

Tabebuia heterophylla (DC.) Britton (trumpet-creeper family, Bignoniaceae)

This wood is called roble blanco, or roble, meaning oak and white oak in Spanish, because of its superficial resemblance (fig. 68) to plainsawed oak, although the wood lacks the characteristic wide rays of the oak group.

The heartwood is light brown with a grayish or somewhat golden hue. Fine lines of brown-colored parenchyma provide the wood with a distinctive and characteristic figure on quartersawed surfaces and an attractive featherlike pattern on flatsawed surfaces. The sapwood is so similar in color to the heartwood that it is very difficult to separate the two.

The grain is straight to interlocked, with a distinct ribbon stripe showing on quartersawed surfaces where interlocked grain is present. The texture is medium to coarse, the luster is low to medium, and no distinct odor or taste is apparent in seasoned wood. The wood is comparatively heavy, weighing 42 pounds air-dry and 59 pounds green.

Roble blanco is a fairly easy wood to season. Green wood air-seasons rapidly with only moderate bow and very slight twist. Other forms of warp and surface checking were not evident in the Puerto Rican tests. Green 1⅛-inch lumber reaches an air-dry moisture content of about 17 percent in 4 months or less under cover in the San Juan area. The wood is also reported to kiln-dry with little degrade. Sap-staining fungi are not apt to be troublesome during seasoning.

The wood undergoes moderate and unusually uniform shrinkage during seasoning. Green

wood shrinks at the rate of 1/8 inch (1.2 percent) per foot in width across the growth rings and 3/16 inch (1.6 percent) per foot parallel to the growth rings in seasoning to 15 percent moisture content. Its longtitudinal shrinkage of 0.18 percent is normal for a wood with interlocked grain.

Roble blanco saws and machines easily with very satisfactory results in all operations except planing, in which the interlocked grain causes considerable pickup. It has fair resistance to screw splitting, takes nails fairly well, and glues easily. The wood accepts mahogany and oak stains satisfactorily or can be finished naturally with excellent results. A high polish can be obtained with all types of finishes.

Roble blanco is considered an excellent wood for veneer, but it requires careful and thorough boiling before slicing or turning. Considerable care must also be taken to avoid torn and rough surfaces during the veneering process. Quartercut veneers have an exceptionally attractive mottled figure, dry evenly to a flat, smooth surface, and possess good gluing properties.

The wood is tough and strong for its weight. It is similar to white oak and ash in all mechanical properties, particularly in stiffness, hardness, shear, cleavage, and shock resistance.

Roble blanco is moderately durable in contact with the ground, but it is very susceptible to attack by termites and marine borers. It is rated only fair in weathering characteristics; the unpainted wood loses its smooth surface and develops considerable checking upon exposure to weather, though it does remain free from warp.

In general, roble blanco is suitable for the same uses as white oak and ash. Because of its good working properties and attractiveness, the wood is used extensively for furniture, cabinetwork, interior trim, and face veneer. It is also well suited for use as flooring, millwork, boat decking, frames and planking, handles of all types, sporting goods, agricultural implements, and both light and heavy construction. The lower and less valuable grades are suitable for boxes, crates, concrete forms, and similar items. Roble blanco's moderate durability in the soil results in a limited use for posts, poles, and other products where durability is a factor.

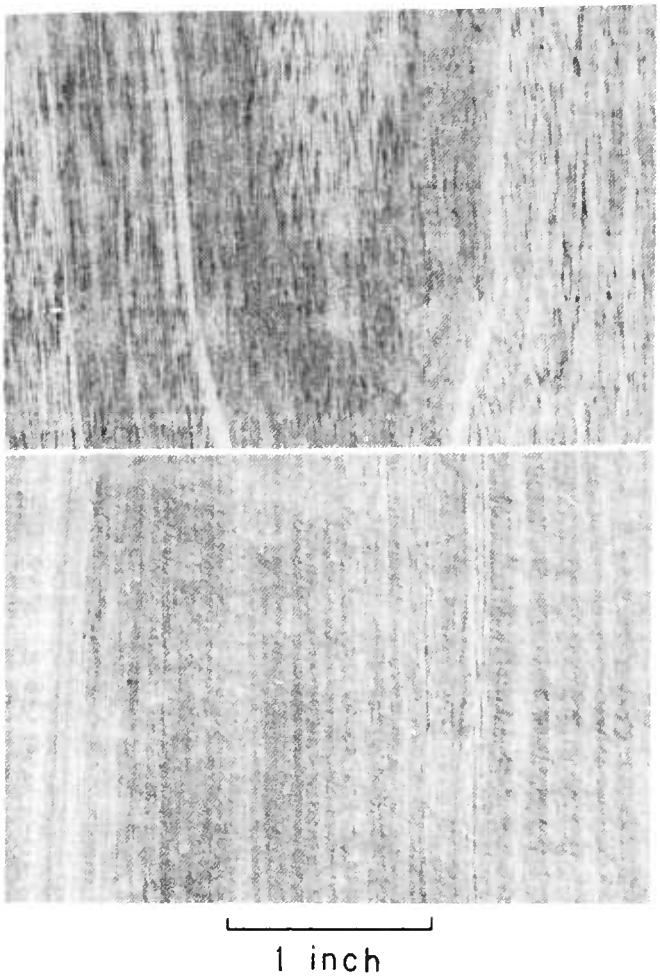

FIGURE 68.—Roble blanco: *Top*, flatsawed; *bottom*, quartersawed.

SAMÁN

Pithecellobium saman (Jacq.) Benth. (legume family, Leguminosae)

Samán is a moderately attractive wood that has some favorable characteristics, but it is often valued more as an ornamental than for its wood. The tree is often known as the rain-tree. It is not native to Puerto Rico but has become widely naturalized after extensive planting over many decades.

Freshly cut samán heartwood (fig. 69) is a dark chocolate brown and distinct from the yellow to light-cinnamon colored sapwood. Dry heartwood is light to golden brown with darker streaks, resembling butternut (*Juglans cinerea*) of the United States. The grain may be either straight or irregular; wood from slow-growing trees tends to be more cross grained and have a darker color than that from fast-growing trees. The texture is medium to coarse, the luster is medium, and there is no distinctive odor or taste. Samán is soft and light, weighing 33 pounds when air-dry and 68 pounds when green at 145 percent moisture content.

Because of the wood's very high moisture content, about 6 months is required to air-dry green wood to 17 percent moisture content in the San

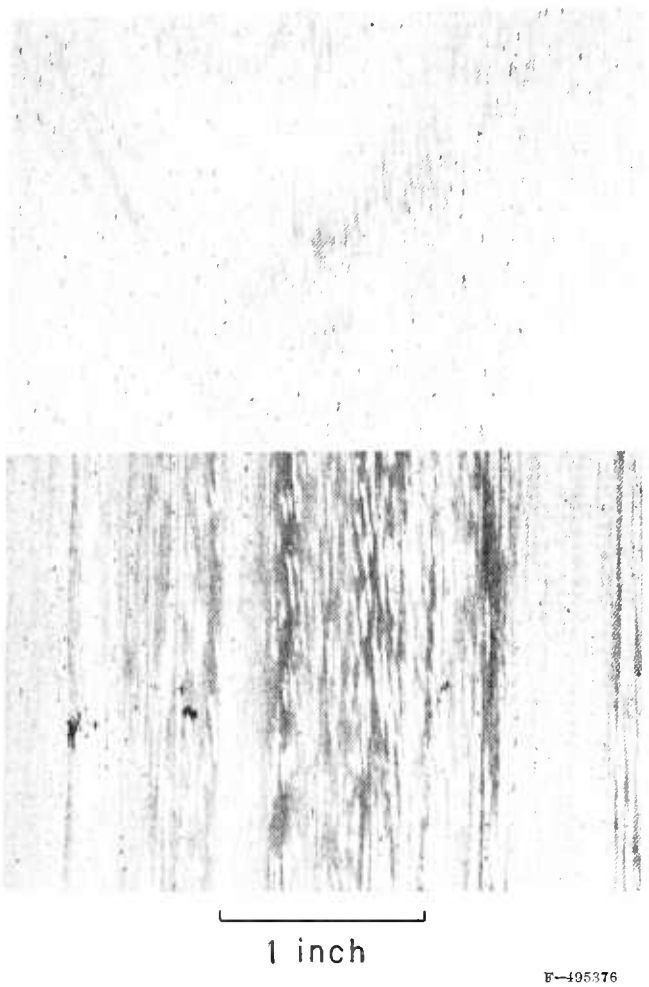

FIGURE 69.—Samán: *Top*, flatsawed; *bottom*, quartersawed.

Juan area. It also seasons rather poorly, with considerable degrade: moderate to severe bow and crook, slight twist, and very slight cup. But surface checking or end splitting were not observed in the Puerto Rican tests. Sap-staining fungi may also develop on freshly sawed wood.

Samán undergoes uniform and exceptionally low shrinkage during seasoning. Green wood shrinks $\frac{1}{10}$ inch (0.7 percent) across the grain and $\frac{1}{6}$ inch (1.2 percent) along the grain per foot in width in drying to an air-dry moisture content of 15 percent.

This wood saws and machines easily but usually develops torn grain and fuzziness in pieces containing irregular grain. In the tests, samán was rated poor in turning, fair in shaping and boring, and moderately good in planing, mortising, sanding, and screw splitting. It would probably machine satisfactorily with special handling and the use of more suitable machining techniques. Well-prepared material glues satisfactorily and takes an excellent finish with lacquer or varnish.

Samán is rated durable to very durable in respect to decay and is resistant to attack by dry-wood termites, rating well above Mexican mahogany and slightly above teak in this respect.

Though the tree is valued mainly for its beauty and shade and to some extent for its sweet pods, which make excellent cattle feed, the lumber possesses an attractive grain and color. It is suitable for some types of furniture and cabinetwork, and for light construction, boxes and crates, house framing, and millwork. Samán's good resistance to decay and insects makes it suitable for special uses where these qualities are important. Its light weight and low, even shrinkage may also make it suitable for patternmaking. It has been recommended for decorative veneer and plywood, interior trim, and paneling.

TABAIBA

Sapium laurocerasus Desf. (spurge family, Euphorbiaceae)

Tabaiba, or manzanillo (fig. 70), is a soft, lightweight wood of uniform pale-brown color throughout. The texture is rather fine except for the fairly numerous large pores, which are visible to the naked eye on the end grain and appear as fine scratches or stipple marks on flatsawed surfaces. The grain is sometimes straight, more frequently tightly interlocked. The luster is medium. Growth rings are not visible, and characteristic odor and taste are not evident in seasoned wood. Air-dry wood weighs 28 pounds per cubic foot and green wood 46 pounds at 96 percent moisture content.

The wood is moderately difficult to season. Green lumber $1\frac{1}{8}$ inches thick air-seasons to about 17 percent moisture content in 6 months under cover in the San Juan area. A small amount of degrade occurs in the form of very slight twist and crook, slight cup, moderate bow, and slight surface checking. No end checking or casehardening were noted in the study. Green wood shrinks about $\frac{1}{16}$ inch (0.6 percent) per foot in width across the grain and $\frac{7}{32}$ inch (1.8 percent) per foot along the grain in drying to 15 percent moisture content. Sap-staining fungi are almost certain to discolor freshly cut wood unless it is immediately immersed in a fungicide or allowed to become surface-dry soon after conversion.

Tabaiba saws and works easily with either hand or power tools, with results varying from excellent in planing to very poor in sanding. Sawed

surfaces tend to be woolly, especially along the grain. Frequent tearing, crushing, and fuzziness occur in all cutting operations except planing, with fair to poor surfaces resulting under conventional machining conditions. Better results could no doubt be attained if more favorable machining conditions were used particularly thin-edged knives and saws and reduced spindle speeds.

The wood shows scratches readily in sanding but works to a very smooth surface when fine abrasive paper is used. It has good resistance to screw splitting. Gluing, staining, and polishing should not be troublesome with well-sanded material.

Dry-wood termites and other insects, decay-causing fungi, and marine borers attack and quickly damage this wood, thereby resistricting it to uses where good durability is not essential. Tabaiba is recommended for boxes, crates, interior construction, and other uses requiring a light, soft, moderately strong wood. The wood has been recommended for paper pulp and plywood and, after preservative treatment, should be suitable for siding and other exterior uses.

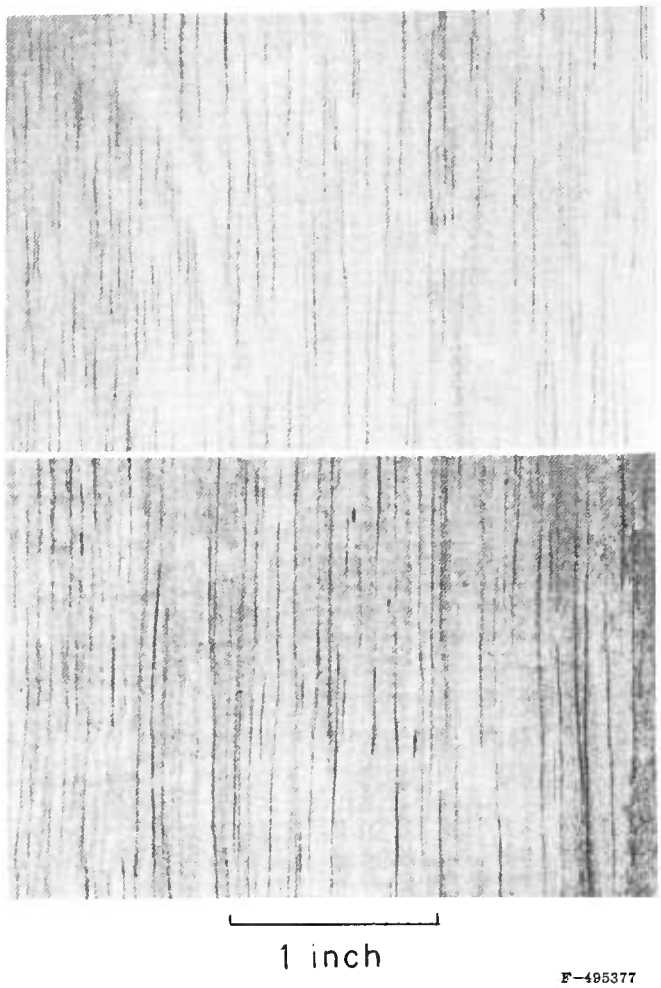

FIGURE 70.—Tabaiba: *Top*, flatsawed; *bottom*, quartersawed.

TABONUCO (GOMMIER)

Dacroydes excelsa Vahl (bursera family, Burseraceae)

Tabonuco, occasionally called candlewood, is the best known and most extensively used wood in the Puerto Rican forests. It is one of the most plentiful timber species on the island. Long, clear logs of large diameter are harvested from centuries-old, hurricane-resistant trees in the rain forests.

The heartwood (fig. 71) is a uniform brown color with an overall pinkish cast when first cut, turning a pinkish brown when seasoned and later a lustrous brown when exposed. The narrow, indistinct sapwood is an attractive grayish color. The texture is fine to medium, and uniform. The grain is more or less roey and commonly interlocked, creating an attractive ribbon stripe on the side surfaces. The luster is high, sometimes satiny in appearance. Growth rings are not distinct. There is no distinctive odor or taste in seasoned wood.

The wood is moderately heavy, weighing 40 pounds per cubic foot air-dry and 52 pounds green. It is appreciably heavier than Mexican mahogany but somewhat lighter than yellow birch, which it resembles superficially.

Tabonuco air-seasons easily and satisfactorily. Green wood 1⅛ inches thick air-dries rapidly with only minor degrade in the form of very slight cup, slight bow, twist, and end checking, and with no apparent surface checking or case-hardening. Green lumber will air-season to about 17 percent moisture content in 4 months under cover in the San Juan area.

The wood undergoes moderate and uniform shrinkage during seasoning and holds its place well after manufacture. Green wood shrinks at the rate of 1/6 inch (1.4 percent) per foot in width across the growth rings and 1/3 inch (2.7 percent) per foot along the growth rings in seasoning to 15

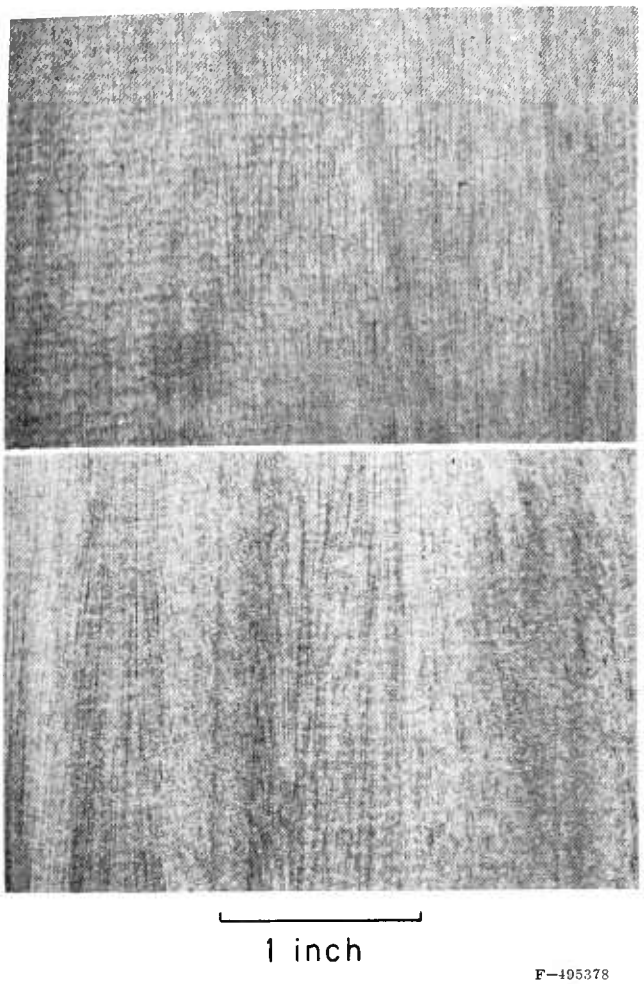

FIGURE 71.—Tabonuco: *Top*, flatsawed; *bottom*, quartersawed.

percent moisture content. The heartwood is not particularly susceptible to sap-staining fungi, but the sapwood is often turned to a bluish gray by fungus action.

Tabonuco is a moderately good machining wood. It cuts and saws easily but, because of an abundance of silica, rapidly dulls saw teeth and other cutting edges. Fairly good surfaces are obtained in planing, mortising, sanding, and shaping. Turning and boring are more difficult; torn grain and occasional fuzziness occur in specimens having roey grain. The wood is easily glued and holds nails well. Mechanical tests show tabonuco to be moderately hard, tough, and strong, comparing well with Mexican mahogany and yellow birch. The wood takes stain well and finishes beautifully with varnish or lacquer; it is very difficult to distinguish from mahogany when finished to resemble that wood.

Tabonuco is only slightly resistant to decay, lasting 3 years or less in the ground, and it is very susceptible to attack by both dry-wood and subterranean termites. Despite the presence of silica, the wood was quickly destroyed by marine borers in the Atlantic waters along the north coast of Puerto Rico. Unfortunately, tabonuco is difficult to impregnate with preservatives by either pressure or nonpressure methods.

In Puerto Rico, tabonuco is used for all types of furniture and for cabinetwork, interior trim, and general construction and carpentry. In other areas of the Caribbean, it is used for crates, boxes, shingles, and small boats. It should be suitable for soft-drink cases, fruit and vegetable containers, and similar uses, and it has been recommended for decorative veneer. The wood is used extensively in Puerto Rico as a substitute for mahogany in furniture manufacture and could be substituted for that wood in many other products.

TECA (TEAK)

Tectona grandis L.f. (verbena family, Verbenaceae)

Teca, teak in English, is one of the best known and most highly valued timbers in the world. The tree is native to southeastern Asia and Malaya but has been planted successfully in Puerto Rico and other areas in the American tropics.

Freshly cut heartwood (fig. 72) is olive green when freshly cut, becoming a golden brown upon seasoning and exposure. The sapwood is yellowish to white in color and sharply demarcated from the heartwood. Growth rings are distinct and, except for occasional false rings, are of annual occurrence. They show on the side surfaces as narrow brown lines that are darker than the rest of the heartwood.

Teca has unusually straight grain, uniformly fine texture, an oily feel, and a strong, characteristic fragrance when freshly cut. Seasoned wood retains its oily feel but possesses only a faint fragrance and no detectable taste. Plantation-grown wood from Puerto Rico averages 40 pounds per cubic foot when air-dry and 62 pounds green.

The wood air-seasons easily and satisfactorily. It also seasons rapidly, reaching 17 percent moisture content in 17 weeks under cover in the San Juan area. A minor amount of warping occurs during air-seasoning, but no surface checking or casehardening. Teca kiln-dries slowly but very well, with little tendency to check, split, or warp. However, considerable variation occurs in the drying rate of individual boards.

The wood is well known for its low and uniform shrinkage and excellent stability after manufacture and, accordingly, is the only wood acceptable for decking on aircraft carriers and other large

vessels. Green wood shrinks approximately 1/16 inch (0.5 percent) per foot in width across the growth rings and about 1/8 inch (1.1 percent) along the growth rings in seasoning to 15 percent moisture content.

Teca is, in general, comparable to white oak in strength. Plantation-grown wood is equally as strong as forest-grown wood. Air-dry wood averages about 10 to 20 percent stronger in bending and stiffness than oak but is inferior in hardness by a like amount.

Plantation-grown teca works easily with both hand and power tools, but it contains silica which dulls cutting edges. Special carbide or other high-quality steel cutting edges are recommended, although ordinary good-quality knives are used successfully with reduced spindle speeds.

In the tests, teca gave good to excellent results in all operations except sanding, in which very fine abrasives are required to prevent visible scratching of the wood. Under ordinary conditions there is a tendency for roughness to occur on the end grain in shaping operations. Teca takes nails fairly well, glues moderately well despite its oily nature, and can be varnished and polished with good results. It is a moderately good wood for steam bending, but it is likely to buckle on the concave surface if bent to a small radius of curvature.

The heartwood is resistant to attack by dry-wood termites, being comparable to West Indies mahogany (*Swietenia mahagoni*) in this respect. It is also moderately resistant to subterranean termites and very durable in the ground, but it is readily attacked by marine borers. The sapwood shares none of the durability properties of the heartwood, being readily attacked by all the above-named organisms in addition to being vulnerable to damage by pinhole borers.

The heartwood is extremely difficult to impregnate with preservatives, because only the vessels absorb the solution. The sapwood is not difficult to treat and can be impregnated successfully by the open-tank process. Treating the outer sapwood layer of small round or split posts by this method adds considerably to their service life. Unpainted wood possesses excellent weathering characteristics and is almost entirely free from warp and checking when exposed without the protection of paint.

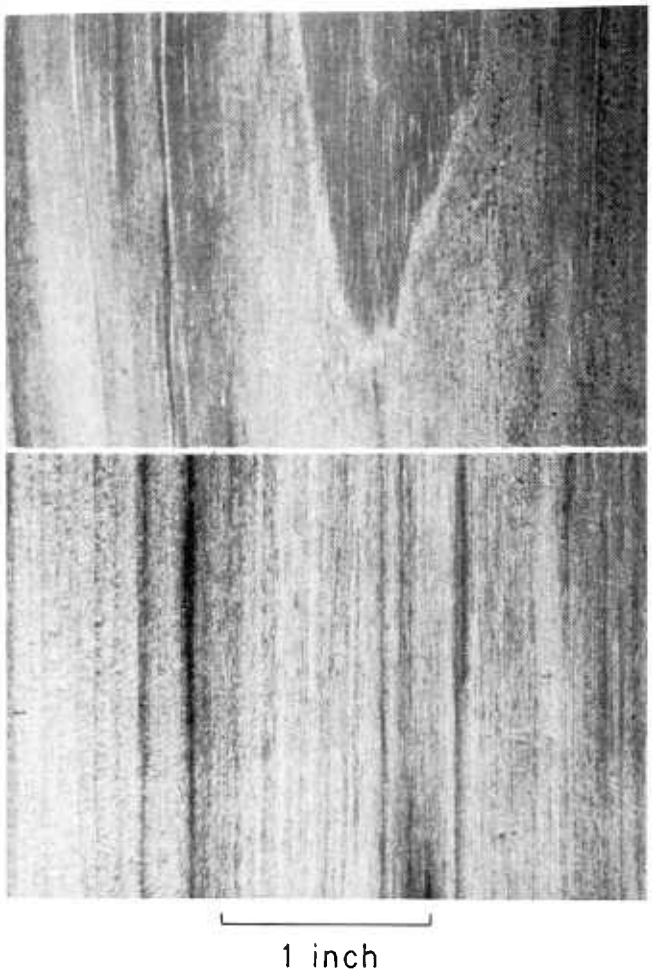

FIGURE 72.—Teca: *Top*, flatsawed; *bottom*, quartersawed.

Teca is best known for its extensive use in ship decking, for which no other wood is its equal. It has many other uses, including flooring, joinery, interior trim, durable outdoor structural work, door and window frames, carvings, furniture, doors, interior paneling, and fancy turned items. The wood's low and even shrinkage, stability, and durability suits it exceptionally well for tanks and vats. Because of its high resistance to acids, the wood is also very useful in laboratories and chemical plants for benches and other fixtures. Thinnings from teca plantations are often split and used in the manufacture of wire fencing, squared for house framing, treated and used as round posts, or sawed into lumber for furniture.

UCAR

Bucida buceras L. (combretum family, Combretaceae)

Ucar is also known in English as oxhorn bucida. Short logs of medium to large diameter are obtained in limited numbers from the semiarid forests along the south coast of Puerto Rico.

The wood of ucar is very hard, heavy, and strong. The attractive heartwood (fig. 73) frequently has a roey grain. It is a dark greenish brown clearly demarcated from the yellowish to light-brown sapwood. Longitudinal stripes are frequent as a result of the roey grain, giving the wood an attractive figure on the side surfaces. The wood is moderately fine in texture, very lustrous,

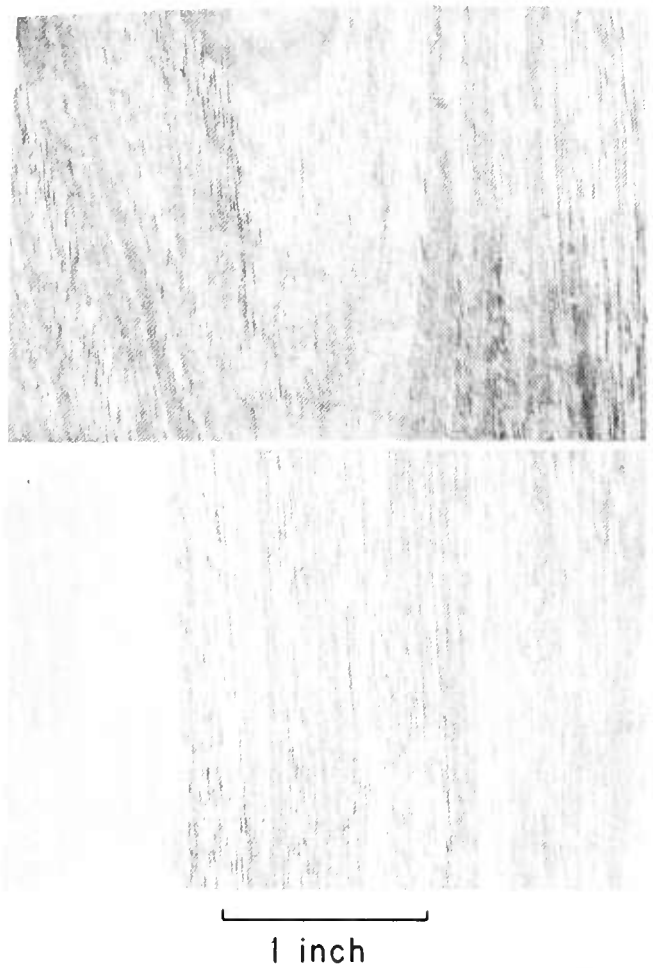

FIGURE 73.—Ucar: *Top*, flatsawed; *bottom*, quartersawed.

and without distinct growth rings. Although green wood has a tarry odor, seasoned wood has no characteristic odor or taste. Air-dry wood weighs about 69 pounds per cubic foot and green wood about 79 pounds per cubic foot, making it one of the heaviest woods available for general use on the island.

The wood is moderately easy to season; it air-dries satisfactorily for a timber of its high density. Green 1⅛-inch lumber air-seasons to 17 percent moisture content in 6 months under cover in the San Juan area. A moderate amount of warping and surface checking and a minor amount of end checking occur during the seasoning process.

Shrinkage is unusually low and uniform for a wood of its density. Green wood shrinks $\frac{5}{32}$ inch (1.3 percent) per foot across the growth rings and $\frac{9}{32}$ inch (2.3 percent) per foot along the growth rings during seasoning to an air-dry moisture content of 15 percent.

Ucar is rather difficult to saw and machine with power tools and is very hard to work with hand tools because of its very high density and hardness. However, very smooth glasslike surfaces are obtained in all operations except planing, in which torn grain is troublesome in pieces containing roey grain.

Although good, clean holes can be cut in boring and mortising, the bits tend to heat and char the interior of the holes. If sufficient power is available, charring can be prevented by an increased rate of speed. Because the wood is easily split by screws or nails, it is necessary to prebore sufficiently large lead holes to reduce splitting to an acceptable minimum. Well-sanded wood takes an excellent polish with all types of finishes.

Ucar is resistant to dry-wood termites and durable in contact with the ground, but it is not considered resistant to marine borers. Its resistance to impregnation with preservatives is probably high. Sap-staining fungi, pinhole borers, and other insects are not troublesome in either the logs or sawed lumber.

Ucar is a poor bending wood, but it is otherwise an exceptionally strong wood, resembling greenheart (*Ocotea rodiaei*) in both weight and strength properties. It is sawed into lumber and planks in Puerto Rico and is used in carts, gates, wooden fences, and occasionally for the construction and repair of farm buildings. Ucar is also particularly well suited for heavy-duty flooring, work benches, machinery platforms, and heavy, durable exterior construction of all types. The wood is not suitable for decorative purposes in furniture and cabinetmaking and is too difficult to work for general building purposes. Because of its great strength and good durability, ucar is used in other countries for railway ties, piling in nonteredo areas, house posts, and to some extent for bridge timbers. The wood may be suitable for certain machinery parts and sporting goods requiring a heavy, hard, and extremely strong wood. Its technical properties also indicate that it might be useful as a substitute for greenheart except for marine use in teredo-infested waters.

YAGRUMO HEMBRA

Cecropia peltata L. (mulberry family, Moraceae)

Yagrumo hembra is one of the lightest woods growing in Puerto Rico, but it is especially tough for its weight. The tree grows rapidly and is short lived, producing small to medium-size logs with a characteristic hollow between the nodes. It is frequently called trumpet-tree in English.

The wood (fig. 74), which appears to be all sapwood, is whitish when freshly cut, becoming a pale-brown to oatmeal color upon exposure. It is soft but fairly lustrous, coarse textured, and generally straight grained. Green wood, containing 125 percent moisture content, weighs 41

pounds per cubic foot. Air-dry wood at 15 percent moisture content weighs about 22 pounds per cubic foot as compared with an average of 17 pounds for guano growing in Puerto Rico.

The wood seasons rapidly, reaching a moisture content of about 17 percent in 14 weeks when piled under cover in the San Juan area. In the initial tests, air-seasoning was accompanied by rather severe bow and twist, and moderate cupping and crook.[9] However, it usually seasons without noticeable surface checking or end splitting. Some difficulty is encountered with sap-staining fungi if the lumber is not treated with a fungicide or allowed to become surface-dry immediately after sawing.

Yagrumo hembra underwent moderate but exceptionally uneven shrinkage during the initial seasoning tests. Shrinkage from green to oven-dry averaged ¼ inch (2.0 percent) across the grain and ¾ inch (6.2 percent) parallel to the grain per foot in width. The better than 3 to 1 ratio of tangential to radial shrinkage is unusually high and accordingly subject to question. Shrinkage from green to air-dry is normally about one-half of these values.

Dry, seasoned wood is very easy to saw and machine compared with green wood, which adheres to the face of circular saws. Because of yagrumo hembra's soft wood, surfaces tend to tear and fuzz in shaping and turning, and to crush or crumble in boring and mortising. However, it takes screws and nails readily, holds them firmly, and gives good results in planing and sanding. Trouble is often encountered in obtaining a smooth finish with varnish or lacquer, because of the soft, porous nature of the wood and a tendency for fuzziness to develop during the finishing process.

Yagrumo hembra is very susceptible to decay, termites, pinhole borers, and other insects and is considered nondurable in contact with the ground. It is used for match sticks, boxes and crates, excelsior, interior boarding, and other uses for which a soft, easily worked wood of low durability and strength is acceptable. The wood should be entirely acceptable as a substitute for guano in the manufacture of toys, models of all types, and other commercial products for which the moderately heavy grades of balsa are acceptable. Yagrumo hembra is used for paper pulp in some areas.

This wood is used in Puerto Rico for the manufacture of excelsior and, in combination with cement, is made into a type of insulation board suitable for certain light interior construction and partitions.

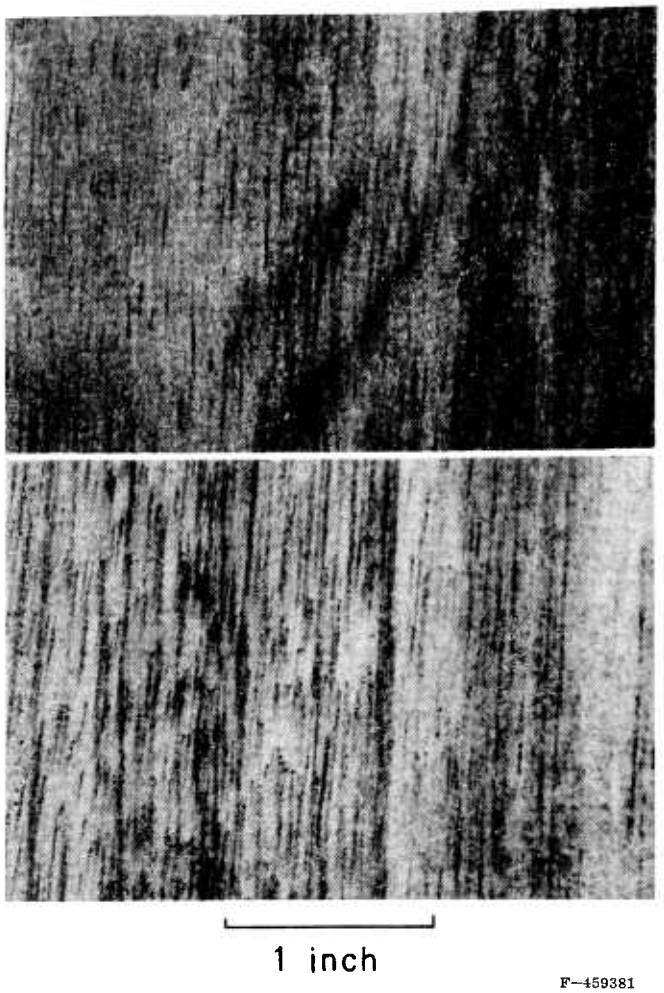

FIGURE 74.—Yagrumo hembra: *Top*, flatsawed; *bottom*, quartersawed.

[9] Later tests indicate that yagrumo hembra can be air-seasoned quickly and without excessive degrade under some conditions. This would also indicate a more favorable ratio of tangential to radial shrinkage than the values listed here.

YAGRUMO MACHO

Didymopanax morototoni (Aubl.) Dec. & Planch. (ginseng family, Araliaceae)

Yagrumo macho, or matchwood, is a small to medium-sized tree found only in the rain forest in openings created by clearing, hurricanes, or other catastrophes. The wood (fig. 75) is a pale-brownish color throughout, without distinction between heartwood and sapwood. It is lustrous, has fairly fine texture and straight grain, and it is soft and firm yet quite brittle. Air-dry wood weighs about 28 pounds per cubic foot and green wood about 40 pounds per cubic foot at 81 percent moisture content.

The wood seasons rapidly but with considerable degrade. Green lumber 1⅛ inches thick air-seasons to about 16 percent moisture content in 14 weeks under cover in the San Juan area. Degrade occurs as moderate to severe warping, but without

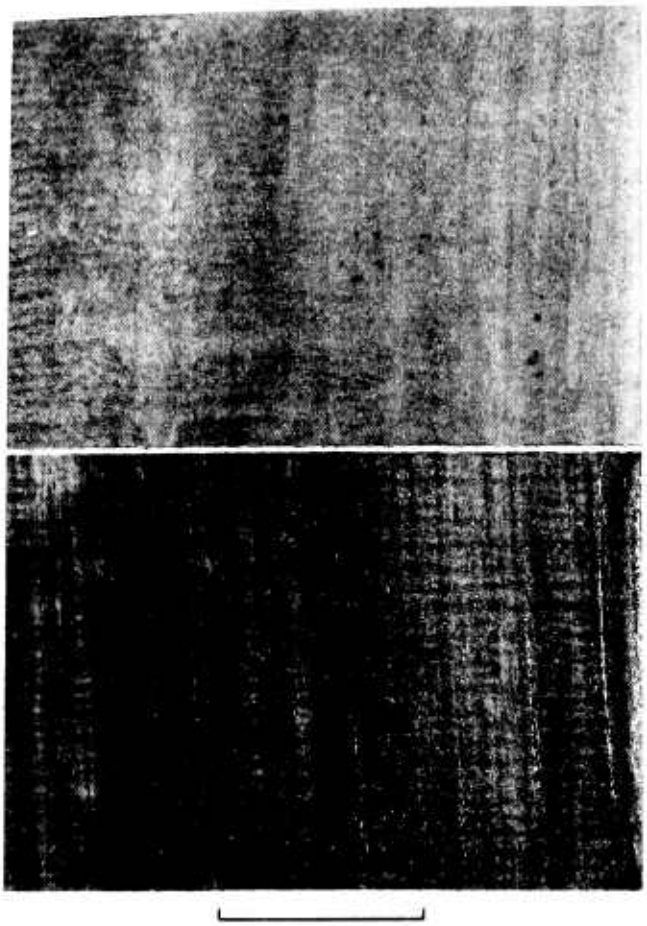

FIGURE 75.—Yagrumo macho: *Top*, flatsawed; *bottom*, quartersawed.

apparent surface checking or end splitting. Green lumber is discolored quickly after sawing by sap-staining fungi unless the surface moisture is lost within a few hours or the wood is immersed in a fungicide.

A rather high rate of shrinkage occurs during seasoning for a wood of yagrumo macho's density, but this shrinkage is fairly uniform in the radial and tangential directions. Green wood seasoned to air-dry condition shrinks at the rate of 3/8 inch (3.1 percent) across the growth rings and 2/3 inch (5.6 percent) along the growth rings per foot in width.

Yagrumo macho works easily with either hand or power tools. Good results are obtained in planing, shaping, and sanding except for occasional fuzziness in some pieces. However, the wood is difficult to turn, bore, or mortise; excessive tearing and crushing of the fibers occurs during these operations. The use of very sharp and thin cutting edges and reduced feed rates would have improved the quality of the machined surfaces. The wood takes nails and screws very well without splitting. Polishing is somewhat difficult, with a tendency for woolliness to occur during rubbing and after application of the finishes.

Yagrumo macho logs are very susceptible to damage by pinhole borers unless removed from the forest and converted into lumber soon after felling. Seasoned lumber is very susceptible to termites and other insects, decay, and marine borers; it requires preservative treatment for use in exposed locations or in contact with the ground.

Yagrumo macho is an excellent wood for boxes and crates, and it has been recommended for match splints, interior construction, utility grade plywood, and toys. It may also have good pulping properties and should be suitable for many of the same purposes as the heavier grades of guano (balsa).

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