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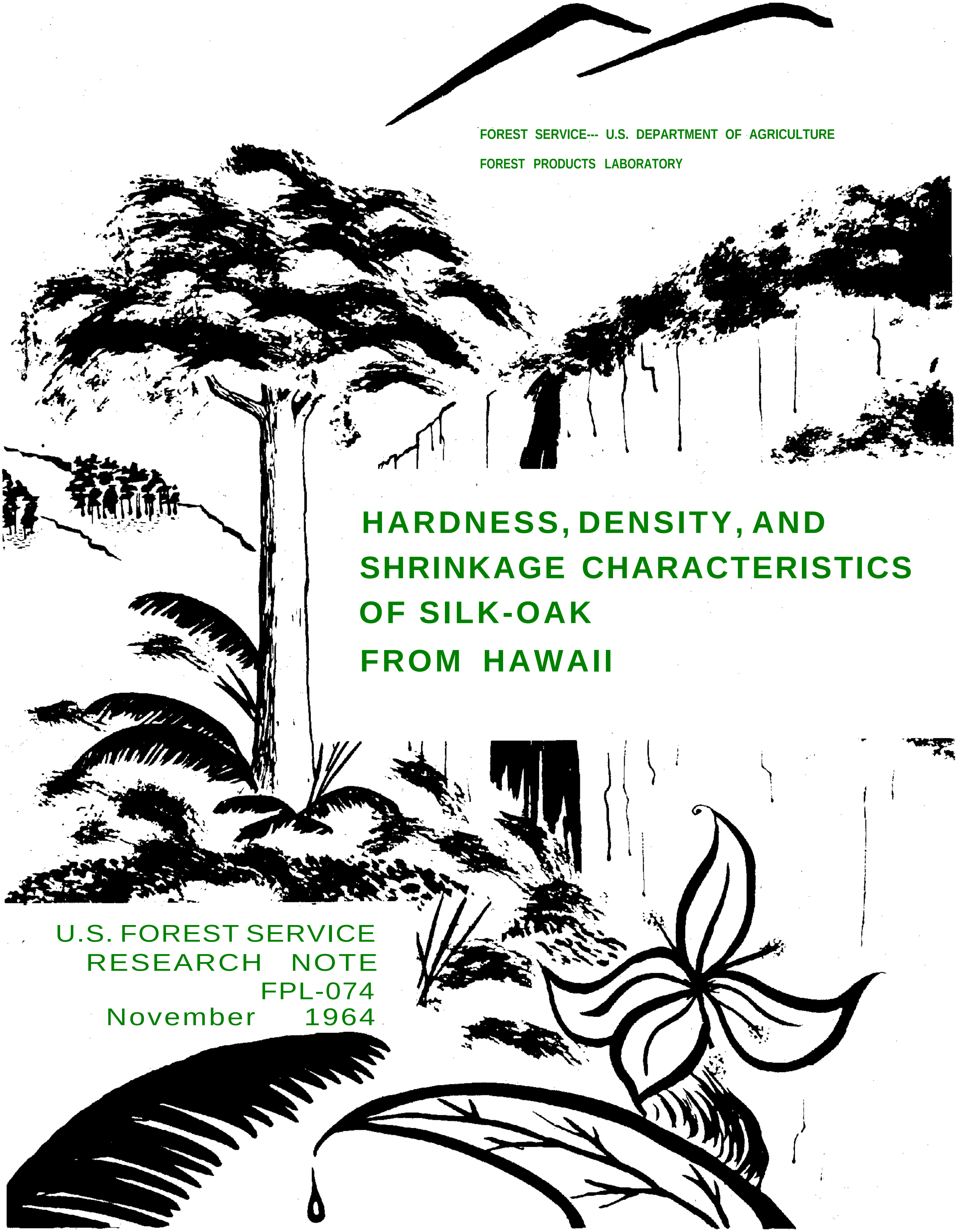

HARDNESS, DENSITY, AND SHRINKAGE CHARACTERISTICS OF SILK-OAK FROM HAWAII

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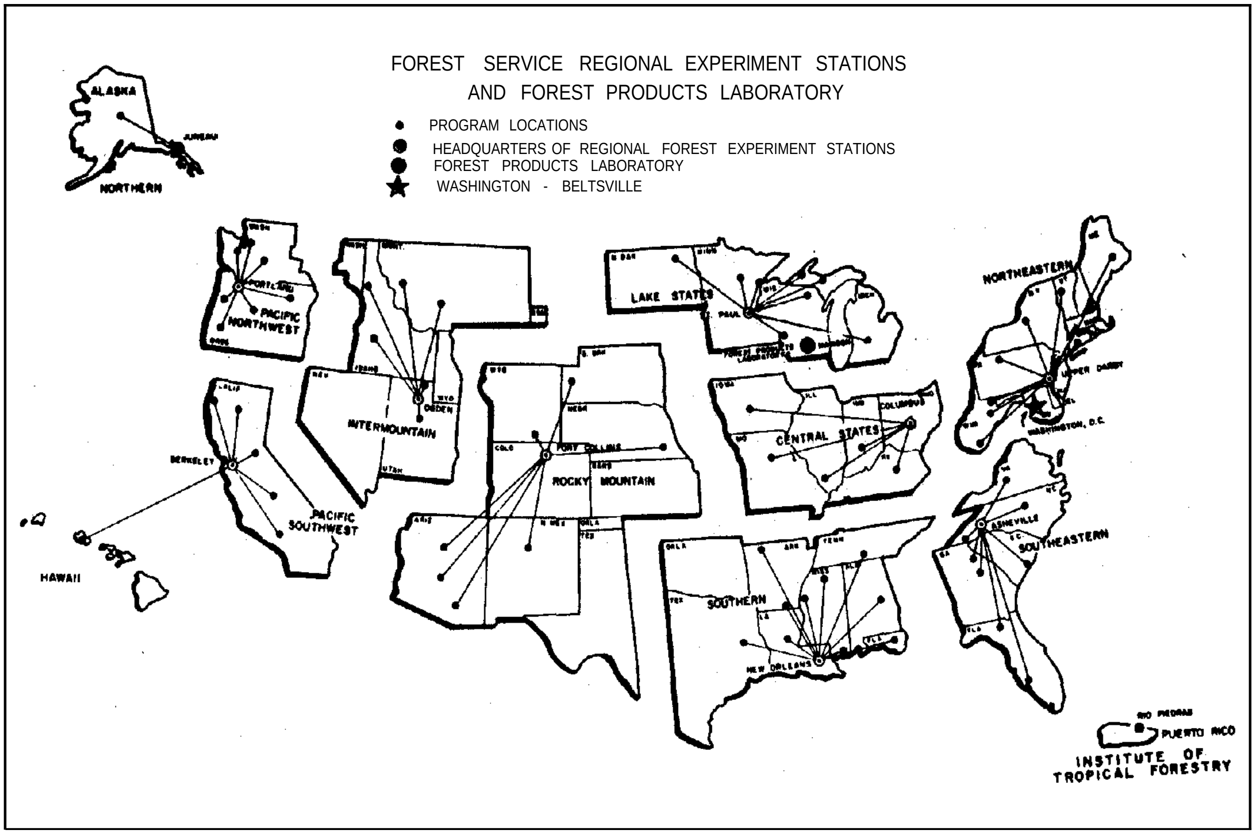

Forest Service regional experiment stations and Forest Products Laboratory

Prepared in cooperation with the Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service; the Forestry Division, Hawaii Department of Land and Natural Resources: and Hawaiian Fern-Wood, Ltd.

HARDNESS, DENSITY, AND SHRINKAGE

CHARACTERISTICS OF SILK-OAK FROM HAWAII

by

R. L. YOUNGS, Technologist

Forest Products Laboratory,[1] Forest Service
U.S. Department of Agriculture

Abstract

Shrinkage, specific gravity, and hardness of two shipments of silk-oak (Grevillea robusta) from Hawaii were evaluated to provide basic information pertinent to the use of the wood for cabinet and furniture purposes.

The wood resembles Hawaii-grown shamel ash (Fraxinus uhdei) in the properties evaluated. Shrinkage compares well with that of black cherry, silver maple, or red lauan. Side hardness of green wood considerably exceeds that of black cherry and paper birch, but that of air-dry wood is closely comparable to that of those two Mainland species. End hardness of green wood compares well with that of black cherry, but that of air-dry wood more closely resembles that of paper birch Density of the wood is generally comparable to that of paper birch.

Introduction

Silk-oak Grevillea robusta, A. Cunn.) is a timber species native to Australia and extensively planted as a shade tree for coffee and tea plantations in Africa, India, Ceylon, and other parts of the world (5).[2] The species has been planted in Hawaii for similar purposes and for erosion control, as well as to supplement the limited supply

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Underlined numbers in parentheses refer to Literature Cited at the end of this report.

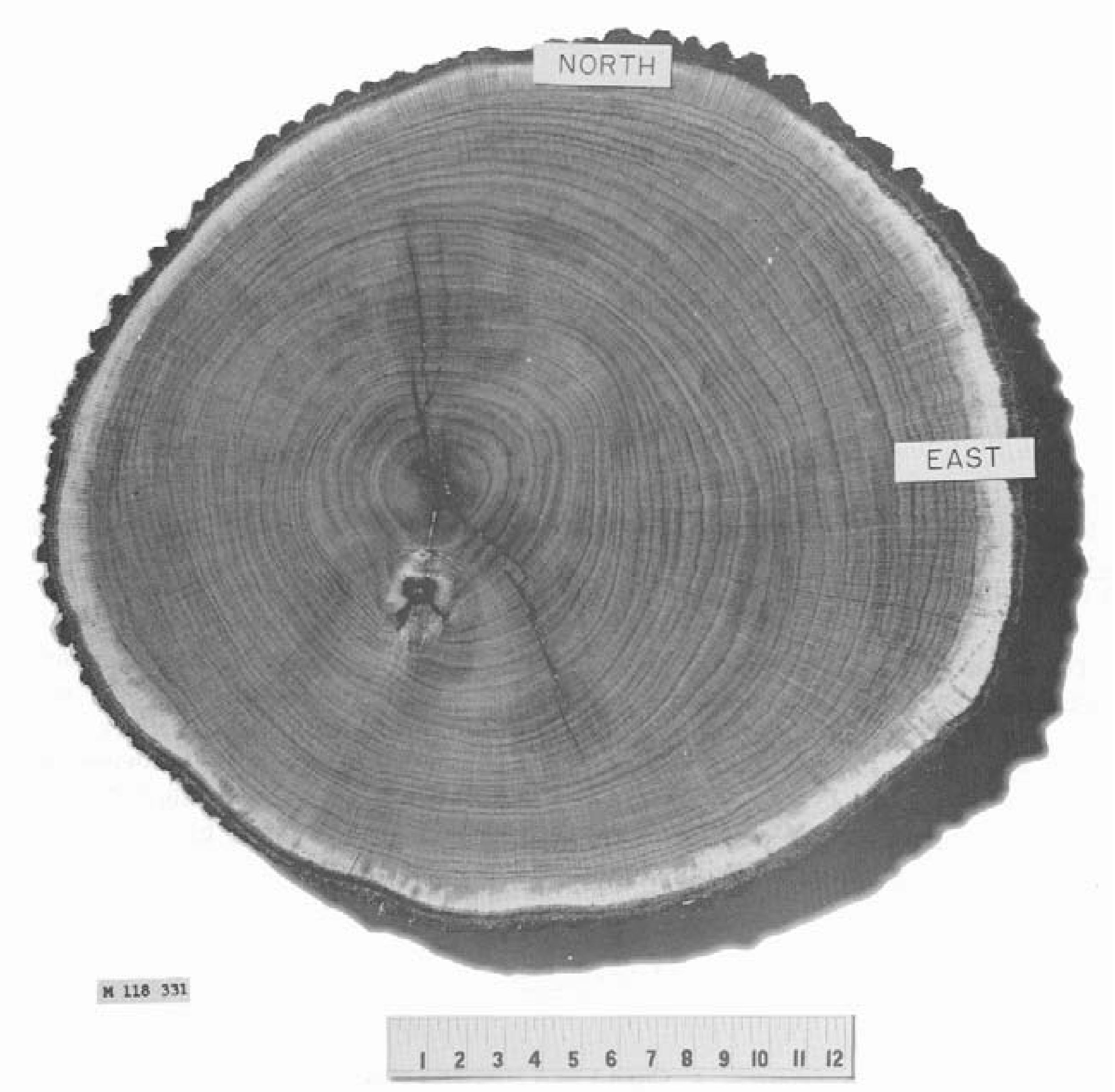

Figure 1.--Cross section of bolt 3 c-d from tree 3 of the shipment from Hawaii County. The eccentric growth and size are typical of the material of that shipment.

of native timber suitable for commercial use. Silk-oak is one of the few species now growing in Hawaii that shows promise for supplying wood of commercial value (7,9,10). The wood is considered easy to work and very useful for many purposes, including paneling, furniture, and cabinet work from the upper grades, and boxes, pallets, and crates from the lower grade material (7). It seems likely to be of greatest value for the various furniture and cabinet uses, but information on the applicable wood properties of Hawaii-grown material is needed to provide a basis for most effective use in that area,

It was the object of this study to provide some of the necessary basic wood properties information by evaluating the density, shrinkage, and hardness characteristics of material selected as being representative of the timber of silk-oak currently growing in Hawaii. The selection of properties to be evaluated was made with the intention of limiting such evaluation to characteristics most closely related to cabinet use; thus this information could be combined with that from another study (6) for application in cabinet and furniture uses. The research was done at the Forest Products Laboratory in 1961 and 1962 in collaboration with the Pacific Southwest Forest and Range Experiment Station and the Forestry Division, Hawaii Department of Land and Natural Resources. Hawaiian Fern-Wood, Ltd., assisted with logging the experimental material.

Material

Specimen material for this study was provided by two shipments of silk-oak (*G. robusta*), each from a different location in Hawaii.

One shipment included five bolts representing five different trees from a 60-year-old planted stand in Paauilo, Hawaii County. Those bolts were 8 feet long and averaged about 24 inches in diameter. They represented the 10- to 18-foot height of the trunk and were thus generally equivalent to the standard ASTM designation of c-d (8- to 16-foot) height (1). They were cut in August 1960 and arrived at the Forest Products Laboratory about a month later. The locality in which they were grown is at an elevation of 1,800 feet and is characterized by an average annual rainfall of about 85 inches, well distributed throughout the year but likely to be heaviest in the winter months. All of the bolts were somewhat eccentric in growth (fig. 1).

The other shipment included five bolts representing three trees from a 50-year-old planted stand in Waianae-Kai, Honolulu County, Island of Oahu. Those bolts represented approximately the b-c (5- to 13-foot) height of one tree and the a-b (1- to 9-foot) and c-d (9- to 17-foot) heights of two other trees. The bolts were 8 feet

Figure 2.--Cross sections showing size and general growth characteristics of the three trees of the shipment from Honolulu County.

long and averaged about 14 inches in diameter. They were cut in late September 1960 and arrived at the Forest Products Laboratory about 2 months later. The locality in which they were grown is at an elevation of about 1,560 feet and is characterized by an average annual rainfall of about 50 inches distributed throughout the year but heaviest in winter, These bolts were also somewhat eccentric in growth (fig. 2).

In spite of the relatively long shipping times, the material arrived at the Forest Products Laboratory in good condition. The principal defect was splitting from the pith outward (shown in figs. 1 and 2), which extended the full length of most of the bolts. However, it was not difficult to avoid such splits in selection of specimen material.

Specimen Preparation

Specimens for evaluating specific gravity, shrinkage, and hardness characteristics were removed from each of the 10 bolts provided in the two shipments. The specimens conformed to standards of ASTM in size and orientation (1), but the manner of their selection differed somewhat from standard procedures due to the special nature of the study and its objectives.

Each bolt was crosscut at midlength to remove two full cross-section disks 2 inches in the grain direction. One of the disks was photographed to provide an illustration of general size and growth characteristics, similar to those shown in figures 1 and 2. The other disk provided specimens for evaluation of radial and tangential shrinkage, such specimens being 4 inches long in the direction of shrinkage to be measured and 1 inch square in cross section. Ten radial and 10 tangential shrinkage specimens were prepared from each bolt from Hawaii County, but the smaller bolts from Honolulu County yielded only 4 to 7 suitable specimens in each direction. Specimens were distributed to represent various radial positions from pith to bark in the bolt (fig. 3). One of the approximately 4-foot-long bolts (resulting from crosscutting each of the original 8-foot bolts as just described) was ripped lengthwise to provide a single 3-inch-thick flitch from bark to bark through the pith. An attempt was made to orient the flitches as nearly as possible in a north-south direction in the bolt, but consider-able deviation from that ideal was generally necessitated by the location of major splits and the eccentricity of the bolts.

Specimens were selected from these flitches to evaluate hardness and longitudinal shrinkage (fig. 4). Specimens were distributed in such a way as to represent various radial positions in the bolt. Ten longitudinal shrinkage specimens and an equal number of hardness specimens were selected to represent each tree from Hawaii

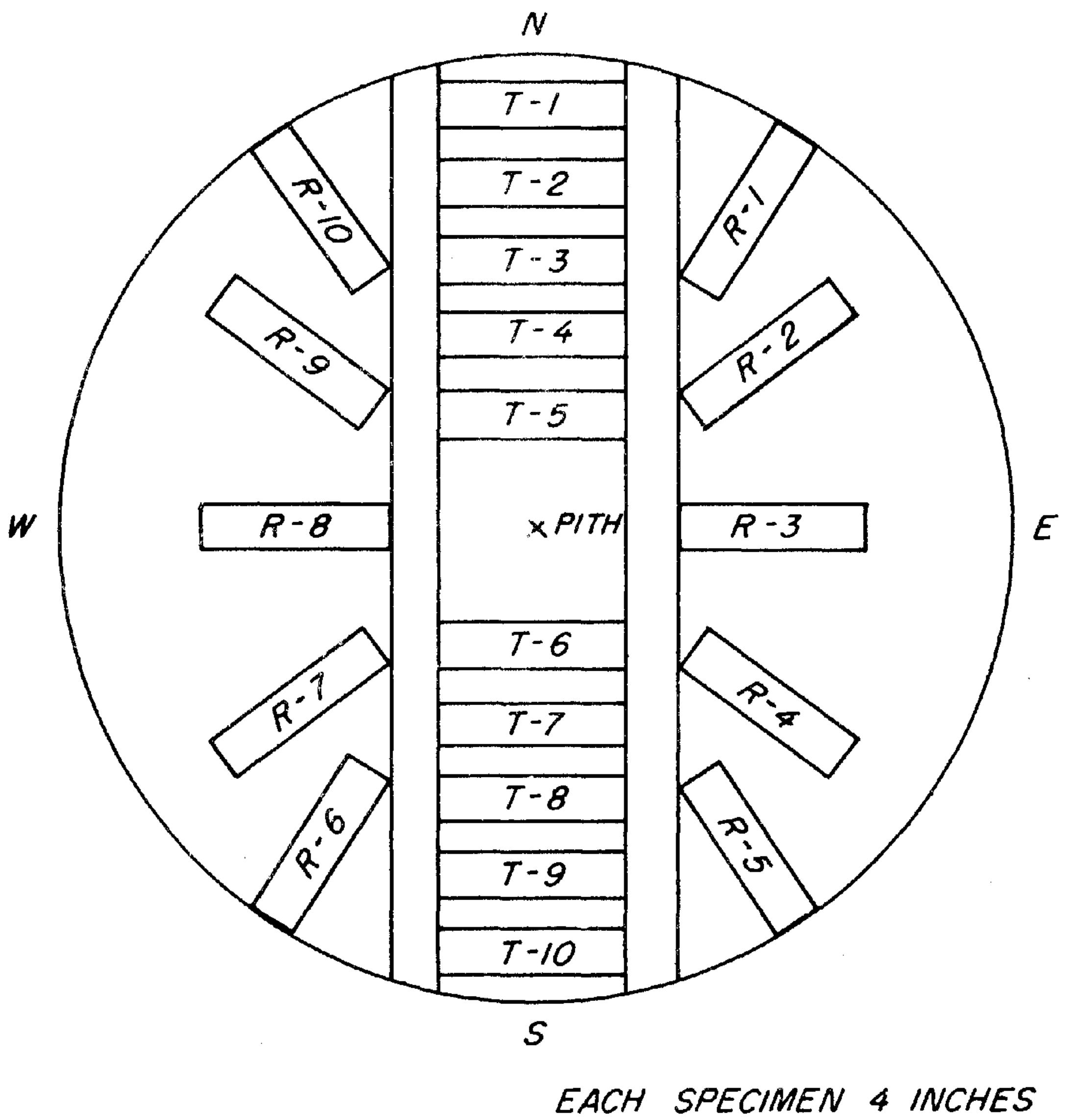

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Figure 3.--General arrangement for selecting radial (R) and tangential (T) shrinkage specimens from various positions in a full cross section disk cut at midlength of each 8-foot bolt.

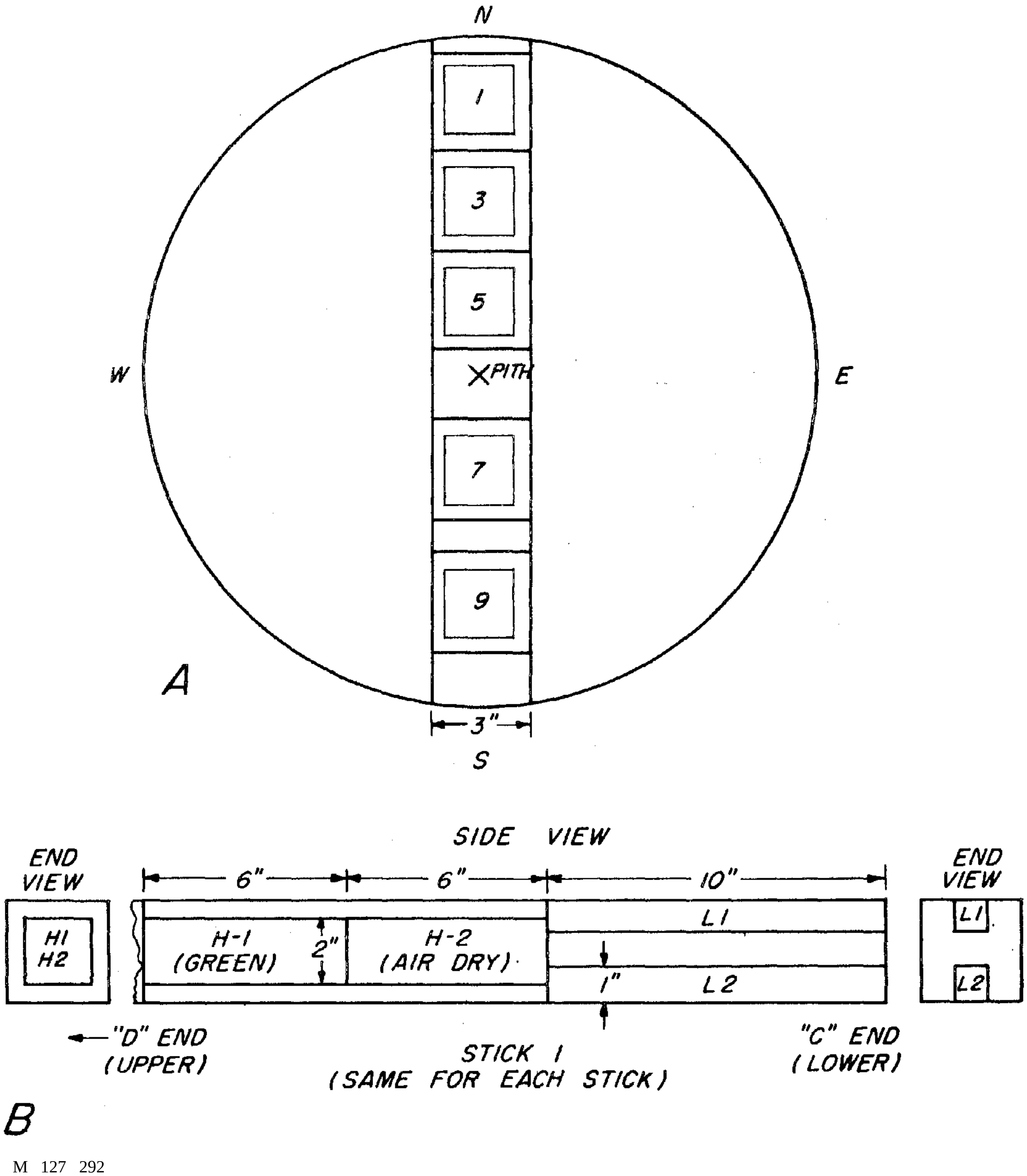

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Figure 4.--A. General arrangement for selecting sticks for hardness and longitudinal shrinkage specimens from a 3-inch flitch ripped from a 4-foot length of each of the original 8-foot bolts. B. Arrangement for selecting hardness (H) and longitudinal shrinkage (L) specimens from each of the sticks.

County, but the smaller diameter of the bolts from Honolulu County necessitated a smaller number of specimens per bolt. Each longitudinal shrinkage specimen was 10 inches long in the grain direction and 1 inch square in cross section. Hardness specimens were 6 inches long in the grain direction and 2 inches square in cross section. They were grouped in end-matched pairs within each bolt, one of each pair to be tested in the green condition and the other to he tested after it had reached the standard air-dry condition.

Experimental Procedure

Procedures followed in carrying out the evaluations were essentially those specified by ASTM for testing small clear specimens (1). The notable exception was the fact that shrinkage specimens were brought to equilibrium under conditions of 80° F. and 30 percent relative humidity (approximately 6 percent moisture content) as well as under conditions of 75° F. and 64 percent relative humidity (approximately 12 percent moisture content) and at the ovendry condition. Radial, tangential, and longitudinal shrinkage from the green condition to each of those conditions were determined, with specimens being exposed to the indicated conditions successively in order of decreasing equilibrium moisture content.

Specific gravity of each hardness specimen was determined on the basis of ovendry weight and volume at test to provide specific gravity data for the specimen material. Wafers 1 inch long and the full cross section of the specimen were removed from the specimens for this purpose after hardness penetrations had been completed. These wafers were also used to determine moisture content of the hardness specimens by the ovendrying method.

Some of the Laboratory staff most directly involved in preparation and testing of specimens of silk-oak were bothered by skin and eye irritation after handling the wood. Others as directly involved in this work were not affected. The irritation developed after handling green wood or exposure to sawdust or exuded sap. It was not observed as a result of handling the dry prepared specimens. As a precautionary measure, all Laboratory personnel directly involved in the experimental work were instructed to wash their hands thoroughly after handling the wood and to avoid contacting the eyes or other sensitive body parts with their hands until they had washed.

Presentation of Results

Table 1 presents average values of radial, tangential, and longitudinal shrinkage for moisture content changes from green to 12 percent, green to 6 percent, and green

Table 1.--Results of shrinkage evaluations of silk-oak from Hawaii in comparison with averages for other species

Species	Source of material	Tree	Bolt	Radial: Specimens	Radial: Green to 12 percent	Radial: Green to 6 percent	Radial: Green to ovendry	Tangential: Specimens	Tangential: Green to 12 percent	Tangential: Green to 6 percent	Tangential: Green to ovendry	Longitudinal: Specimens	Longitudinal: Green to 12 percent	Longitudinal: Green to 6 percent	Longitudinal: Green to ovendry
					Pct.	Pct.	Pct.		Pct.	Pct.	Pct.		Pct.	Pct.	Pct.
Silk-oak	Hawaii County	1	C-D	10	1.07	2.00	2.35	10	4.04	6.22	7.39	10	0.12	0.21	0.29
		2	C-D	10	1.14	1.90	2.38	10	4.02	6.24	7.43	10	.13	.18	.25
		3	C-D	10	1.04	1.95	2.26	10	4.27	6.46	7.71	10	.08	.23	.30
		4	C-D	10	1.34	2.48	2.95	10	4.57	6.86	8.13	10	.06	.16	.24
		5	C-D	10	1.05	2.02	2.40	10	3.93	6.20	7.46	10	.02	.06	.13
		Average			1.13	2.07	2.47		4.17	6.40	7.62		.08	.17	.24
	Honolulu County	11	B-C	5	1.25	2.35	3.01	6	4.58	7.15	8.65	8	.01	.07	.15
		12	A-B	5	1.69	2.87	3.55	7	3.90	5.94	7.21	8	-.04	-.02	.03
		12	C-D	4	1.21	2.20	2.75	5	4.34	6.47	7.84	6	-.05	-.02	.03
		13	A-B	5	1.48	2.61	3.22	6	4.37	6.55	7.80	8	-.03	.01	.08
		13	C-D	5	1.44	2.59	3.24	6	4.15	6.34	7.62	6	-.02	.02	.08
		Average[1]			1.40	2.51	3.14		4.31	6.59	7.94		-.02	.02	.09
	Overall average[1]				1.2	2.2	2.7		4.2	6.5	7.7		.04	.11	.18
Shamel ash[2]							3.5				7.4				.21
Pumpkin ash[3]							3.7				6.3				
Black cherry[3]							3.7				7.1				
Yellow birch[3]							7.2				9.2				
Silver maple[3]							3.0				7.2				
Sugar maple[3]							4.9				9.5				
Red lauan[3]							3.3				8.0				

[1]Each tree given equal weight.
[2]U.S. Forest Products Laboratory Report 2191.
[3]U.S. Dept. of Agr. Handbook No. 72.

Table 2.--Specific gravity and hardness of silk-oak from Hawaii in comparison with averages for other species

Species	Source of material	Tree	Bolt	Number of specimens	Moisture content	Specific gravity[1]	Hardness: Radial	Hardness: Tangential	Hardness: Average side	Hardness: End
					Pct.		Lbs.	Lbs.	Lbs.	Lbs.
					GREEN					
Silk-oak	Hawaii County	1	c-d	5	122	0.52	760	810		660
		2	c-d	5	122	.52	830	840		720
		3	c-d	5	128	.45	750	750		610
		4	c-d	5	116	.47	850	840		680
		5	c-d	5	128	.46	770	800		680
		Average[2]			123	.48	790	810	800	670
	Honolulu County	11	b-c	4	97	.58	940	980		790
		12	a-b	4	107	.54	870	890		720
		12	c-d	3	102	.56	940	930		770
		13	a-b	4	101	.56	950	880		810
		13	c-d	3	98	.56	890	920		750
		Average[2]			100	.56	920	930	920	770
	Overall average[2]				110	.51	840	850	850	710
Shamel ash[3]					46	.47			700	790
Paper birch[4]					65	.48			560	470
Yellow birch[4]					67	.55			780	810
Black cherry[4]					55	.47			660	750
Silver maple[4]					66	.44			590	670
Sugar maple[4]					58	.56			970	1,070
					DRY					
Silk-oak	Hawaii County	1	c-d	5	11.7	.54	790	870		860
		2	c-d	5	11.5	.56	890	960		880
		3	c-d	5	11.7	.53	790	750		790
		4	c-d	5	11.8	.58	960	990		940
		5	c-d	5	11.8	.55	850	860		890
		Average[2]			11.7	.55	860	890	880	870
		Adjusted[2]			12.0	.55	860	880	870	870
	Honolulu County	11	b-c	4	12.4	.62	1,110	1,100		1,010
		12	a-b	4	11.6	.57	960	970		910
		12	c-d	3	11.6	.59	960	1,030		910
		13	a-b	4	11.7	.60	970	1,000		910
		13	c-d	3	11.7	.62	1,010	1,020		980
		Average[2]			11.9	.60	1,020	1,040	1,030	950
		Adjusted[2]			12.0	.60	1,020	1,040	1,030	950
	Overall average[2]				12.0	.57	920	940	930	900
Shamel ash[3]					12	.50			860	1,270
Paper birch[4]					12	.55			910	890
Yellow birch[4]					12	.62			1,260	1,480
Black cherry[4]					12	.50			950	1,470
Silver maple[4]					12	.47			700	1,140
Sugar maple[4]					12	.63			1,450	1,840

[1] Based on ovendry weight and volume at indicated moisture content.
[2] Each tree given equal weight.
[3] U.S. Forest Products Laboratory Report 2191.
[4] U.S. Dept. of Agr. Handbook No. 72.

to ovendry (total shrinkage) for specimens from each bolt, each shipment, and for all of the silk–oak evaluated. Also included are average values of total radial and tangential shrinkage of a few other hardwoods for comparison.

Table 2 presents average values of hardness and related specific gravity and moisture content data for green and air–dry material from each bolt, each shipment, and for all of the silk–oak evaluated. Also included are average values of a few other hardwoods for comparison.

Discussion of Results

The two shipments of silk–oak supplied for this study differed appreciably in the characteristics considered. The shipment from Honolulu County averaged higher in specific gravity and correspondingly higher in shrinkage and hardness than the shipment from Hawaii County. The exception was in longitudinal shrinkage, in which the material from Hawaii County was so much higher that it indicated a strong possibility of abnormal wood in most of the trees of the Hawaii County shipment. This might also be suspected from their pronounced eccentricity of growth. However, trees of both shipments were noticeably eccentric in growth, and differences in other properties are generally in agreement with what would be expected on the basis of specific gravity differences.

It would seem possible that the specific gravity differences are related to differences in growth conditions in the two locations sampled. The Hawaii County site is somewhat higher and has appreciably more rainfall than the Honolulu County site. Silk–oak is reported to develop best in Hawaii at elevations of 1,000 to 3,000 feet under rainfall of 35 to 60 inches annually (7). Also, the information supplied by those responsible for collecting the material would indicate that the Hawaii County site is more open and free from competing vegetation than the Honolulu County site. These factors, possibly combined with others that are not determined, could conceivably have been responsible for the more rapid growth and lower density of the Hawaii County material.

It should be emphasized in this regard, however, that neither of the shipments is extensive enough to be considered characteristic of the material growing throughout the areas from which they were collected. Unless further sampling or supplementary information can more firmly establish significant regional differences in properties of silk–oak grown in different parts of Hawaii, it must be assumed that such properties are best defined by values derived from all of the material studied.

It is interesting to note that shrinkage data developed in Tanganyika for shrinkage of G. robusta from the green to the air-dry condition agree closely with those developed in this study for shrinkage from green to 12 percent moisture content (11). Results of mechanical evaluation of material at 12 percent moisture content in Australia agree closely with the specific gravity data developed in this study for comparable material, but side hardness is indicated as averaging about 10 percent lower than that of the present material (3). Data on material at 12 percent moisture content evaluated in the Union of South Africa indicate a slightly lower average specific gravity of 0.54, though that is well within the range of the present material (2). The same report indicates average side and end hardness of material at 12 percent moisture content to be about 10 percent lower than that of comparable Hawaii-grown wood of the species.

Of the various other Hawaii-grown hardwoods evaluated to date, silk-oak appears to resemble shamel ash most closely as far as the properties considered in this study are concerned (13), Radial shrinkage of silk-oak averaged slightly less than that of shamel ash, while tangential shrinkage averaged slightly higher and longitudinal shrinkage about the same. It appears likely that the slight differences observed would have little significant effect on use characteristics. Specific gravity and side hardness of silk-oak average somewhat greater and end hardness somewhat less than that of the Hawaii-grown shamel ash evaluated.

Shrinkage characteristics of Hawaii-grown silk-oak compare reasonably well with those of red lauan from the Philippines, as well as with those of black cherry and silver maple grown on the Mainland. Shrinkage of silk-oak averages much less than that of yellow birch or sugar maple, two well-known cabinet and furniture woods.

Side hardness of silk-oak in the green condition averages somewhat greater than that of yellow birch and considerably greater than that of black cherry, paper birch, or silver maple, though it is still appreciably less than that of sugar maple. However, end hardness of green silk-oak averages less than that of yellow birch, about the same as that of black cherry, and greater than that of silver maple and paper birch. The air-dry wood of silk-oak averages about the same as black cherry and paper birch in side hardness but is considerably less hard on the side grain than either yellow birch or sugar maple. End-grain hardness of the air-dry wood is quite low, averaging less than that of the much less dense silver maple and about the same as that of paper birch.

The tendency of the green wood, sawdust, and sap exudate of silk-oak to cause irritation of the eyes and skin of some persons will necessitate that special precautions be taken by those who are exposed to such material and who are sensitive to such irritation. The tendency of silk-oak to cause such irritation is recognized by its inclusion in a rather extensive listing published 30 years ago by the American

Medical Association (8). However, it should also be pointed out that the same listing includes such commonly used woods as paper birch, white pine, Sitka spruce, white spruce, sweetgum, and yellow-poplar, as well as many others that are not ordinarily considered to require special care in handling. The freedom from any such irritation when handling finished products or dry wood of otherwise irritant woods was recognized some years ago, though silk-oakwas not then singled out as an irritant wood (4). One case of dermatitis was reported in the Utilisation Section of the Tanganyika Forest Division during the course of their recent study of silk-oak (11).

Conclusions

Results of this study of the shrinkage, specific gravity, and hardness of silk-oak from two locations in Hawaii lead to the following conclusions:

1. Shrinkage and specific gravity of Hawaii-grown silk-oak compare closely with those reported for wood of the species grown and evaluated in other parts of the world. Side hardness of the air-dry Hawaii-grown material averages about 10 percent greater than that reported from other regions of growth.

2. Of the various other Hawaii-grown hardwoods whose physical and mechanical properties have been evaluated to date, silk-oak resembles shamel ash most closely in shrinkage, specific gravity, and hardness.

3. Shrinkage of Hawaii-grown silk-oak compares reasonably well with that of black cherry and silver maple grown on the Mainland and with that of red lauan grown in the Philippines.

4. Side hardness of green silk-oak averages greater than that of yellow birch and considerably greater than that of paper birch and black cherry, but side hardness of air-dry silk-oak averages about the same as that of paper birch and black cherry. End hardness of green wood compares well with that of black cherry, while end hardness of air-dry wood averages about the same as that of paper birch.

5. Density of silk-oak in both the green and the air-dry conditions compares closely with that of paper birch.

6. The tendency of the green wood, sawdust, and sap exudate to cause eye and skin irritation will necessitate special precautions in handling the wood on the part of persons sensitive to such effects.

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