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PHYSICAL AND MECHANICAL PROPERTIES OF MOLUCCA ALBIZZIA GROWN IN HAWAII

SUMMARY

Physical and mechanical properties of the wood species Molucca albizzia (Albizia falcata) grown in Hawaii, were determined in studies conducted at the U.S. Forest Products Laboratory. Results show this species to be light in weight (specific gravity is 0.32 for green wood and 0.33 for air–dry). It is moderately weak in bending and compressive strength, moderately soft, and moderately limber; however, for its specific gravity, the wood has normal shrinkage but has above average strength, hardness, and stiffness.

ACKNOWLEDGEMENT

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.

PHYSICAL AND MECHANICAL PROPERTIES OF MOLUCCA ALBIZZIA GROWN IN HAWAII [1]

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UNITED STATES DEPARTMENT OF AGRICULTURE

INTRODUCTION

Molucca albizzia (Albizia falcata) (L.) Backer,[3] indigenous to the Moluccas of Indonesia, was introduced throughout the Far East late in the 19th century.[4] The tree, growing rapidly under favorable conditions, has been used primarily as a shade or nurse tree for coffee and tea crops and as an ornamental species. The tree is being used in Malaya for afforestation of degraded and idleland.

Molucca albizzia was introduced in Hawaii from British North Borneo in 1918. It has shown remarkable growth in several plantings, mainly on islands of Kauai and Hawaii.

In the Far East, Molucca albizzia wood is used in packing cases, tea chests, and for fuel. The wood is light brown in color with a pinkish tinge; grain is deeply interlocked and spiral, with a rather coarse and even texture.[5] Rays are small but readily distinguishable on radial surfaces. In Hawaii, the principal use of the wood is in pallets, boxes, and crates, but it is also used locally in ladders and light work tables.

In manufacturing, two minor disadvantages of the wood should be noted. It is abrasive to saws, and dust or fumes resulting from working the wood tend to cause sneezing and tears. The wood has an odor of garlic or onion when green.

Although the wood is reported to be light and soft,[5] no records of any systematic evaluation of its strength could be found. Therefore research was conducted by the U.S. Forest Products Laboratory in collaboration with the Pacific Southwest Forest and Range Experiment Station and the Forestry Division of the Hawaii Department of Land and Natural Resources to determine the physical and mechanical properties of Molucca albizzia wood grown in Hawaii. This paper presents the results and evaluation of that research.

[1] Appreciation is extended to the Forestry Division, Hawaii Department of Land and Natural Resources for providing financial support for the study; to R. G. Skolmen of the Hawaii Forestry Research Center, Pacific Southwest Forest and Range Experiment Station, who selected the sample material and provided background information on the description of material uses of the wood; and to Hawaiian Fern-Wood, Ltd., for providing logging, milling, and material handling facilities.

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

[3] Also known as Albizia moluccana.

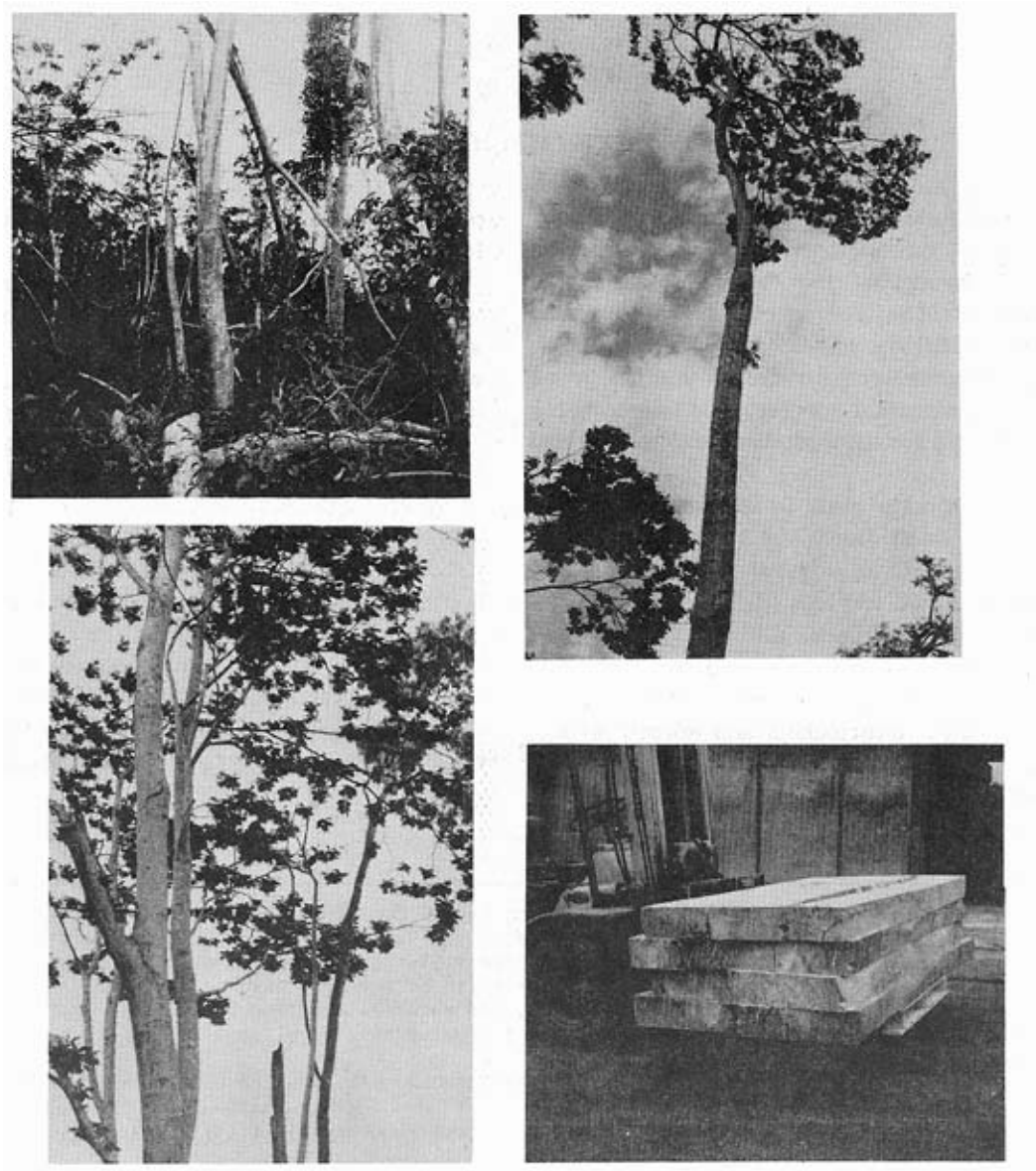
[4] Streets, R. J. Exotic forest trees in the British Commonwealth. Oxford Univ. Press, London, 765 pp., illus. 1962.

[5] Desch, H. E. Manual of Malayan timbers. Malayan Forest Records Vol. I (of 2 volumes), 328 pp., illus. 1941.

DESCRIPTION OF MATERIAL

Sample trees of Molucca albizzia were obtained from a 36-year-old plantation in Wood Valley, located about five miles from Pahala, Hawaii. About 50 percent of the trees on the plantation were Molucca albizzia. Other species included: silk-oak (Grevillea robusta) 30 percent: guava (Psidium guajava) 10 percent; and eucalypts (Eucalyptus spp.) 10 percent. The sample site is a nearly level valley bottom at 2,200 feet elevation. Annual precipitation averages about GO inches, and temperature ranges from about 50° to 90°F. A eucalypt stand adjacent to the sample site was logged 1 year prior to a "Kona" storm that uprooted or broke off about 95 percent of the Molucca albizzia, 80 percent of the silk-oak, and most of the eucalypts in 1963. The sample was obtained from standing Molucca albizzia trees later in 1963.

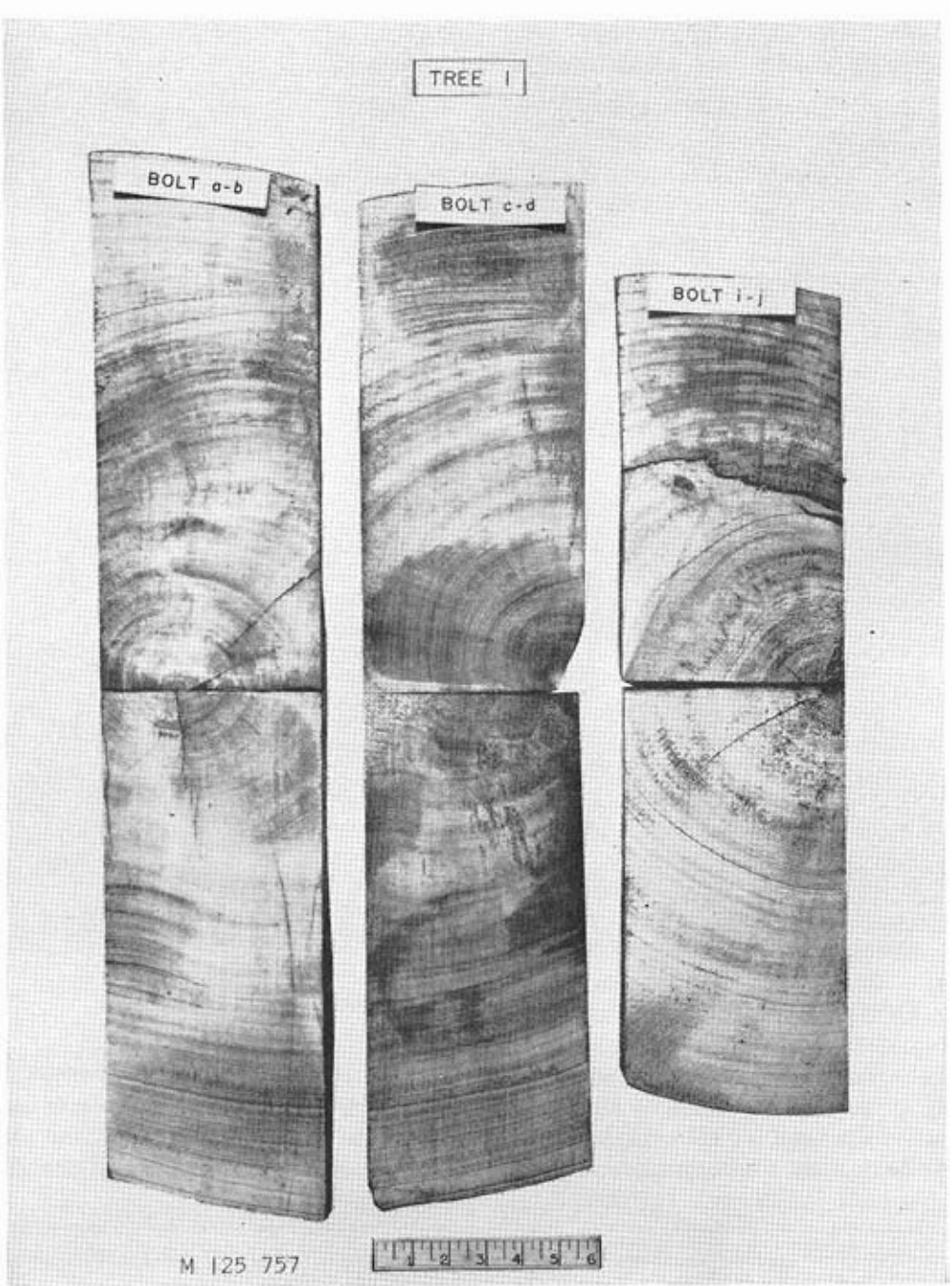
Figure 1.--Molucca albizzia trees and flitches prepared for shipment M 125 754



Five trees were sampled. Sample trees ranged from 19 to 32 inches in diameter at breast height (d.b.h.) and from 84 to 145 feet high; merchantable height ranged from 58 to 82 feet. All trees were 36 years old. Incipient decay was noted in the heart of three of the trees, and logs from two of the trees had split ends which were probably a result of growth stresses.

A 6-inch-thick section containing the pith was cut from an 8-foot log generally representing the 8- to 16-foot height of each tree. Similar sections were cut from the 8-foot-butt log and the log representing the 32- to 40-foot height of one of the trees. Sections were marked, then brush-coated with a 5 percent solution of penta-chlorophenol. All bare surfaces were coated with

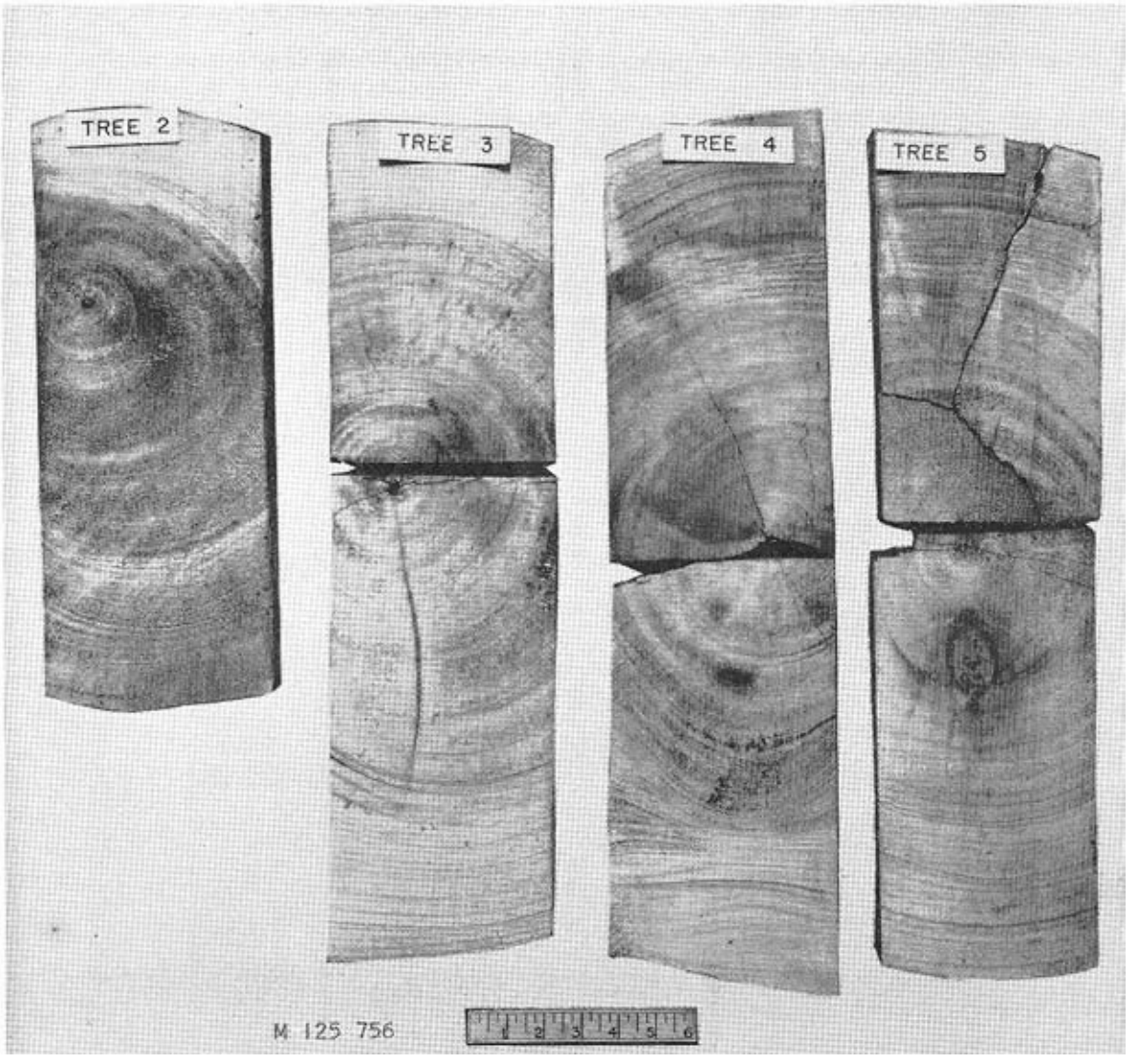
Figure 2.--Cross sections of Molucca albizzia flitches from sample tree No. I.



an emulsified wax.

Representative pictures of standing trees and prepared sections are shown in figure 1. Three flitches had to be split because of size. Cross sections of flitches from the five sample trees are shown in figures 2 and 3.

Figure 3.--Cross sections of Molucca albizzia flitches from sample trees Nos. 2, 3, 4, and 5.



PROCEDURES

In general, standard methods[6] were used in determining properties of Molucca albizzia. A random method was used for selecting specimens for strength tests, and a different specimen was used lor determining volumetric shrinkage.

Volumetric shrinkage specimens consisted of a 1-inch-long cross section, cut about 6 inches from the top end of each flitch. An adjacent cross section was used for radial and tangential shrinkage specimens.

[6] American Society for Testing and Materials. Standard methods of testing small clear specimens of timber. ASTM D 143-52. 1952.

The remainder of each flitch was ripped into 2-1/2-inch-square sticks from locations corresponding to the standard cruciform pattern. Eight sticks from each flitch were randomly selected--four for green specimens and four for air-dry specimens. Static bending, toughness, compression parallel and perpendicular to grain, hardness, and shear specimens were cut from each stick. In addition, four specimens 1-inch square by 10-inches long were obtained for determining longitudinal shrinkage.

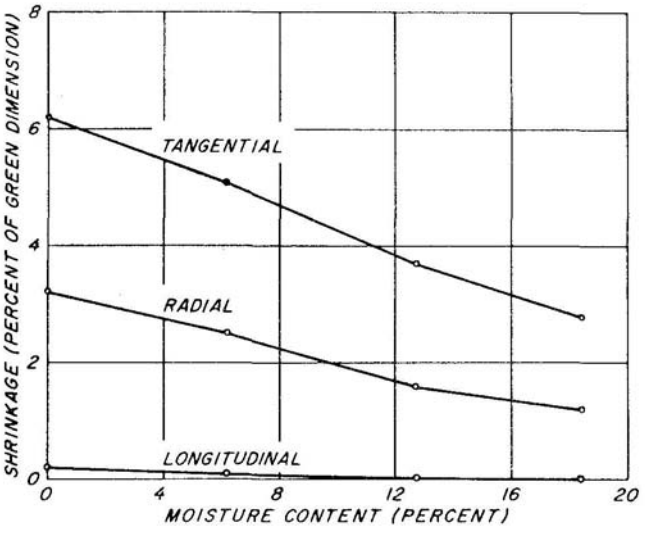
Volumetric shrinkage was determined from green to ovendry. Radial, tangential, and longitudinal shrinkages were measured at about 18, 13, 6, and 0 percent moisture content.

PRESENTATION OF RESULTS

Data on physical properties are presented in table 1 and data on mechanical properties in table 2 as averages for each bolt and as the species average (average for the live "c-d" or equivalent height flitches). Data on variations of those properties are presented in table 3. Similar data for certain Mainland species are included in the tables for comparison.

Average shrinkage-moisture relationships obtained from data given in table 1 are shown in figure 4.

Figure 4.--Average shrinkage-moisture relationships for Molucca albizzia grown in Hawaii.



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DISCUSSION OF RESULTS

Specific gravity of the Molucca albizzia sample averaged 0.32 for green wood and 0.33 for air-dry wood. Thus, the wood can be classed as comparatively light in weight.[7] It is directly comparable in density to American basswood (Tilia americana), black cottonwood (Populus trichocarpa), and Engelmann spruce (Picea engelmannii). The range in specific gravity for the Molucca albizzia sample, given as coefficient of variation in table 3, is essentially comparable to the average determined for samples of several Mainland species.[8]

Average shrinkage of Molucca albizzia from green to ovendry is lower, in general, than that of any of the four Mainland species shown in table 1 for comparison, but it is essentially comparable to shrinkage of Engelmann spruce and ponderosa pine (Pinus ponderosa), both of which have moderately small shrinkage.

Average "shrinkage" fiber-saturation point of Molucca albizzia may be estimated from shrinkage-moisture relationships shown in figure 4 by extrapolating to zero shrinkage. The moisture content of the fiber saturation point estimated from radial shrinkage data is about 28 percent and from tangential shrinkage data is about 32 percent. The fiber saturation point is accepted as about 30 percent moisture content.[8]

Radial shrinkage of Molucca albizzia, though not as high, is more variable than tangential shrinkage. This can be seen by comparing average flitch values in table 1 and values for coefficient of variation in table 3. The coefficient of variation for tangential shrinkage is comparable to the average for samples of many Mainland species, but the coefficient of variation for radial shrinkage is about twice the normal.

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[7] U.S. Forest Products Laboratory. Standard terms for describing wood. Forest Products Lab. Rpt. 1169, 2 pp., tables. 1961.

[8] U.S. Forest Products Laboratory. Wood Handbook. U.S. Dept. Agr., Agr. Handb. 72, 528 pp., illus. 1955.

Table 1.--Shrinkage and specific gravity of Molucca albizzia grown in Hawaii and of four Mainland species for comparison

Species	Sample tree number	Bolt	Specific gravity[1]	Shrinkage from green condition to equilibrium at--															
				80° F., 80 percent relative humidity				80° F., 65 percent relative humidity				80° F., 30 percent relative humidity				Ovendry			
				Moisture content	Radial	Tangential	Longitudinal	Moisture content	Radial	Tangential	Longitudinal	Moisture content	Radial	Tangential	Longitudinal	Radial	Tangential	Longitudinal	Volumetric
				Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Molucca albizzia (Albizia falcata)	1	c-d	0.35	18.3	1.6	2.8	0.03	12.6	2.3	3.9	0.08	6.0	3.3	5.4	0.17	4.4	6.4	0.30	9.8
	2	c-d	.29	18.1	.8	2.6	.01	12.7	1.2	3.7	.04	6.2	1.9	5.0	.11	2.4	6.0	.21	9.7
	3	c-d	.32	18.7	1.1	3.2	.01	12.8	1.4	3.9	.02	6.4	2.2	5.5	.07	2.9	6.6	.16	9.1
	4	b-c	.30	18.4	1.1	2.8	.00	12.5	1.4	3.5	.02	6.3	2.2	4.9	.08	2.9	5.9	.17	9.2
	5	c-d	.32	18.8	1.3	2.7	.00	12.8	1.8	3.6	.02	6.3	2.8	4.6	.07	3.5	6.1	.15	9.5
Average	.....	...	.32	18.4	1.2	2.8	.01	12.7	1.6	3.7	.04	6.2	2.5	5.1	.10	3.2	6.2	.20	9.5
	1	a-b	.32	18.4	1.0	2.8	.01	12.7	1.7	4.3	.05	6.0	2.6	6.0	.13	3.4	7.1	.25	10.5
	1	i-j	.34	18.4	.9	1.8	.06	12.7	1.4	3.9	.11	6.1	2.3	5.6	.23	2.9	6.7	.40	9.3
Species from the Mainland[2]																			
American basswood (Tilia americana)	.....	...	.32	....	...	...	....	.....	...	...	.....	...	...	...	.....	6.6	9.3	....	15.8
Black cottonwood (Populus trichocarpa)	.....	...	.32	....	...	...	....	.....	...	...	.....	...	...	...	.....	3.6	8.6	....	12.4
Ponderosa pine (Pinus ponderosa)	.....	...	.38	....	...	...	....	.....	...	...	.....	...	...	...	.....	3.9	6.3	....	9.6
Engelmann spruce (Picea engelmannii)	.....	...	.32	....	...	...	....	.....	...	...	.....	...	...	...	.....	3.4	6.6	....	10.4

[1] Based on green volume and ovendry weight.
[2] From U.S.D.A. Agr. Handb. 72, "Wood Handbook," 1955.

Table 2.--Mechanical properties of Molucca albizzia grown in Hawaii and of four Mainland species for comparison

Species	Sample tree number	Bolt	Moisture content	Specific gravity[1]	Static bending					Toughness		Compression parallel to grain			Compression perpendicular to grain--stress at proportional limit	Hardness		Maximum shearing strength
					Stress at proportional limit	Modulus of elasticity	Modulus of rupture	Work to -		Radial	Tangential	Stress at proportional limit	Modulus of elasticity	Maximum crushing strength		End	Side	
								Proportional limit	Maximum load									
			Pct.		P.s.i.	1,000 p.s.i.	P.s.i.	in.-lb. per cu. in.	in.-lb. per cu. in.	in.-lb.	in.-lb.	P.s.i.	1,000 p.s.i.	P.s.i.	P.s.i.	Lb.	Lb.	P.s.i.
Molucca albizzia (Albizia falcata)	1	c-d	55	0.35	3,900	1,140	6,000	0.75	5.5	300	290	2,000	1,390	2,770	280	450	420	940
			12	.36	5,700	1,370	9,400	1.36	9.8	220	220	2,140	1,560	4,530	470	640	550	1,280
	2	c-d	53	.29	2,400	840	3,900	.38	3.7	250	250	1,460	1,160	2,300	190	390	300	700
			12	.32	4,200	1,150	7,900	.85	7.0	160	130	1,980	1,310	3,830	400	540	420	1,080
	3	c-d	48	.32	4,000	1,140	5,900	.77	6.2	270	290	2,150	1,410	2,700	220	480	410	800
			12	.32	4,700	1,270	8,200	.98	9.3	180	190	2,380	1,430	4,560	390	540	440	1,110
	4	b-c	69	.30	3,700	1,190	5,700	.65	5.4	220	210	1,860	1,350	2,600	210	360	310	770
			12	.29	4,100	1,210	7,400	.77	8.2	190	160	2,610	1,430	4,360	300	490	330	970
	5	c-d	61	.32	3,200	1,090	5,300	.59	6.9	220	220	1,950	1,360	2,680	240	390	360	800
			12	.36	5,400	1,400	9,100	1.20	8.9	210	220	2,940	1,540	5,060	420	650	510	1,180
Average, green	...	...	57	.32	3,400	1,080	5,300	.63	5.5	250	250	1,880	1,340	2,610	230	410	360	800
Average, air-dry	...	...	12	.33	4,800	1,280	8,400	1.04	8.7	190	180	2,420	1,460	4,490	400	580	450	1,130
	1	a-b	108	.32	3,200	1,160	5,500	.49	6.7	220	220	1,750	1,380	2,660	240	400	390	770
			12	.34	4,900	1,340	8,900	1.02	10.7	230	210	2,680	1,550	4,690	380	600	410	1,270
	1	i-j	46	.34	3,300	1,120	5,700	.59	5.3	310	270	2,320	1,490	2,990	260	410	370	750
			12	.36	6,600	1,460	10,300	1.68	9.0	220	250	3,080	1,680	5,160	440	680	510	1,290
Species from the Mainland[2]																		
American basswood (Tilia americana)	...	...	105	.32	2,700	1,040	5,000	.40	5.3	...	...	1,690	.....	2,220	170	290	250	600
	...	...	12	.37	5,900	1,460	8,700	1.37	7.2	...	...	3,800	.....	4,730	370	520	410	990
Black cottonwood (Populus trichocarpa)	...	...	132	.32	2,900	1,070	4,800	.44	5.0	...	...	1,760	.....	2,160	160	280	250	600
	...	...	12	.35	5,300	1,260	8,300	1.25	6.7	...	...	3,270	.....	4,420	300	540	350	1,020
Ponderosa pine (Pinus ponderosa)	...	...	91	.38	3,100	970	5,000	.59	5.1	...	...	2,070	.....	2,400	280	300	310	680
			12	.40	6,300	1,260	9,200	1.85	6.6	...	...	4,060	.....	5,270	580	550	450	1,160
Engelmann spruce (Picea engelmannii)	...	...	80	.32	2,600	960	4,500	.42	5.1	...	...	1,850	.....	2,190	220	310	260	590
	...	...	12	.34	5,500	1,280	8,700	1.34	6.4	...	...	3,580	.....	4,770	470	560	350	1,030

[1] Based on volume at test and ovendry weight.
[2] From U.S.D.A. Agr. Handb. 72, "Wood Handbook," 1955.

Table 3.--Variationof data on strength and related properties of Molucca albizzia grown in Hawaii (green condition)[1]

Property	Number of specimens	Mean	Standard error of mean	Coefficient of variation	Coefficient of variation of 50 species[2]	Units for columns 3 and 4
(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Pct.	Pct.	
Specific gravity[3]	20	0.318	0.008	11.7	10	.....
Shrinkage[4]						
Radial	19	3.25	.21	27.7	15	Pct.
Tangential	19	6.22	.21	14.7	14	Pct.
Longitudinal	16	.191	.017	35.5	....	Pct.
Static bending						
Stress at proportional limit	18	3,473	189	23.1	22	P.s.i.
Modulus of elasticity	18	1,091	38	14.8	22	1,000 p.s.i.
Modulus of rupture	18	5,381	240	18.9	16	P.s.i.
Work to proportional limit	18	.634	.055	36.8	38	In.-lb. per cu. in.
Work to maximum load	18	5.64	.50	37.9	38	In.-lb. per cu. in.
Toughness						
Radial	18	249	13	21.4	....	In.-lb.
Tangential	18	248	13	21.6	....	In.-lb.
Compression parallel to grain						
Stress at proportional limit	16	1,931	105	21.7	24	P.s.i.
Modulus of elasticity	18	1,341	50	15.7	29	1,000 p.s.i.
Maximum crushing strength	17	2,613	79	12.5	18	P.s.i.
Compression perpendicular to grain						
Stress at proportional limit	20	228	15	29.8	28	P.s.i.
Hardness						
End	20	414	20	21.9	17	Lb.
Side	20	316	20	24.6	20	Lb.
Shear parallel to grain						
Maximum shearing strength	38	808	27	20.4	14	P.s.i.

[1] Based on specimens from c-d bolts or equivalent.
[2] From U.S.D.A. Agr. Handb. 72, "Wood Handbook," 1955.
[3] Green volume and ovendry weight.
[4] Green to ovendry.

The average mechanical properties of Molucca albizzia shown in table 2 are generally good for wood of such low density. For example, green Molucca albizzia has relatively high hardness and strength in shear and crushing parallel to grain, and somewhat high static bending properties in comparison to properties of the four species listed for comparison. Except for shear strength, hardness, and work to maximum load in static bending, properties of air-dry Molucca albizzia do not compare so favorably; however, this is probably due to the relatively low specific gravity of the air-dry Molucca albizzia.

Based on the average mechanical properties given in table 2, Molucca albizzia may be classified as moderately weak in bending or compressive strength, moderately soft, and moderately limber,--the same, in general, as for ponderosa pine.[7]

As for specific gravity, data on variability of mechanical properties given in table 3 generally follow expected trends. Modulus of elasticity and maximum crushing strength, however, show considerably lower variability than the normal.

It should be noted that specimens used in this study were typically straight grained and free of strength-reducing characteristics. Interlocked grain, though noted in specimens from three of the trees, was rather shallow. This is incontrast to the description previously given for Malayan wood.[5] Although growth stresses may have been present, there was little evidence of pre-existing compression failures in the material. Since some of the trees had incipient decay, specimens were cut to avoid such areas as much as possible. The relatively high results for "work to maximum load" indicate that decay was avoided.

CONCLUSIONS

Wood of Molucca albizzia grown in Hawaii is light in weight. It is moderately weak in bending or compressive strength, moderately soft, and moderately limber, but somewhat above average in those properties for its density. Its shrinkage is about normal for its density.