Basic Data for Oregon Hardwoods

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Report No. G2
October 1953

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BASIC DATA
FOR
OREGON HARDWOODS

INTRODUCTION

Pacific Coast hardwoods have been considered inferior to species from other regions. Two reasons for this attitude on the part of consumers have been poor quality of manufacturing, and lack of a regular supply. Other reasons are lack of a uniform lumber-grading system and lack of knowledge concerning the availability and suitability of these hardwoods for various uses.

Increased knowledge of Oregon hardwoods should lead to greater confidence in these species by producers, distributors and users. The properties of wood from native species are similar to properties of some commonly used woods from other regions, which indicates the suitability of Oregon woods for similar uses. Information concerning twelve Oregon hardwoods is included in condensed form. Species are described, and various properties of the different woods are delineated.

Prospective operators, distributors, and consumers should obtain background information concerning the manufacture and use of hardwood lumber, since hardwood milling is in many ways different from that of fir or pine. Some general information is included on grading and sawing of hardwood logs and lumber. Publications in the bibliography provide more background information, as well as specific facts concerning Oregon species.

The information included in this report has been compiled from so many sources that no attempt will be made to list all contributors. Their assistance is freely acknowledged, however, as without it, the assembling of these data would have been impossible.

DESCRIPTION OF SPECIES

A brief description is given in this section for each of the following species: Red alder, bigleaf maple, Oregon ash, chinquapin, black cottonwood, Pacific madrone, California black oak, Oregon white oak, California laurel, tanoak, Pacific dogwood, and canyon live oak.

Red alder (*Alnus rubra*, Bong.)

Timber characteristics

Average height, from 30 to 100 feet; diameter breast high, from 10 to 30 inches. Maturity is generally considered to be at about 50 to 60 years, shortly after which serious rot often develops.

A fast-growing tree, reaching its best development on moist sites near streams or river bottoms where it generally forms pure even-aged stands; also forms pure stands on many hillsides and valleys where conifers have been logged or burned off.

A prolific seeder, and prunes itself quite well beginning at an early age. Clear cutting is usually the recommended cutting practice.

Range

From Alaska to Southern California; best in Washington and Oregon, usually within 60 miles of the coast. Altitudinal range up to 7000 feet, but optimum growth conditions at elevations up to 2500 feet.

Wood properties

Color when first sawed is whitish; on drying takes on a light yellowish- or reddish-brown color which planes off to light brown with a reddish tinge. Heartwood indistinct.

Works easily, finishes smooth and has a pleasing grain. Because of tendency to resist splitting, is used extensively in upholstered furniture. May be made to resemble more expensive woods by means of special finishes. Has good dimensional stability when dry, but is not durable when exposed to conditions favoring decay.

Uses

Furniture, core stock, woodenware and novelties, millwork, paper roll plugs, and wall paneling. Is expected to be used in the future for sulfate pulp.

Bigleaf maple (Acer macrophyllum, Pursh.)

Timber characteristics

Average height, from 30 to 100 feet; diameter breast high, from 2 to 3 feet. Maximum recorded d.b.h.; 8 feet, 11 inches.* Best on moist, gravelly, rich soils of Oregon and Washington and usually found along margins of foothills and low mountain streams, in alluvial river bottoms, or on well-watered slopes. While sometimes in almost pure stands, is usually in mixture with conifers and other hardwoods. According to dendrologists rapid growth is achieved during the first half-century but growth tends to slow down afterward until maturity at about one hundred years. Open-grown trees have short trunks, while those in dense stands produce timber clear of branches for from 1/2 to 2/3 of their height.

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* Reference 73, bibliography.

Range

From southeastern Alaska through western Washington and Oregon to southern California. Also along the western slopes of the Cascades and Sierra Nevada Mountains in Washington, Oregon and California.

Wood properties

Similar to that of eastern soft maples, being comparable to both silver and red maple. Pinkish to light brown in color, usually fine- and straight-grained; frequently found with quilted, curly or birds-eye figures. Often stained to imitate mahogany or walnut, but since it has extremely attractive figures, could well stand on its own distinctive merits.

Uses

Well suited to the manufacture of furniture, for which it is used extensively in the Pacific Northwest. Suited to any of the purposes for which silver or red maple are used. Wood is being used for flooring; burls are used for face veneers.

Oregon ash, (Fraxinus oregona, Nutt.)

Timber characteristics

Average height, from 60 to 80 feet; diameter breast high, from 16 to 30 inches. Maximum recorded d.b.h.; 5 feet, 8 inches. In rich bottomland sites with plenty of moisture, although often found growing vigorously on moist, sandy, gravelly or rocky sites. Usually found in mixture with other hardwoods and softwoods. Growth rate moderately rapid for the first 60 to 100 years. Fairly tolerant during its seedling stage, although decidedly intolerant after the sapling stage. Trees shaded for extended periods of time are able to resume a normal rate of growth soon after being released.

Range

From the southern coastal area of British Columbia, southward along the coast to San Francisco Bay, and even as far south as the lower western slopes of the Sierras in Southern California. In Oregon usually in the valleys west of the Cascades, especially in the Willamette River bottomlands near Portland, on the Columbia River flats between McClure and The Dalles, in Cascade (North) National Forest, in Bear Creek, and other valleys of the Siskiyou National Forest.

Wood properties

Slightly lighter in weight than the eastern ashes, but in general appearance, quality and strength compares closely with them. The sapwood nearly white and quite wide; the heartwood grayish brown, brown, or yellowish brown. Somewhat lustrous, without characteristic odor or taste, straight-grained, heavy, hard, and stiff. Excellent for handle stock.

Uses

Furniture, handles and oars at the present time, although it has many properties that make it well suited to uses such as sporting equipment and slack cooperage. Makes excellent flooring.

Chinquapin (Castanopsis chrysophylla, Hook., D. C.)

Timber characteristics

Average height, from 60 to 80 feet; diameter breast high, from 18 to 30 inches. Maximum recorded height, 127 feet; d.b.h., 4 feet, 10 inches.

Mountain slopes, sheltered ravines and valleys, slopes of canyons and gulches. In dry rocky and gravelly soils. In dense, pure thickets over large areas, interspersed with low-growing forms of oak, juniper and pine. Largest in valleys of

northwestern California and southwestern Oregon; small or shrubby at high levels elsewhere. Said to be one of the best-formed hardwoods on the west coast. Early growth rapid. Often found in mixture with conifers and other hardwoods.

Range

Best development in southwestern Oregon and northwestern California. Also found in the southwestern part of Washington, through the western part of Oregon and California.

Wood properties

Sapwood narrow, light brown with a pinkish tinge; sometimes difficult to distinguish from the heartwood, although somewhat lighter. Ring porous, glues well, readily worked with all kinds of tools, and takes a good finish.

Recent tests in Mississippi and Wisconsin by the U. S. Forest Products Laboratory indicate that the wood is of somewhat more than moderate durability.

Uses

At present, none, but potentially useful for furniture, cabinet work, paneling, caskets, veneer, and possibly boats because of its reportedly good durability.

Black cottonwood (Populus trichocarpa hastata, Henry)

Timber characteristics

Average height, from 40 to 100 feet; diameter breast high, from 24 to 36 inches. Maximum recorded height, 225 feet; d.b.h., 8 feet. Maturity around 150 to 200 years.

At lower levels on river bottoms, sand bars and banks. At higher levels in canyon bottoms. In belts and limited forests of pure growth, or in mixture with conifers and other hardwoods. Chiefly on moist, sandy, gravelly, or deep alluvial soils. Intolerant to shade.

Range — West Coast and Inland Empire.

Wood properties — Sapwood whitish, often merging into the heartwood and not always clearly defined; both thick and thin in different trees. Heartwood grayish white to light grayish brown or full brown. Usually straight-grained and with little figure. Easy to moderately hard to work with tools, easy to glue, takes paint moderately well, low in nailholding ability, very low in durability, resistant to splitting when nailed.

Uses — Pulp for high-grade book and magazine paper; excelsior; containers; matches. Lumber for boxes and crates, dairy, poultry, and apiary supplies; furniture (concealed parts); laundry appliances; tubs and pails for butter, lard, and other food products. Much cottonwood veneer made for containers.

Pacific madrone (Arbutus mensiesii, Pursh.)

Timber characteristics — Average height, from 20 to 100 feet; diameter breast high, from 1 to 4 feet. Maximum recorded height, 125 feet; d.b.h., 8 feet, 10 inches. Maximum age, from 100 to 500 years. Moderately tolerant of shade. Said to reach sawlog size in 50 to 60 years, although often quite crooked.
Best development on well-drained soils near sea level. Often in nearly pure stands, although in much greater abundance as an understory species in Douglas-fir and redwood forests, or in association with other conifers and hardwoods.

Range — Coastal British Columbia, south through western Washington and Oregon to southern California. Both in the coast ranges and

western Sierras in California below 4000 feet elevation. Perhaps of greatest potential commercial importance in southwestern Oregon and northwestern California.

Wood properties

Pale reddish brown, well figured, with thin, whitish sapwood. Fine grained, diffuse porous. Resembles black cherry to some extent. Easily worked with tools and takes an excellent finish. Hard, heavy and strong.

Uses

Suitable for fine furniture and cabinet work, and a possible substitute for dogwood for shuttles in the textile industry. Present use is limited; some excellent charcoal is made in southwestern Oregon. Is potentially most desirable wherever a fine-grained, attractive and good-machining wood is required. Makes handsomely figured veneer when peeled.

California black oak (Quercus kelloggii, Newb.)

Timber characteristics

Average height, from 50 to 75 feet; diameter breast high, from 15 to 30 inches. Maximum recorded d.b.h., 11 feet, 6 inches. On mountain slopes, benches, valleys; in canyon bottoms and lower sides, and on upper foothill slopes; in dry gravelly and sandy soils, or in very rocky places with scanty soil.

In either open groves or limited pure stands; singly at lower levels with conifers and other hardwoods. Largest in ponderosa pine belt on sheltered benches, valleys, and coves; and smallest on exposed high slopes. Moderately shade tolerant in early life, but requires full overhead light for good growth later.

Range — Central western Oregon, in mountains, southward through California; in coast ranges and west slopes of Sierras nearly to Mexican border.

Wood properties — Ring porous, classified as a red oak in character; fine grained, pale reddish in color. Easily worked with tools. Hard, heavy and strong.

Uses — Potentially useful for furniture, flooring and other uses where red oaks are suitable. At the present time used locally for fuel, but only to a very limited extent.

Oregon white oak (Quercus garryana, Dougl.)

Timber characteristics — Average height, from 50 to 60 feet; diameter breast high, from 18 to 30 inches. Maximum recorded height, 120 feet; d.b.h., 8 feet. In alluvial high bottoms, valleys and prairies; dry hill and (north) mountain slopes. Also, in deep, fresh, humous soils and in dry, gravelly or rocky soils. Largest in western Washington and Oregon. Not infrequently in small pure stands in areas of best development.

Range — Southwestern British Columbia southward through western Washington and Oregon into the coast ranges of northern and central California.

Wood properties — Pale yellowish brown in color, usually with a greenish cast to the heartwood, with a narrow and lighter sapwood. Easily worked with tools and takes an excellent finish. Hard, heavy and strong.

Uses — Limited use at present, but suitable for furniture, flooring, cooperage, cabinet work, interior finish, ship construction, building lumber, woodenware and novelties, and many other uses for which eastern white oak is employed.

California laurel (Umbellularia californica, Nutt.)

Timber characteristics

Average height, from 20 to 80 feet; diameter breast high, from 1 to 3 feet. Maximum recorded height, 175 feet; d.b.h., 11 feet, 8 inches. In dense forests has clean, straight trunks. Sawlog size sometimes reached in 60 years, although usually slower growing.

Borders and vicinity of higher foothill streams, spring-watered gulches, river bottoms, lower mountain slopes and canyons; in moist gravelly, rocky, or rich humus soil. Constant and abundant soil moisture is essential. Occurs as small dense clumps or patches, and single scattered trees or in groups with other hardwoods.

The tree California laurel (official U. S. Forest Service designation) is of the family Lauraceae and is not related to the myrtle tree (Myrtus communis) of the family Myrtaceae of the Holy Land and the Mediterranean region.

Range

In California west of the Sierras and in southwestern Oregon, where it is usually known as Oregon myrtle.

Wood properties

Sapwood whitish to light brown, thick; heartwood light rich brown to grayish brown; often found with dark, sometimes black figures, together with handsome grain irregularities such as burls. Diffuse porous, fine grained, with a pleasant figure, even on fast-growing trees where the grain is straighter. Durability is fair, but is subject to attack by powder-post and other beetles. Easily worked with tools and takes an excellent finish.

Fast-growing trees, which are straight grained, seldom have the dark streaks of color and burls which are desirable for use in the novelty industry. This type of timber is referred to as "white myrtle" in the trade. White myrtle also includes the sapwood.

Uses

Present use is mainly for novelties and gun stocks, but is suitable for veneer, furniture, cabinet work, paneling and interior trim, and many other uses where a fine-grained or decorative wood is desired. Has been used for keel blocks in ship building.

Tanoak (Lithocarpus densiflorus, Rehd.)

Timber characteristics

Average height, from 70 to 90 feet; diameter breast high, from 1 to 3 feet. Maximum recorded height, 150 feet; d.b.h., 8 feet. Said to reach sawlog size in about 60 to 80 years. Valleys and low slopes, borders of low mountain and foothill streams, coves and ravines; in rich, moist, sandy and gravelly soils. Sometimes in nearly pure small stands, but chiefly in mixture with redwood and Douglas-fir. Can exist under forest cover throughout its life; quick to recover when released from dense shade.

Range

Southern Oregon, south along the Coast Ranges to the Santa Ynez Mountains in California; south in the Sierras to Mariposa County, California. Altitudinal distribution; from sea-level to nearly 5000 feet.

Wood properties

Light reddish brown when first exposed, turning darker with age; sapwood wide, and difficult to distinguish from the heartwood. Diffuse porous. Durability generally considered

to be low because of the large amount of sapwood; however, because of this sapwood it can be treated with preservatives quite easily.* Shrinkage in drying (based on experience at this Laboratory) only moderate when collapse is not evident. Resembles the true oaks in appearance and finish and equal to them in most instances, although it actually does not belong to the oak genus. Works easily with tools and capable of taking an excellent finish. Hard, heavy and strong.

Uses

None at present, except for its bark. Holds much promise as a furniture and cabinet wood, as flooring and ship timbers (when impregnated with preservatives) and the hundreds of other uses for which eastern oaks are utilized at the present time.

The bark contains about 20 per cent (dry weight basis) of tannin and has been the principal commercial source of this material on the Pacific Coast for many years. At the present time the trees are cut, the bark peeled, and the wood left to decay in the forest. One operator reports that he has been cutting tanoak for the bark alone for the past 45 years at the rate of about 10 million fbm per year.

Pacific dogwood (Cornus nuttalli, Aud.)

Timber characteristics

Average height, from 20 to 30 feet; diameter breast high, from 6 to 12 inches. Maximum recorded height, 100 feet; d.b.h., 2 feet, 2 inches. Low bottoms, lower gentle mountain

* Reference 70

slopes, valleys, coves, ravines, borders, and well-drained bottoms near mountain streams; in rich, fresh, loamy, gravelly, or rocky soils; largest in fresh, porous soils. Found in mixture, either singly or in small groups, under Douglas-fir and other conifers and hardwoods. Best development is reported in the Puget Sound basin and in the redwood belt of California. No estimate has been made, to this Laboratory's knowledge, of the available volume.

Range

Southwestern British Columbia and south into California in the coast ranges of the San Bernardino Mountains and the western slopes of the Sierra Nevada.

Wood properties

Pale reddish to reddish brown, dense, fine grained, with thick sapwood. Hard, strong and tough.

Uses

Almost entirely neglected at present, although suitable for turning and small cabinet work. Is undergoing service tests as shuttles in the east as a possible substitute for flowering dogwood and common persimmon, now used extensively for shuttles, spools, and bobbins in the textile industry.

Canyon live oak (Quercus chrysolepis, Liebm.)

Timber characteristics

Average height, from 30 to 80 feet; diameter breast high, from 1 to 5 feet. Maximum recorded height, 60 feet; d.b.h., 11 feet, 6 inches.

Commonly in narrow canyon bottoms and their steep slopes, coves, and sheltered depressions, on dry, sandy and gravelly soils; or on exposed slopes, in broken rock and crevices. Largest in rich humus soils of sheltered canyon bottoms.

Sometimes in small pure clumps or patches, but usually in mixture with California black oak and live oaks; occasionally with ponderosa pine and incense cedar. Endures heavy shade, especially during its early life.

Range — Southwestern Oregon, south through the coast ranges and west slopes of the Sierras to lower California; eastward through the mountainous regions of central and southern Arizona and southwestern New Mexico.

Wood properties — Light-brown color, variable in grain from fine to coarse, very heavy, stiff, tough, and strong.

Uses — Formerly used for wagon tongues, wagon wheel stock, and whiffle trees. At present is used only to a limited extent for falling wedges. May have limited potential use for specialty products.

STAND VOLUMES

The volume figures available for the hardwoods of the Pacific Coast were compiled by the United States Forest Service. Data for the state of Oregon are given by counties in Table 1. The locations of the principal hardwood stands of the state are shown in Figure 1. An estimate of the hardwood timber for the state of Washington places the volume at from one to two billion board feet. While the hardwood volume for the state of California has never been published officially by the U. S. Forest Service, it has been estimated for the northwestern counties to be about four billion board feet.

These values are considered by many to be conservative and they are not impressive when compared with volumes of softwoods in the same areas. However, nowhere in the country are hardwoods cut in amounts approaching the volumes of

softwoods cut in many western sawmills. To gain a better picture of the western hardwood stands, volume should be compared to eastern hardwoods. Table 2 summarizes the comparative hardwood sawtimber volumes on commercial forest land in states which include some of the major hardwood-producing areas. Also, the hardwood volume estimates for the eastern states are probably quite accurate since hardwoods have long been used there, while the volume estimates of West Coast hardwoods are believed to be low.

STRENGTH AND RELATED PROPERTIES

Table 3 presents values for physical properties of the major hardwood species of the west coast, and selected eastern species with similar qualities. For many purposes, western hardwoods could be used interchangeably with eastern woods which are similar in physical properties.

Table 1. * Hardwood Saw-timber Volume Estimates for Oregon.

County	Red alder	Oregon ash	Chinquapin	Black cottonwood	Pacific madrone	Bigleaf maple	California black oak	Canyon live oak	Oregon white oak	California laurel (myrtle)	Tanoak	County hardwood volume
	millions of board feet											
Benton	1.6	1.1		1.4		5.1			1.0			10.2
Clackamas	6.2	0.6		7.0		3.9						17.7
Clatsop	36.0					13.2						49.2
Columbia	3.8			13.0		5.4						22.2
Coos	498.1		48.0		0.5	204.0				37.2	7.6	795.4
Curry	124.5				147.8	109.6		2.0		21.2	833.2	1,238.3
Douglas	332.4		10.0		138.0	56.7	21.4		30.2			588.7
Hood River				8.7								8.7
Jackson	0.8				1.2	1.8	50.9		5.5			60.2
Jefferson				1.2								1.2
Josephine	40.9		3.9		137.8	7.5	201.2	15.8	9.1		29.7	445.9
Lane	108.3	3.0		29.0		172.0			2.6			314.9
Lincoln	187.1					5.2						192.3
Linn	11.0			15.1		50.3						76.4
Marion	4.1	1.0		7.0		19.1						31.2
Multnomah	2.0			10.6		4.0						16.6
Polk	5.0	2.0		0.7		11.9			0.4			20.0
Tillamook	155.0					6.1						161.1
Wasco				1.0								1.0
Washington	3.2	2.1		0.5		3.0			0.5			9.3
Yamhill	9.0	9.3		4.1		14.0			6.0			42.4
TOTAL	1,529.0	19.1	61.9	99.3	425.3	692.8	273.5	17.8	55.3	58.4	870.5	4,102.9

* Estimates taken from U.S. Forest Service publications Forest Statistics for Southwest Oregon Unit, November 1951 and Saw-Timber Volume Estimates For Oregon and Washington, May 1948. Both publications are available from the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Saw-timber volume includes those trees 11. inches d.b.h. or larger containing at least one 16-foot log to a variable top diameter inside bark approximating 40 per cent of d.b.h. but never less than 8 inches, and in which one-third or more of the gross board-foot volume is free from rot and defect.

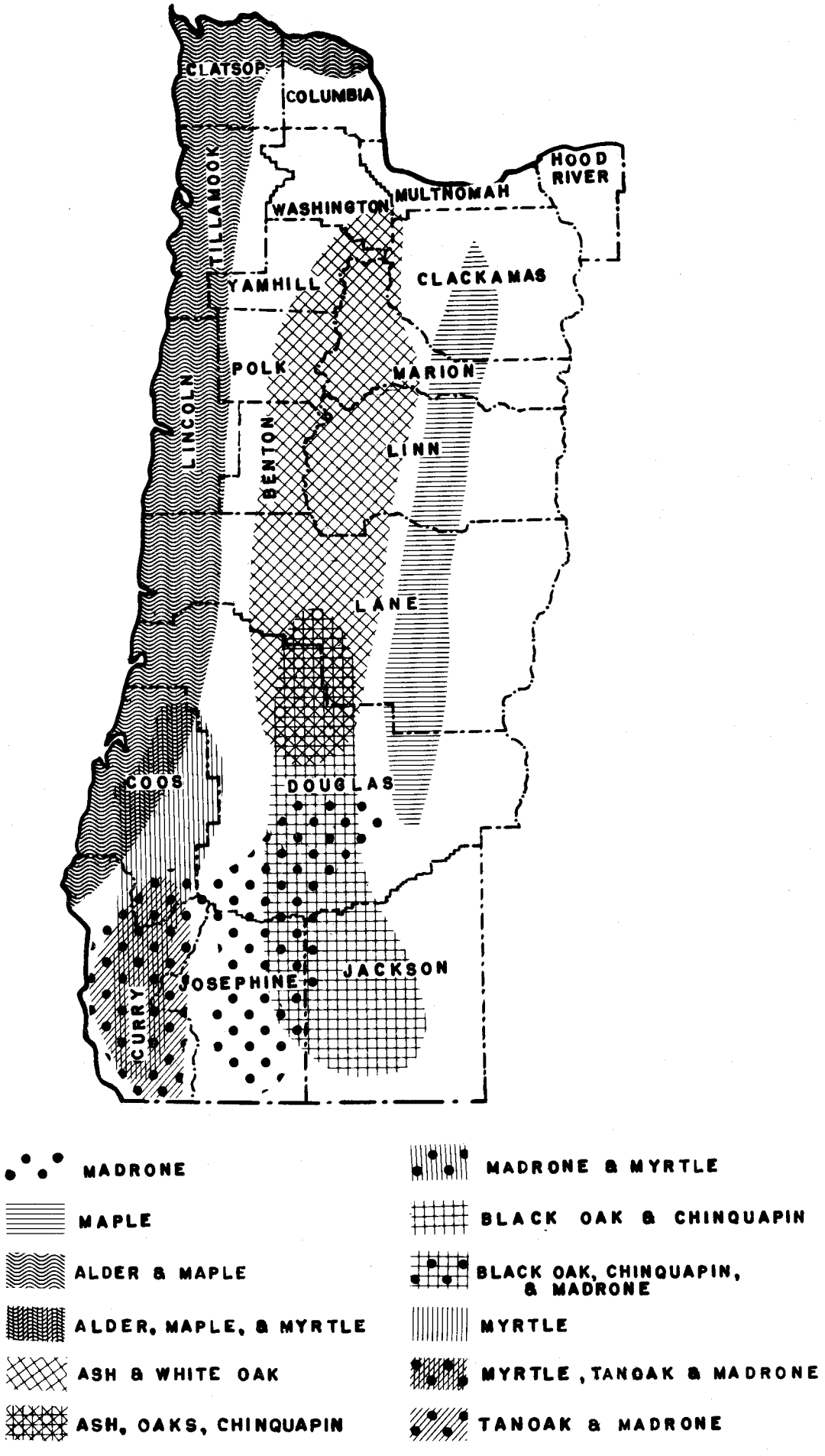


FIGURE 1. PRINCIPAL HARDWOOD TIMBER STANDS OF WESTERN OREGON.

Table 2. Hardwood Sawtimber Volume on Commercial Forest Land in the U. S. in States of Comparable Commercial Forest Land Area.

State	Volume	Area
	Millions of fbm	Thousands of acres
Maine	12,508	16,665
Pennsylvania	17,495	15,127
Minnesota	6,650	16,700
Wisconsin	11,650	16,265
Missouri	11,169	15,074
North Carolina	14,279	17,997
Alabama	12,680	18,800
Florida	4,717	21,451
Georgia	11,602	21,107
Mississippi	16,949	16,509
Arkansas	15,213	19,928
Louisiana	22,965	16,169
Oregon	4,103*	15,615 (Douglas-fir region only)

* It is estimated that there are 3,128,000 fbm of hardwoods on approximately 7 million acres of forest land in southwestern Oregon (Coos, Douglas, Curry, Josephine and Jackson counties).

TABLE 3. STRENGTH AND RELATED PROPERTIES OF OREGON HARDWOODS COMPARED WITH EASTERN SPECIES[a]

Species (common and botanical names)	Place of growth of material tested	Moisture condition	Moisture content	Specific gravity, oven dry, based on volume —		Weight per cubic foot	Shrinkage from green to oven dry condition based on dimensions when green			Static bending						Impact bending			Compression parallel to grain		Compression perpendicular to grain; fiber stress at proportional limit	Hardness; load required to embed a 0.444 in. ball to ½ its diameter		Shear parallel to grain; maximum shearing strength	Cleavage; load to cause splitting	Tension perpendicular to grain; maximum tensile strength
				At test	When oven dry		Volumetric	Radial	Tangential	Fiber stress at proportional limit	Modulus of rupture	Modulus of elasticity	Work to—			Fiber stress at proportional limit	Work to proportional limit	Height of drop causing complete failure (50-pound hammer)	Fiber stress at proportional limit	Maximum crushing strength		End	Side			
													Proportional limit	Maximum load	Total											
			Per cent			*Pounds*	*Per cent*	*Per cent*	*Per cent*	*Lb per sq in.*	*Lb per sq in.*	*1,000 lb per sq in.*	*In.-lb per cu in.*	*In.-lb per cu in.*	*In.-lb per cu in.*	*Lb per sq in.*	*In.-lb per cu in.*	*Inches*	*Lb per sq in.*	*Lb per sq in.*	*Lb per sq in.*	*Pounds*	*Pounds*	*Lb per sq in.*	*Lb per inch of width*	*Lb per sq in.*
Alder, red (*Alnus rubra*)	Washington	Green	98	0.37	0.43	46	12.6	4.4	7.3	3,800	6,500	1,170	0.70	8.0	15.3	8,000	2.6	22	2,620	2,960	310	550	440	770	220	390
		Dry	12	.41	.....	28	.....	.....	.....	6,900	9,800	1,380	1,85	8.4	10.7	11,600	4.8	20	4,530	5,820	540	980	590	1,080	270	420
Poplar, yellow (*Liriodendron tulipifera*)	Kentucky, Tennessee	Green	64	.38	.43	38	12.3	4.0	7.1	3,400	5,400	1,090	.62	5.4	8.9	8,600	3.3	18	1,930	2,420	330	390	340	740	220	450
		Dry	12	.40	.....	28	.....	.....	.....	6,100	9,200	1,500	1.43	6.8	11.2	13,500	5.6	20	3,550	5,290	580	560	450	1,100	280	520
Ash, Oregon (*Fraxinus oregona*)	Oregon	Green	48	.50	.58	48	13.2	4.1	8.1	4,200	7,600	1,130	.92	12.2	33.3	8,900	3.0	39	2,760	3,510	650	850	790	1,190	310	590
		Dry	12	.55	.....	38	.....	.....	.....	7,000	12,700	1,360	2.08	14.4	22.3	13,300	5.2	33	4,100	6,040	1,540	1,430	1,160	1,790	410	720
Ash, black (*Fraxinus nigra*)	Michigan, Wisconsin	Green	85	.45	.53	52	15.2	5.0	7.8	2,600	6,000	1,040	.41	12.1	31.7	.....	.....	33	1,690	2,300	430	590	520	860	280	490
		Dry	12	.49	.....	34	.....	.....	.....	7,200	12,600	1,600	1.57	14.9	34.4	.....	.....	35	4,520	5,970	940	1,150	850	1,570	380	700
Chinquapin, golden (*Castanopsis chrysophylla*)	Oregon	Green	134	.42	.48	61	13.2	4.6	7.4	4,200	7,000	1,020	1.09	9.5	20.4	8,800	3.4	31	2,030	3,020	490	730	600	1,010	230	480
		Dry	12	.46	.....	32	.....	.....	.....	7,900	10,700	1,240	3.11	9.5	19.1	10,900	4.8	30	4,150	5,540	680	840	730	1,260	.....	.....
Cottonwood, northern black (*Populus trichocarpa hastata*)	Washington	Green	132	.32	.37	46	12.4	3.6	8.6	2,900	4,800	1,070	.44	5.0	12.7	6,800	2.2	20	1,760	2,160	200	280	250	600	170	270
		Dry	12	.35	.....	24	.....	.....	.....	5,300	8,300	1,260	1.24	6.7	10.8	9,800	3.8	22	3,270	4,420	370	540	350	1,020	220	330
Dogwood, Pacific (*Cornus nuttalli*)	Oregon	Green	52	.58	.70	55	17.2	6.4	9.6	4,200	8,200	1,090	.92	17.0	38.7	9,800	3.6	56	2,410	3,640	870	1,140	980	1,300	340	740
		Dry	12	.64	.....	45	.....	.....	.....	7,200	10,500	1,470	2.02	11.0	46.8	10,500	3.7	34	4,300	7,540	1,650	1,870	1,250	1,720	410	1,040
Dogwood (*Cornus florida*)	Tennessee	Green	62	.64	.80	64	19.9	7.1	11.3	4,800	8,800	1,180	1.11	21.0	49.1	7,100	3.5	58	.....	3,640	1,030	1,410	1,410	1,520	.....	.....
		Dry	12	.73	.....	51	.....	.....	.....	9,200	14,900	1,530	3.10	19.5	38.9	14,600	7.5	44	.....	7,700	1,920	2,430	2,150	2,260	.....	.....
Laurel, California (*Umbellularia californica*)	Oregon	Green	70	.51	.51	54	11.9	2.8	8.1	3,900	6,600	720	1.23	16.8	45.6	8,300	4.1	57	1,980	3,020	800	1,020	1,000	1,270	430	780
		Dry	12	.55	.....	39	.....	.....	.....	5,400	8,000	940	1.85	8.2	12.8	10,700	5.3	31	3,520	5,640	1,400	1,540	1,270	1,860	420	870
Cherry, black (*Prunus serotina*)	Pennsylvania	Green	55	.47	.53	45	11.5	3.7	7.1	4,200	8,000	1,310	.80	12.8	31.8	10,200	4.7	33	2,940	3,540	440	750	660	1,130	330	570
		Dry	12	.50	.....	35	.....	.....	.....	9,000	12,300	1,490	3.11	11.4	14.2	13,600	5.4	29	5,960	7,110	850	1,470	950	1,700	350	560
Madrone, Pacific (*Arbutus menziesii*)	California, Oregon	Green	68	.58	.69	60	17.4	5.4	11.9	4,700	7,600	880	1.43	11.2	22.0	10,200	4.7	40	2,430	3,320	780	1,120	940	1,420	430	770
		Dry	12	.65	.....	45	.....	.....	.....	7,300	10,400	1,280	2.46	8.8	12.4	10,400	4.3	23	4,040	6,880	1,620	1,890	1,460	1,810	490	.....
Maple, bigleaf (*Acer macrophyllum*)	Washington	Green	72	.44	.51	47	11.6	3.7	7.1	4,400	7,400	1,100	1.02	8.7	14.2	8,500	2.8	23	2,510	3,240	550	760	620	1,110	320	600
		Dry	12	.48	.....	34	.....	.....	.....	6,600	10,700	1,450	1.66	7.8	11.8	.....	.....	28	4,790	5,950	930	1,330	850	1,730	400	540
Maple, silver (*Acer saccharinum*)	Wisconsin	Green	66	.44	.51	45	12.0	3.0	7.2	3,100	5,800	940	.61	11.0	22.3	6,800	2.6	29	1,930	2,490	460	670	590	1,050	300	560
		Dry	12	.47	.....	33	.....	.....	.....	6,200	8,900	1,140	1.90	8.3	13.1	12,400	6.9	25	4,360	5,220	910	1,140	700	1,480	340	500
Oak, California black (*Quercus kelloggii*)	Oregon, California	Green	106	.51	.58	66	12.1	3.6	6.6	3,400	6,200	740	1.03	8.8	16.0	8,200	3.4	30	1,880	2,800	890	910	850	1,140	350	700
		Dry	12	.57	.....	40	.....	.....	.....	6,100	8,700	990	2.28	6.5	10.0	8,800	4.0	16	3,300	5,640	1,440	1,180	1,100	1,470	360	770
Oak, canyon live (*Quercus chrysolepis*)	California	Green	62	.70	.84	71	16.2	5.4	9.5	6,300	10,600	1,340	1.70	14.4	30.9	11,200	3.9	47	3,940	4,690	1,480	1,590	1,570	1,700	520	970
		Dry	12	.77	.....	54	.....	.....	.....	9,300	12,900	1,610	3.15	9.9	21.5	13,000	5.5	37	6,110	9,080	2,260	2,530	2,420	2,290	640	.....
Oak, Oregon white (*Quercus garryana*)	Oregon	Green	72	.64	.75	69	13.4	4.2	9.0	4,600	7,700	790	1.51	13.7	29.8	10,300	4.8	49	2,480	3,570	1,380	1,430	1,390	1,630	450	940
		Dry	12	.72	.....	50	.....	.....	.....	6,600	10,300	1,100	2.28	9.8	18.2	11,900	5.4	29	3,960	6,530	2,110	1,880	1,660	2,020	380	830..
Oak, red (*Quercus borealis*)	Arkansas, Indiana, Louisana, New Hampshire, Tennessee	Green	80	.56	.66	63	13.5	4.0	8.2	4,100	8,300	1,350	.73	13.2	34.5	10,600	3.8	44	2,360	3,440	760	1,060	1,000	1,210	430	750
		Dry	12	.63	.....	44	.....	.....	.....	8,600	14,300	1,820	2.33	14.5	33.4	17,600	8.5	43	4,580	6,760	1,250	1,580	1,290	1,780	410	800
Oak, White (*Quercus alba*)	Arkansas, Indiana, Louisiana	Green	68	.60	.71	62	15.8	5.3	9.0	4,700	8,300	1,250	1.08	11.6	28.2	10,700	4.2	42	3,090	3,560	830	1,120	1,060	1,250	420	770
		Dry	12	.68	.....	48	.....	.....	.....	8,200	15,200	1,780	2.27	14.8	29.1	17,100	7.5	37	4,760	7,440	1,320	1,520	1,360	2,000	450	800
Tanoak[b] (*Lithocarpus densiflorus*)		Green	89	.....	.....	66	.....	.....	.....	6,570	10,700	1,680	.....	.....	.....	.....	.....	.....	.....	4,845[c]	1,355[d]	.....	.....	1,414	.....	.....
		Dry	14	.....	.....	45	.....	.....	.....	9,080	15,500	2,080	.....	.....	.....	.....	.....	.....	.....	8,172	1,656	.....	.....	1,960[e]	.....	.....

[a] U.S.D.A. Technical Bulletin 479, Sept. 1935, *Strength and Related Properties of Woods Grown in the United States,* by L. J. Markwardt and T. R. C. Wilson.
[b] U.S.D.A. Bulletin 75, Sept. 20, 1911, *California tanbark oak,* by W. J. Jepson, H. S. Betts, C. D. Mell.
[c] Moisture content: green, 87%; dry, 14%.
[d] Moisture content: green, 78%; dry, 13%.
[e] Moisture content: green, 83%; dry, 13%.

GRADING

Log grades

Log grading rules which have been developed by the United States Forest Products Laboratory are recognized quite widely in the eastern part of the United States at the present time. They were developed to conform with the National Hardwood Lumber Association rules for lumber, and both sets of rules may be used together. These rules are published in two reports: (1) Hardwood Log Grades for Standard Lumber and How to Apply Them, Report No. D1737-A, and (2) Hardwood Log Grades for Standard Lumber, Proposals and Results, Report No. D1737, Forest Products Laboratory, United States Forest Service. These rules are summarized in Table 4. They were used during log-and-lumber-grading studies of red alder and bigleaf maple conducted cooperatively during the summers of 1952 and 1953 by the Oregon Forest Products Laboratory and U. S. Forest Products Laboratory, and were found to be satisfactory for these species with few modifications. The modifications made in these rules for the alder logs studied were as follows:

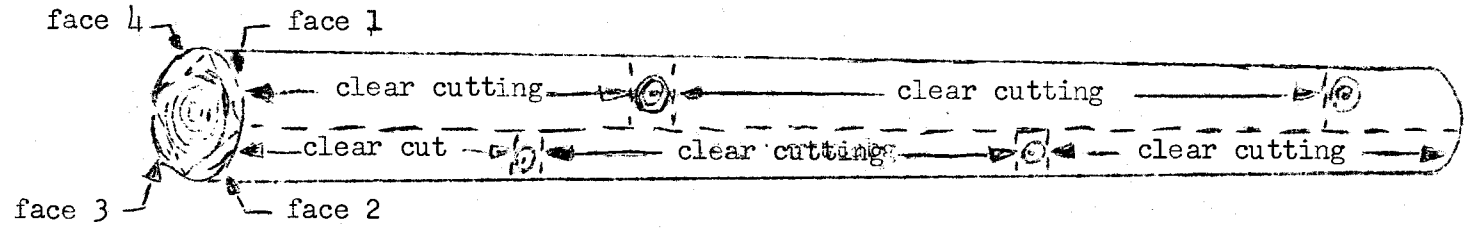
1. Minimum length lowered to 8 feet for all log grades.
2. Log grade 2 to admit logs with one 3-foot cutting and one 2-foot cutting on the same face.
3. Log grade 3 to include logs that grade No. 2 or better on only two faces.

The detailed procedure for grading logs according to these rules is covered in both of the previously mentioned publications and need not be repeated here. The general steps in grading logs according to these rules are:

1. Measure length and small-end diameter of logs.
2. Visually divide the log surface full length into four quarters or faces so oriented as to give the largest possible number of good faces

Table 4. Hardwood Log Grades for Standard Lumber.*

Grade factors	Log grade 1			Log grade 2		Log grade 3
	Butts only	Butts and uppers		Butts and uppers		Butts and uppers
DIAMETER (minimum)	13"-15"	16"-19"	20"+	11		8"+
LENGTH (minimum)	10'+	10'+		8'-11	12'+	8'+
CLEAR CUTTINGS (on the 3 best faces)						
Length (minimum)	7'	5'	3'	3'		2'
Number on face (maximum)	2	2		2	3	Unlimited
Yield in face length (minimum)	5/6	5/6		4/6		3/6
SWEEP AND CROOK DEDUCTION (maximum)	15%	15%		30%		50%
CULL DEDUCTION, including sweep (maximum)	40%	40%		50%		50%
SOUND END DEFECTS, area (maximum)	--- See instruction* ---					



Exceptions. --In ash and basswood 12" d.i.b. for grade 1 butts.
Grade 2 10" d.i.b. must be grade 1 surface quality.
Grade 2 11" d.i.b. limited to two cuttings.
Grade 2 8' and 9' lengths limited to 12" d.i.b.; 3/4 yield in not more than two 3'+ cuttings.
Sweep and crook allowance reduced 1/3 in logs with more than 1/4 diameter in sound end defects.
Sixty per cent cull deduction permitted in grade 2 if otherwise of grade 1 quality.
Sixty per cent cull deduction permitted in grade 3 if otherwise of grade 2 quality.

* Hardwood Log Grades for Standard Lumber. Report No. D1737, Forest Products Laboratory, United States Department of Agriculture, Madison, Wisconsin. 1949.

3. Establish the grade of the best three faces on the basis of the clear-cutting requirements.
4. The log grade is that of the poorest of the faces chosen as the three grading faces.

Clear cuttings include those portions of the log faces that lie between defects or between the ends of logs and defects, extending over the full width of the face. Defects include bark-covered features such as bumps, overgrown knots and grub holes; knots; rot; and other blemishes that will affect the quality of lumber sawed from the log, whether projecting or recessed. Shallow fire and other scars, seams and frost cracks whose maximum depth extends one-fifth or less the diameter of the log are not considered defects.

Lumber grades

At the present time a few western hardwood mills use a grading system, but most sell their lumber on a mill-run basis. Various rules for grading western hardwoods have been developed. However, only limited acceptance has been accorded even the most-used of these rules, which is the set published by the Pacific Lumber Inspection Bureau, Seattle, Washington. The hardwood lumber grading rules used throughout the eastern part of the country (which are recognized both nationally and internationally) are those published and administered by the National Hardwood Lumber Association, Chicago, Illinois. The PLIB rules are somewhat simpler and seemingly easier to use than the NHLA rules. There are several differences between the rules, but perhaps the most important difference is that the PLIB rules permit grading from the better side of the lumber and the NHLA rules require grading from the poorer side unless otherwise stated. Both rules are based on the percentages of clear cuttings in boards.

Lumber from the eastern hardwood-producing areas finds more ready acceptance and usually sells for higher prices -- especially in the upper grades and heavier thicknesses. It seems logical that if western hardwoods are to

TABLE 5. CHART OF CUTTING REQUIREMENTS FOR STANDARD N.H.L.A. LUMBER GRADES FOR STANDARD LUMBER.
(From hardwood lumber grading rules, published January 1952 by the National Hardwood Lumber Association)

FIRSTS	SECONDS	SELECTS	NO. 1 COMMON	NO. 2 COMMON	NO. 3A COMMON	NO. 3B COMMON
Widths: 6″ and wider Lengths: 8 to 16 ft.	Widths: 6″ and wider Lengths: 8 to 16 ft.	Widths: 4″ and wider Lengths: 6 to 16 ft.	Widths: 3″ and wider Lengths: 4 to 16 ft.	Width: 3″ and wider Lengths: 4 to 16 ft.	Width: 3″ and wider Lengths: 4 to 16 ft.	Width: 3″ and wider Lengths: 4 to 16 ft.
*S.M. — %Cl. Face — Cuts	*S.M. — %Cl. Face — Cuts	*S.M. — %Cl. Face — Cuts	*S.M. — %Cl. Face — Cuts	*S.M. — %Cl. Face — Cuts		
4′ to 9′ — 91⅔ — 1	4′ & 5′ — 83⅓ — 1	2′ & 3′ — 91⅔ — 1	1′ — Clear — ..	1′ — 66⅔ — 1	Yield: 33⅓% Clear Face cuttings	Yield: 25% sound cuttings
10′ to 14′ — ″ — 2	6′ & 7′ — ″ — 1		2′ — 75 — 1	2′ & 3′ — 50 — 1	No. cuttings: No limit	No. cuttings: No limit
15′ & up — ″ — 3	8′ to 11′ — ″ — 2	Reverse side cutting sound.	3′ & 4′ — 66⅔ — 1	4′ & 5′ — ″ — 2		
	12′ to 15′ — ″ — 3	4′ and over shall grade on one face as required in Seconds with reverse side of board not below No. 1 Common or reverse side of cuttings sound. See Rule (Par. 69) defining edges of boards 4″ and 5″ wide.	5′ & 7′ — ″ — 2	6′ & 7′ — ″ — 3		
	16′ & up — ″ — 4		8′ to 10′ — ″ — 3	8′ & 9′ — ″ — 4		
	**		11′ to 13′ — ″ — 4	10′ & 11′ — ″ — 5		
	6′ to 15′ S.M. will admit 1 additional cut to yield 91⅔% Clear Face.		14′ & up — ″ — 5	12′ & 13′ — ″ — 6		
			3′ to 7′ S.M. will admit 1 additional cut to yield 75% Clear Face.	14′ & up — ″ — 7		
				2′ to 7′ S.M. will admit 1 additional cut to yield 66⅔% Clear Face.		
Minimum cutting 4″ x 5′ or 3″ x 7′			Minimum cutting 4″ x 2′ or 3″ x 3′	Minimum cutting 3″ x 2′	Minimum cutting 3″ x 2′	Minimum cutting not less than 1½″ wide and containing not less than 36 sq. in.

* Surface Measure.

** Admits also, pieces 6″ to 7″ wide of 6′ to 10′ measure and pieces 8″ to 9″ wide of 8′ to 12′ surface measure that will yield 97% in two clear-face cuttings of any length, full width of the board.

attain an equivalent position they must be of equal quality and be graded by the same rules. However, hardwood lumber produced in Oregon is practically all in 8-foot lengths, a practice that is definitely penalized in NHLA rules. For example: NHLA grades for "Firsts and Seconds" specify: "Lengths: 8' to 16', admitting 30 per cent of 8' to 11' of which one half may be 8' and 9'." For this reason, producers of short-length western hardwood lumber are at a disadvantage in competition with eastern hardwood producers who saw logs in lengths up to 16 feet.

Those interested in obtaining a copy of the National Hardwood Lumber Association grading rules may write to the Association at 59 E. Van Buren Street, Chicago 5, Illinois (The amount of 25 cents per copy should be included). These rules are summarized in Table 5 to help acquaint interested parties with the grades as they are applied to hardwood lumber. It is not suggested that proficiency in grading hardwood lumber can be gained by memorizing it, since there are many additional details which are not included for lack of space.

Lumber-grade recovery

Prices for hardwood lumber published in monthly market reports from the east show the advantages to a mill operator from sawing logs for maximum recovery of high-quality lumber. Sawing for quality, rather than quantity, gives higher returns in hardwood lumber manufacture.

There are no insurmountable difficulties to be encountered in the manufacture of quality hardwood lumber from western hardwoods, or in the fabrication of end products from this lumber. However, the users of this lumber should be able to depend on a reliable supply of uniform-quality lumber. Many western mills have sawed hardwood logs only during periods of lowered returns from softwood lumber manufacturing, and have turned to the sawing of softwoods

Table 6. Lumber-grade Yields for Red Alder Compared with Yields from Several Eastern Hardwoods; by Log Grades, in Per Cent.*

Log grade	Lumber grade FAS	Sel	No.1C	No.2C	No.3A	No.3B	Timber and SSE**
	- - - - - - - - - - -Per cent- - - - - - - - - -						
Red alder							
1	10.0	13.5	42.0	25.1	6.6	2.8	-
2	4.7	3.8	31.3	40.6	15.9	3.7	-
3	2.1	3.8	23.8	43.2	20.7	6.4	-
4	--	--	20.9	47.0	27.0	5.1	-
Yellow birch							
1	36.3	7.5	26.5	10.6	3.8	14.7	0.6
2	8.3	4.6	29.6	20.8	6.6	29.8	0.3
3	0.7	.9	11.6	19.3	7.6	59.9	-
Sap gum							
1	35.6	8.3	27.7	19.6	8.8		-
2	10.4	5.6	33.4	33.6	17.0		-
3	1.6	1.6	20.7	47.5	28.6		-
Hard maple							
1	24.7	12.9	30.6	12.3	4.5	14.0	1.0
2	5.6	5.9	29.4	21.3	8.2	27.6	2.0
3	0.4	1.0	13.8	23.9	12.7	47.3	0.9
Red oak (Lowland)							
1	27.8	8.6	30.8	12.8	6.2	6.8	7.0
2	6.5	4.6	32.8	21.3	12.7	14.8	7.3
3	0.8	1.2	21.3	26.5	18.5	25.2	6.5
Red oak (Upland)							
1	34.7	8.5	29.0	10.9	4.8	10.9	1.2
2	7.9	4.4	32.2	19.7	8.7	24.9	2.2
3	0.8	0.6	16.8	23.8	12.2	43.5	2.3
Beech							
1	24.9	5.4	37.0	12.5	5.1	13.2	1.9
2	7.5	4.2	35.1	20.2	6.8	19.0	7.1
3	0.6	0.7	17.4	26.4	11.6	31.4	11.9
Soft maple							
1	30.6	6.6	35.5	20.8	6.5		-
2	15.3	4.7	43.6	19.2	17.2		-
3	3.2	1.4	20.6	52.5	22.3		-

* Data for eastern species from Hardwood Log Grades for Standard Lumber, Report No. D1737, Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wisconsin. 1949.

** Sound square edge.

Table 7. Lumber-grade Recovery from Red Alder Compared with Recovery from Hardwoods in the Tennessee Valley.*

Species	Lumber grade							
	FAS	Sel	No.1 Com	No.2 Com	Sound Wormy	No.3A Com	No.3B Com	Ties & Timbers
	100 Per Cent							
Ash	13.4	12.7	28.8	29.1	0.5	10.3	4.9	0.3
Basswood	17.0	5.8	30.1	37.3	---	6.9	2.9	---
Beech	2.8	3.2	24.4	34.3	0.1	16.3	7.1	11.8
Birch	5.8	2.3	31.0	38.1	---	13.5	9.3	---
Buckeye	8.4	3.3	23.1	43.6	---	12.6	8.7	0.3
Chestnut	0.6	1.7	13.5	34.9	10.9	17.0	20.7	0.7
Gum, black	4.9	1.8	18.9	39.9	0.7	14.8	7.0	12.0
Gum, sweet	2.2	0.8	18.5	31.3	---	7.4	2.0	37.8
Hickory	2.8	0.5	19.2	28.7	0.6	21.6	11.9	14.7
Maple, hard	7.1	7.1	27.0	35.2	1.3	15.6	6.4	0.3
Maple, soft	5.8	4.7	24.0	44.6	1.3	10.9	4.4	4.3
Oak, black	4.7	3.9	14.7	20.5	1.4	20.7	14.9	19.2
Oak, blackjack	---	---	----	----	---	17.2	27.6	55.2
Oak, chestnut	2.1	3.0	12.8	19.1	22.4	14.4	16.2	10.0
Oak, chinquapin	1.5	2.8	8.5	6.7	---	----	0.9	79.6
Oak, post	1.0	1.1	5.9	15.0	3.8	18.7	18.1	36.4
Oak, red, Northern	17.4	10.3	25.7	18.7	1.2	10.5	6.0	10.2
Oak, red, Southern	4.8	3.1	16.5	21.2	0.8	12.8	10.5	30.3
Oak, scarlet	1.9	2.3	11.8	20.2	0.9	22.3	19.3	21.3
Oak, water	4.3	---	7.3	3.1	---	----	8.0	77.3
Oak, white	3.9	3.6	14.0	21.0	3.6	18.2	12.6	23.1
Oak, willow	---	---	36.7	18.3	---	20.0	25.0	----
Yellow poplar**	0.7	7.6	29.0	36.9	21.2	2.9	1.5	0.2
Miscellaneous***	4.1	1.5	18.6	39.6	10.3	11.3	3.5	11.1
ABOVE SPECIES	5.0	4.6	19.1	26.0	6.4	14.6	10.7	13.6
Red oaks	7.0	4.9	16.8	20.0	1.1	17.9	13.5	18.8
White oaks	3.0	3.1	12.8	19.7	11.1	16.7	14.4	19.2
Oaks	5.5	4.3	15.4	19.9	4.6	17.5	13.8	19.0
Alder, red	4.1	4.2	29.4	40.7	---	17.2	4.4	----

* Lumber Grade Recovery from Hardwood Sawlogs in the Tennessee Valley, Technical Note No. 11, Tennessee Valley Authority, Division of Forestry Relations, Norris, Tennessee, August 1952.

** Saps included in Select grade; 2A included in No. 2 Com; 2B included in Sound Wormy.

*** Includes butternut, black cherry, cottonwood, cucumbertree, elm, hackberry, black locust, mulberry, sassafras, sourwood, sycamore, black walnut.

such as Douglas-fir when changing prices have made such practices more profitable. This unfortunate situation has led to abrupt changes in the volume of hardwood lumber produced in the west.

A representative of a major Los Angeles outlet wrote that the Pacific Coast hardwoods have a strong place in the southern California market, but that expanded production and merchandising of these woods is dependent on increased investments as well as greater confidence in their products. He added that producers should confine their efforts to hardwoods alone, disregarding the softwoods.

An argument that is often given against selling on grade and one which the new operator must face is the apparently large amount of low-grade stock that frequently develops. This is similar to conditions in eastern hardwood operations. Results from the recent sawmill study of red alder (Table 6) show that in the milling of this species there is no higher percentage of low-grade lumber produced than that with which eastern operators must contend in species peculiar to their areas. Table 7 shows that the volume of low-grade red alder lumber recovered in the recent study was less than 22 per cent. Such data are not now available for the other western species although it is likely that similar results will be obtained from further studies. The large amount of low-grade lumber from eastern hardwoods is illustrated in a report entitled, "The Utilization of No. 3 Common Northern Hardwood Lumber for Mechanized Processing Into Glued Products," and published in the Forest Products Research Society Proceedings for 1949: "In northern hardwoods, such as those typified by operations in the Upper Peninsula of Michigan, the grades of No. 3A and 3B Common may now constitute from 30 to 50 per cent of an average mills' production."

In order to reduce the quantity of submarginal lumber careful attention must be given to (1) sawing, edging, ripping and trimming practices, (2) elimination of waste, and (3) utilization of low-grade material which cannot be

avoided. Further comments on (1), above, may be found in the section on sawing. The bibliography at the end of this report includes some excellent references covering specific points on utilization of low-grade material.* However, some suggested uses for low-grade lumber and logs are as follows:

1) Dimension, or cut stock, in which the clear material is cut out of the boards and cut to dimensions for a customer's specific requirements.
2) Cutting out the clear material and gluing it into panels, either for use in solid furniture, or as core material for veneered panels.
3) Paneling for home and office interiors.
4) Boxing the heart on the carriage and selling this material for fence posts, mine timbers, or railroad ties.
5) Items such as brush handles and backs, novelties, toys, and other uses where short, clear lengths can be used; or paper roll plugs, in the case of alder.
6) Semi-chemical pulp
7) Construction lumber
8) Fuel
9) Milpak (bundled short clears)**
10) Flooring
11) Chips and small particles for consolidated products.

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* Cf. section on small sawmills.

** Reference 140.

SAWING

To get the maximum returns from sawing hardwood logs, the plan followed should be aimed at the maximum recovery of No. 1 Common and better lumber, rather than at maximum volume production.

The general precedure for obtaining the greatest yield of high-grade lumber is to visualize the log as having four faces, or quarters, attempt to have as many of the defects in one face as is possible, and cut the lumber from each face by turning the log frequently until all of the high-grade material has been worked from it.

Hardwood lumber is usually cut oversize to allow for shrinkage. This allowance amounts to about 1/16-inch oversize per inch (nominal) of width. Consequently, green Firsts and Seconds should be at least 6 3/8 inches wide, and green Common lumber at least 3 3/16 inches wide. Four- and five-quarter inches thick lumber is cut 1/16-inch oversize, and six- and eight-quarter lumber is cut 1/8-inch oversize. However, because few small mills can cut to these tolerances, this oversize allowance is usually doubled.

Standard widths are random, in multiples of one inch. Standard lengths are to the nearest foot from a minimum of 4 feet to 16 feet. Standard thicknesses for hardwood lumber according to NHLA rules are as follows:

Rough		Surfaced
Inches		Inches
3/8	S2S to	3/16
1/2	" "	5/16
5/8	" "	7/16
3/4	" "	9/16
1	" "	13/16
1 1/4	" "	1 1/16

Rough		Surfaced
Inches		Inches
1 1/2	S2S to	1 5/16
2	" "	1 3/4
2 1/2	" "	2 1/4
3	" "	2 3/4
3 1/2	" "	3 1/4
4	" "	3 3/4

Careful attention to accuracy in sawing is highly desirable, for miscut lumber would be difficult to dispose of at other than greatly reduced prices. Miscut lumber is so graded according to National Hardwood Lumber Association grading rules when thickness variation of the rough lumber is greater than that shown in the following table:

Board thickness	Allowable variation
Inches	Inches
1/2 or less	1/16
5/8 and 3/4	1/8
1 and 2	1/4
2 1/2 and 3 1/2	3/8
4 to 6	1/2

Requirements for hardwood-lumber sawmills are no different than those for other woods, so long as they are capable of cutting accurate lumber at all times. The saw kerf should be as narrow as practicable, in order to increase lumber yields.

There are not many large hardwood mills in the east; most cut in the neighborhood of 10 M fbm per 8-hour day. Types of equipment used vary widely--from small stationary mills and portable rigs to bolter saws. These latter are seen very rarely on the west coast, but play an important role in some eastern sections for sawing small logs.

Information on proper sawing, edging and trimming techniques for hardwood lumber manufacture is contained in various references in the bibliography section on small sawmills. Two which are recommended in particular are publications of the U. S. Forest Products Laboratory at Madison, Wisconsin. These are: (1) Small Sawmill Operator's Manual, and (2) Instructions on Sawing Hardwood Logs, and Edging and Trimming Hardwood Lumber for Grade and Value Recovery.*

* References 158 and 138.

SEASONING

It has been demonstrated that all of the species native to the west coast can be dried satisfactorily, although some are more refractory than others. At the present time alder, maple, ash, and cottonwood are kiln-dried economically green from the saw. Other species that are believed possible to kiln-dry green from the saw are Pacific madrone and California laurel (myrtle). It might be noted here that it is not recommended that the highly-colored and figured myrtle used by the novelty manufacturer be kiln-dried green from the saw. However, it is believed that straight-grained, so called white myrtle, can be dried in this manner. Other species, such as tanoak, chinquapin, Oregon white oak and California black oak, have been dried satisfactorily in a dry kiln provided the lumber was air-dried prior to kiln-drying. However, this need not be a seriously limiting factor, as this is a common practice in eastern operations where similar refractory woods are being dried. This practice is standard operating procedure in redwood operations, where air drying is a prerequisite to kiln drying.

Schedules and seasoning practices for handling the various species are covered in two publications which may be obtained by writing to the Oregon Forest Products Laboratory.* Two publications concerning the seasoning of California black oak are available from the California Forest and Range Experiment Station, Berkeley, California.**

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* References 68 and 80.

** References 42 and 43.

MACHINABILITY

Machining properties of four western hardwoods are compared with these properties of several eastern species in Table 8. This information is from a U. S. Forest Products Laboratory publication, Machining of Madrone, California Laurel, Tanbark Oak, and Chinquapin.* Information such as in the above report is not available for the other western hardwoods. However, many users, both furniture manufacturers and others, consider red alder to be one of the finest woods available for their purposes. Black cottonwood probably would rate similarly to eastern cottonwood. Bigleaf maple undoubtedly would compare favorably with other soft maples. Oregon ash has properties similar to those of other ashes, and California black oak and Oregon white oak may be compared to red or white oak.

GLUABILITY

The gluing characteristics of respective species are very important, particularly in furniture manufacturing. Table 9 shows the relative percentages of wood failure, and ease of gluing of various western hardwoods compared with certain eastern species. The data indicate that, with moderate control of gluing conditions, the gluing of western hardwoods should offer no greater difficulties than those normally encountered with the eastern species.

VENEER

Several studies have been made to determine the suitability of western hardwoods for veneer. In a progress report of a study** conducted by the U. S. Forest Products Laboratory in cooperation with the California Forest and Range

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* Reference 76.

** Reference 100.

Table 8. Machining Properties of Four Western Hardwoods and Several Commonly used Furniture Woods*

Species	Planing	Shaping	Turning	Boring	Mortising	Sanding
	Defect-free pieces	Good to excellent pieces	Good to excellent pieces	Good to excellent pieces	Good to excellent pieces	Good to excellent pieces
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Ash (eastern)	75	51	79	94	62	75
Cottonwood, eastern	21	3	70	70	52	19
Chestnut	74	24	87	91	72	64
Chinquapin	75	25	77	90	90	--
Laurel, California	40	60	86	100	100	--
Madrone, Pacific	90	75	88	100	95	--
Mahogany	80	68	89	100	100	--
Maple, hard	54	62	82	99	95	38
Maple, soft	41	22	76	80	36	37
Oak, red	91	21	84	99	100	81
Tanoak	80	39	81	100	100	--
Oak, white	87	28	85	95	100	83
Sweetgum	51	21	86	92	58	23
Walnut, black	62	34	91	100	98	--
Poplar, yellow	70	12	81	87	63	19

* Ref. 74.

Table 9. Relative Ease of Gluing of Four Western Hardwoods and Certain Commonly Used Eastern Species[a]

Species	Difficult (0-49 per cent wood failure[b])						Moderately Easy (50-89 per cent wood failure[b])						Easy (90-100 per cent wood failure[b])					
	Casein	Vegetable	Animal	Animal[c]	Urea resin	Resorcinol resin	Casein	Vegetable	Animal	Animal[c]	Urea resin	Resorcinol resin	Casein	Vegetable	Animal	Animal[c]	Urea resin	Resorcinol resin
Alder, red										X			X	X	X			
Poplar, yellow							X			X				X	X			
Ash, white	X	X		X														
Chestnut										X			X	X	X			
Chinquapin				X			X	X				X			X		X	
Cottonwood							X			X				X	X			
Madrone, Pacific				X			X	X	X			X					X	
Cherry, black				X			X	X	X									
Maple, soft				X			X	X	X									
California laurel (myrtle)	X	X		X					X		X	X						
Oak, red				X			X	X	X									
Oak, white	X			X				X	X									
Tanoak	X			X				X	X			X					X	

[a] Ref. 92 and 121.

[b] Wood failure in block-shear tests.

[c] When used under conditions favoring starved joints.

Experiment Station, W. E. Showalter stated concerning tanoak, Pacific madrone, California laurel, and chinquapin:

"There was no difficulty in cutting tight, smooth, and uniformly thick veneer in 1/28- and 1/16-inch thicknesses in any of the four species of California hardwoods included in this study when they had been heated in water at 210° F., in spite of the fact that the size of the study did not warrant experimentation to establish the best lathe knife and nosebar adjustments."

A progress report of a similar study by the Oregon Forest Products Laboratory demonstrated similar favorable results for tanoak.

Cottonwood is being peeled on a commercial scale in Oregon at the present time; the veneer is used mainly for wire-bound boxes.

Studies have not been made of the peeling characteristics of the other species such as red alder, bigleaf maple, Oregon white and California black oak, although a few logs have been peeled at several mills. However, while there are no data available from any of these trials, these species are expected to react favorably to peeling, provided logs are selected especially for the purpose when face stock is to be produced. These logs, of course, must be given different treatment than is common practice for softwoods. Most hardwood veneer logs and bolts are boiled or steamed before making into veneer. Also, rotary cutting of hardwood veneer is usually done at a slower rate than is customary with softwoods.

CONCLUSIONS

There are no insurmountable difficulties in the manufacture of high-quality hardwood lumber from western hardwoods, nor in the use of this lumber.

There are many opportunities for development in this phase of the lumber industry in Oregon, both in lumber and in finished products. Increased use of western hardwoods seems likely, in view of the growing furniture industry on

the west coast, and the possibility of using western hardwoods instead of woods with similar qualities which are shipped from the eastern United States.

In a bulletin published in 1948 by this Laboratory, Utilization of Oregon Hardwoods, by Dan D Robinson, a list was included of six items about which information was needed. These items, and accomplishments or solutions suggested since that date, are as follows:

Item	Accomplishment or Suggested Solution
1) Volume tables adapted to hardwood species.	1) Board-foot and cubic-foot volume tables have been developed for California black oak, Oregon white oak, Pacific madrone, and tanoak as they occur in California.
2) Standard log grading rules for all species of native hardwoods.	2) Log grading rules as developed by the U. S. Forest Products Laboratory have been found applicable for use with red alder and bigleaf maple.
3) Standard hardwood lumber grading rules.	3) Lumber grading rules as set forth in the NHLA rule book were found to be well adapted to red alder and bigleaf maple.
4) Better air and dry-kiln seasoning practices.	4) Schedules for seasoning various western hardwoods have been developed.
5) Ways and means of closer utilization from tree to the final product.	5) Methods of utilizing low grade material (such as MILPAK) are available. However, this problem is different for every mill.
6) Uses for species hitherto classed as non-commercial.	6) Pacific dogwood and madrone are undergoing service tests for shuttles in the textile industry. Emphasis is being placed on tanoak as possible ship building material. Additional uses, such as in cooperage and plywood, are being investigated for all species.

B I B L I O G R A P H Y

Individual Species

Bigleaf maple

1) Betts, H. S. American Woods: Maple. Forest Products Laboratory, United States Forest Service, Madison, Wis. 1945.

2) Broadleaf Maple. Silvical Leaflet 51, United States Department of Agriculture, 1912.

3) Collingwood, G. H. "Bigleaf Maple". American Forests, 44:466. October 1938.

4) Johnson, H. M. Utilization of Bigleaf Maple of the Pacific Northwest. Circular No. 225, United States Department of Agriculture. June 1932.

5) "Trees and Their Uses; Bigleaf Maple." American Forests, 44:466. October 1938.

California Laurel

6) Brush, W. D. "California Laurel." American Forests, 52:378-79. August 1946.

7) Bunnell, W. F. "Oregon Myrtle Logging, Milling, and Marketing." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon.

8) Drake, M. E. and Stuhr, E. T. "Some Pharmacological and Bactericidal Properties of Bellulone." Journal of American Pharmaceutical Association, 24(3). March 1935.

9) Hill, J. E. "The Growth of Oregon Myrtlewood in Southwestern Oregon." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon.

10) Moore, J. "Oregon Myrtle, a Vanishing Forest Tree." Nature Magazine, 42:37-42. January 1949.

11) Ross, C. R. Seasoning Oregon Myrtle. School of Forestry, Oregon State College, Corvallis, Oregon.

12) Rupert, P. M. "Myrtlewood Lane." American Forests, 54:75. February 1948.

13) Thomas, F. L. "Myrtlewood." Timberman, June 1924.

14) Wharton, M. "Western Myrtle." American Forests, 32:659-60. November, 1926.

Chinquapin

15) Gravatt, G. E. and Crandall, B. S. Phytophthera Root Diseases of Chestnut and Chinquapin. Report, Northern Nut Growers Association. 1944.

16) Sudworth, G. B. "New Chinquapin." American Forests, 28:300-1. May 1922.

Black cottonwood

17) Betts, H. S. American Woods: Cottonwood. Forest Products Laboratory, United States Forest Service, Madison, Wis. October 1945.

18) Bronson, V. D. "Management Plan for the Production of Black Cottonwood in the Upper Willamette Valley of Oregon." Thesis, School of Forestry, Oregon State College. 1942.

19) Cottonwood. Silvical Leaflet 25, United States Department of Agriculture. October 1908.

Pacific madrone

20) Brandt, L. E., Ihrig, H. G., and Stephenson. "Arbutus menziesii in Its Native Habitat." Royal Horticultural Society Journal, 72:159-60. April 1947.

21) Brush, W. D. "Pacific Madrone." American Forests, 54:122-3. March 1948.

22) "California Giant Madrone." American Forests, 47:356. August 1941.

23) Eley, C. "Arbutus menziesii." Royal Horticultural Society Journal, 72:32-3. January 1947.

24) "Giant Madrone of California." American Forester. February 1918.

Oregon ash

25) Ash Handles (Simplified Practice Recommendation R76-40). National Bureau of Standards, Department of Commerce, Washington, D. C. 1940.

26) Betts, H. S. American Woods: Ash. Forest Products Laboratory, United States Forest Service, Madison, Wis. 1938.

27) Starrett, W. D. Ashes: Their Characteristics and Management. Bul. No. 299, United States Department of Agriculture. December 1915.

28) ---------- Utilization of Ash. Bul. No. 523, United States Department of Agriculture. June 1917.

Oregon white oak

29) Bateman, L. K. "Commercial Utilization and Seasoning of Oregon White Oak." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. March 1944.

30) Betts, H. S. American Woods: Oaks. Forest Products Laboratory, United States Forest Service, Madison, Wis. October 1945.

31) Collingwood, G. H. "Oregon White Oak." American Forests, 49: 446-7. September 1943.

32) Gilkey, J. L. "Oregon White Oak as an Overlay in Plywood Flooring." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. April 1948.

33) Johnson, H. M. "Oregon White Oak: Properties and Uses." Timberman, Vol. 34, p. 14. September 1933.

34) McCulloch, W. F. "Oregon Oak--Tree of Conflict." American Forests, 46:264-6. June 1940.

35) Oak Flooring. National Bureau of Standards, United States Department of Commerce, Washington, D. C. (Commercial Standard CS56-49, 1949).

36) Oregon Oak, Quercus garryana. Silvical Leaflet 52, United States Department of Agriculture. September 1912.

37) Oregon White Oak. Forest Service Research Note No. 11, United States Department of Agriculture. May 1933.

38) "Trees and Their Uses; Oregon White Oak." American Forests, 49: 448. September 1943.

39) Webster, A. D. "Trees and Shrubs: Quercus garryana." Gard Chronicle (Lund), 68:289. December 1920.

40) "Wedges by Carter." Timberman. October 1946.

California black oak

41) Betts, H. S. American Woods: Oaks. Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. 1945.

42) Smith, H. S. Seasoning California Black Oak. Forest Research Note No. 62, California Forest and Range Experiment Station. July 1949.

43) ---------- Further Experiments in Seasoning California Black Oak. Forest Research Note No. 75, California Forest and Range Experiment Station. September 1950.

Pacific dogwood

44) Cuno, J. B. Utilization of Dogwood and Persimmon. Bul. No. 1436, United States Department of Agriculture. September 1936.

45) Rickett, H. W. "Distribution of Species of Cornus." Abstract, American Journal of Botany, 28:18. December 1941.

Red alder

46) Aufderheide, R. "Plan of Management for Red Alder in Nestucca Working Circle." Unpublished. Siuslaw National Forest, Corvallis, Oregon. March 1940.

47) Baker, W. J. "Some Factors Involved in the Promotion of Alder-using Industries in Tillamook, Oregon. Special Report 1, Oregon Forest Products Laboratory, Corvallis, Oregon. January 1951.

48) Betts, H. S. American Woods: Red Alder. Forest Products Laboratory, United States Department of Agriculture, Madison, Wis. August 1945.

49) Collingwood, G. H. "Red Alder." American Forests, 51:126-7. March 1945.

50) Grondal, B. L. "Seattle Shoe Factory Utilizes Red Alder." West Coast Lumberman, 34(398): 21, 32. 1918.

51) Harris, K. F. "Growing Good Quality Second-growth Alder." British Columbia Lumberman, 34(7):41-. July 1950.

52) Johnson, H. M. "Alnus oregona: Its Value as a Forest Type on the Siuslaw National Forest." Journal of Forestry, Vol. 15, p. 981. December 1917.

53) Johnson, H. M., Hanzlik, E. J., and Gibbons, W. H. Red Alder of the Pacific Northwest. Bul. No. 1437, United States Department of Agriculture. September 1926.

54) "Natural Dyes From Peat, Brown Coal, and Alder Bark." Chemistry Abstracts, 38:645. 1943.

55) Pfeiffer, J. R., and Wollin, A. C. Red Alder Log and Lumber Grading. Bulletin 5, Oregon Forest Products Laboratory, Corvallis, Oregon 1953.

56) Red Alder. Silvical Leaflet 53, United States Department of Agriculture. August 1945.

57) "Red Alder Potential Studied at Ottawa." British Columbia Lumberman, 37(1), p. 78. January 1953.

58) Rymer, K. W. Red Alder in British Columbia. Bul. No. 98, Department of Research and Development, Vancouver, B. C. 1951.

59) Semichemical-pulping Characteristics of Pacific Coast Red Alder, Douglas-fir, Western Red Cedar, and Western Hemlock. Report No. R1912, Forest Products Laboratory, United States Department of Agriculture, Madison, Wis.

60) "Shoes From Oregon Alder." Timberman. June 1946.

61) Timber Disposal Program for the National Forest Resources of the Hebo Management Unit. Siuslaw National Forest, Corvallis, Oregon. July 1948.

62) "Unique Wood Utilization." West Coast Lumberman. November 1940.

63) Webster, A. D. "Alder for Clog Soles." Garden Chronicles (Lund) 72: 85. August 1922.

Tanoak

64) "Ancient Industry Thrives on Tanbark Oak." Timberman, 53(6), 96. April 1952.

65) Baker, W. J. The Utilization of Tanbark Oak. Thesis, School of Forestry, Oregon State College, June 1928.

66) "Big Trees: Tanbark Oak King." American Forests, 48: 436-74. October 1942.

67) Brush, W. D. "Tanbark, Lithocarpus densiflorus." American Forests, 53:126-75. March 1947.

68) Espenas, L. D. The Seasoning of One-Inch Tanoak Lumber. Bulletin 3, Oregon Forest Products Laboratory, Corvallis, Oregon. January 1953.

69) Fowler, M. E. Prevent Tanbark Deterioration. Leaflet No. 286, United States Department of Agriculture. 1950.

70) Graham, R. D. Seasoning and Preservative Treatment of Tanoak. Mimeograph Report No. P-1, Oregon Forest Products Laboratory, Corvallis, Oregon. October 1953.

71) Kurth, E. F., and Becker, E. L. "The Chemical Nature of the Extractives from Red Alder." Tappi, 36(10) 461-7. October 1953.

72) Jepson, W. J., Betts, H. S., Mell, C. D. California Tanbark Oak. Forest Service Bulletin 75, United States Department of Agriculture. September 1911.

References Including Several Species

73) American Tree Monarchs. The American Forestry Association, 919 Seventeenth St., N. W., Washington 6, D. C.

74) Andrews, H. J. and Cowlin, R. W. Forest Resources of the Douglas-fir Region. Forest Service Miscellaneous Report No. 389, United States Department of Agriculture. December 1940.

75) Brown, H. P., Panshin, A. J., and Forsaith, C. C. Textbook of Wood Technology. Vol. I. McGraw-Hill Book Company, Inc., N. Y. 652 p. 1949.

76) Davis, E. M. Machining of Madrone, California Laurel, Tanbark Oak and Chinquapin. Report No. R1727, Forest Products Laboratory, United States Forest Service, Madison, Wis. December 1947.

77) Dempsey, R. The Commercial Utilization of Tanbark Oak and Western White Oak in Oregon. Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. 1938.

78) Dunn, L. C. The Role of Subsidiary Forest Crops in the Douglas-fir Forests. Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. May 1942.

79) Eliot, W. A., and McLean, G. B. Forest Trees of the Pacific Coast. G. P. Putnam's Sons, New York. 1938.

80) Espenas, L. D. Seasoning of Oregon Hardwoods. Information Circular 6, Oregon Forest Products Laboratory, Corvallis, Oregon. December 1951.

81) Forest Resources of Oregon. Oregon State Board of Forestry, School of Forestry, Oregon State College, Corvallis, Oregon, and Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

82) Forest Resources Reports for Following Counties: Lincoln, Polk, Tillamook, Yamhill, Lane, Clackamas, Multnomah, Columbia, Clatsop, Coos, Washington, Benton, Linn, Marion. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Various dates, 1936 to 1948.

83) Forest Statistics for Southwest Oregon Unit. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. November 1951.

84) Forest Type Classification for the Pacific Northwest. Forest Economics Division, Pacific Northwest Forest and Range Experiment Station. May 1949.

85) Hanzlik, E. J. Trees and Forests of the Western United States. Portland Printing Company. Dunham Printing Company, Portland, Oregon. 1928.

86) Harlow, W. M., and Harrar, E. S. Textbook of Dendrology. McGraw-Hill Book Company, Inc., N. Y. 542 p. 1941.

87) Hornibrook, E. M., Larson, R. W., Van Akkeren, J. J., and Hasel, A. A. Board-foot and Cubic-foot Volume Tables for Some California Hardwoods. Research Note 67, California Forest and Range Experiment Station, Berkeley, California. February 1950.

88) Kurth, E. F. "Chemical Analysis of Western Woods: Part I." Reprint from Paper Trade Journal, 126(6). Oregon Forest Products Laboratory, Corvallis, Oregon. February 1948.

89) ---------- "The Chemical Analysis of Western Woods: Part III." Reprint from Tappi, 33(10). Oregon Forest Products Laboratory, Corvallis, Oregon. October 1950.

90) Markwardt, L. J., and Wilson, T. R. C. Strength and Related Properties of Woods Grown in the United States. Technical Bulletin No. 479, United States Department of Agriculture. September 1935.

91) McComb, F. "The Utilization of Oregon Hardwoods in Furniture Manufacturing." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. June 1938.

92) McMinn, H. E., and Maino, E. An Illustrated Manual of Pacific Coast Trees. 396 p. University of California Press, Berkeley, California. 1935.

93) Moravets, F. L. Production of Lumber in Oregon and Washington. Forest Survey Report 100, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

94) Olson, W. Z. Some Tests on the Gluing Characteristics of Four West Coast Hardwoods: Chinquapin, Tanoak, California Laurel, and Madrone. Forest Products Laboratory, United States Forest Service, Madison, Wis. 1949.

95) "Origin and History of Hardwoods Used on the Pacific Coast." Timberman, February 1924.

96) Robinson, D. D Utilization of Oregon Hardwoods. Information Circular 2, Oregon Forest Products Laboratory, Corvallis, Oregon. January 1948.

97) Sargent, C. S. Silva of North America. Houghton, Mifflin and Company, Boston and N. Y. 14 vol. 1890-1902.

98) ---------- Manual of the Trees of North America. Houghton, Mifflin and Company, Boston and N. Y. 910 p. Reprinted 1933.

99) Schoonover, S. E. American Woods. Watling and Company, Santa Monica, California. 250 p. 1951.

100) Schowalter, W. E. Exploratory Tests in the Rotary-Cutting of Veneer from Certain California Hardwoods. Six Rivers National Forest, Eureka, California. Unpublished.

101) Sudworth, G. B. Forest Trees of the Pacific Slope. Government Printing Office, Washington, D. C. 1908. Reprinted 1950.

102) ---------- Check List of the Forest Trees of the United States; Their Names and Ranges. Miscellaneous Circular 92, United States Department of Agriculture. March 1927.

103) Thompson, D. "Oregon Hardwoods." Thesis, School of Forestry, Oregon State College, Corvallis, Oregon. June 1939.

104) "Thriving Business Built from Western Hardwoods." Timberman, 55(1), p. 56. November 1953.

105) Torgeson, O. W. Kiln-drying Schedules For 1-inch Laurel, Madrone, Tanoak, and Chinquapin. Report No. R 1684, Forest Products Laboratory, United States Forest Service, Madison, Wis. 1947.

106) Voorhies, G. The Essentials of Kiln Drying Oregon Hardwood Lumber. Research Leaflet No. 2, Oregon Forest Products Laboratory, Corvallis, Oregon. 1944.

107) "Western Hardwood Manufacturers Organize." Timberman, Vol. 10, p. 44. August 1933.

Hardwoods in General

108) Craig, R., Jr. Manufacture and Use of Small Dimension; a Progress Report. Michigan Department of Economic Development, Lansing, Michigan. 1947.

109) Garver, R. D., and Miller, R. H. "Relation of Tree Size to Output for Southern Hardwoods." Southern Lumberman. February 1934.

110) Grading Rules for Hardwood Dimension (cut-stock) Lumber, Interior Trim and Moulding, Stair Treads and Risers, and Solid Hardwood Wall Paneling. Hardwood Dimension Manufacturers Association, Inc., Heyburn Building, Louisville 2, Kentucky.

111) Grading Rules for Northern Hard Maple, Beech and Birch Flooring. Maple Flooring Manufacturers Association, 46 Washington Boulevard, Oshkosh, Wisconsin.

112) Haig, I. T. "Solving the Riddle of Low Grade Hardwoods." American Forests, 56:26-30. February 1950.

113) Hardwood Plywood Rules. Hardwood Plywood Institute, 600 South Michigan Avenue, Chicago 5, Illinois.

114) Humboldt County Hardwoods. Forest Supervisor; Six Rivers National Forest, Eureka, California. Unpublished.

115) Industrial Uses of Selected Timber Species. Industrial Series No. 69, United States Department of Commerce. June 1947.

116) Lumber Grade Recovery from Hardwood Sawlogs in the Tennessee Valley. Technical Note No. 11, Division of Forestry Relations, Tennessee Valley Authority. August 1952.

117) Lumber Grade-Use Guide for Softwood and Hardwood Lumber in Building and General Construction. National Lumber Manufacturers Association, Washington, D. C.

118) Neubrech, W. L. American Hardwoods and Their Uses. Trade Promotion Series No. 178, United States Department of Commerce. 1938.

119) Noltemeyer, V. E. Accounting and Cost Controls in the Hardwood Conversion Industry. 4601 Almond Avenue, Louisville 9, Kentucky.

120) Oak Flooring, Commercial Standard. United States Department of Commerce. Obtained from Superintendent of Documents, Washington 25, D.C.

121) Rules for the Measurement and Inspection of Hardwood Lumber, Cypress, Veneer and Thin Lumber. National Hardwood Lumber Association, 59 East Van Buren Street, Chicago 5, Illinois.

122) Southern Hardwood Buyer's Guide. Southern Hardwood Producers, Inc., Memphis, Tennessee. 1953.

123) Toole, A. W. and Danielson, C. W., Jr. "The Utility of No. 3 Common Northern Hardwood Lumber for Mechanized Processing into Glued Products." Proceedings Forest Products Research Society, Vol. 3, p. 94. 1949.

124) Truax, T. R. The Gluing of Wood. Bulletin 1500, United States Department of Agriculture.

125) Veneer Cutting and Drying Properties; Cottonwood. Technical Paper 3555, D1766-3, Central States Forest Experiment Station. December 1950.

Small Sawmills

126) Benson, A. D. Dimension-stock Methods for New England Hardwoods. Circular No. 394, United States Department of Agriculture. August 1936.

127) ---------- Manufacture of Dimension Stock from Northern Hardwoods. Circular No. 163, United States Department of Agriculture. 1931.

128) Better and More Economical Sawing. Henry Disston and Sons, Philadelphia, Pennsylvania.

129) Brooks, R. D. Circular Saws--Design, Manufacture and Operation. Paper No. 48-WD1-9, American Society of Mechanical Engineers, 29 West 39 Street, New York 18. 1948.

130) Cahal, R. R. Sawmilling Practices that Pay. Southern Pine Inspection Bureau, New Orleans, Louisiana.

131) Cut-stock Possibilities in Wood-consuming Industries in Midwestern States. Report No. D1724, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. September 1948.

132) Darwin, W. N. and Thurmond, A. K. Good Management -- Key to Successful Sawmilling. Division of Forestry Relations, Tennessee Valley Authority.

133) Efficient Use of Power. Report No. R899-19, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. April 1944.

134) Establishing and Operating a Small Sawmill Business. Industry Series No. 20, United States Department of Commerce.

135) Facts for Millmen and the Circular Saw. Simonds Saw and Steel Company, Fitchburg, Massachusetts.

136) Foyster, J. R. Modern Mechanical Saw Practice. Crosby Lockwood and Son, Ltd., South Tudor Street, London. 1947.

137) Hanchett, K. S. Hanchett Saw and Knife Fitting Manual. Hanchett Manufacturing Company, Big Rapids, Michigan. 1950.

138) Instructions on Sawing Hardwood Logs, and Edging and Trimming Hardwood Lumber for Grade and Value Recovery. Report No. R899-27, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

139) List of Publications on Logging, Manufacture, and Utilization of Timber, Lumber, and Other Products. Report No. R790, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. July 1950.

140) Low Grade Hardwood Lumber Utilization and Milpak. Timber Engineering Company, 1319 Eighteenth Street, N.W., Washington 6, D. C.

141) Malcolm, F. B. Fabrication of Wood Products at Small Sawmills and Woodworking Plants. Report No. D1666-8, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin, December 1947.

142) Operating Small Sawmills in Wartime. Miscellaneous Publication No. 509, United States Department of Agriculture.

143) Sawmilling -- A Report on Small Sawmilling Equipment. The Research Council of Ontario, 39 Queen's Park Crescent, Toronto 5, Ontario.

144) Saws in the Filing Room. E. E. Atkins and Company, Indianapolis, Indiana.

145) Setting up a Ground Mill. Report No. R899-11, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

146) Short-cut Method of Finding the Minimum Sized Tree that Pays Its Way through Small Sawmill Operations. Report No. R899-13, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

147) "Small Circular Sawmills." Southern Lumberman, September 1945 through July 1946.

148) Small Sawmill Accounting. Report No. R899-12, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

149) Telford, C. J. Labor-saving Devices for Small Mills. Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

150) _____ Saw Lead. Report No. R899-21, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. September 1944.

151) _____ Self-loading Auto Truck Devices. Report No. R899-24, Forest Products Laboratory, Madison, Wisconsin. June 1945.

152) _____ Small Mill Conveyor. Report No. R899-21, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. September 1944.

153) _____ When to Move Portable Mills. Report No. R899-3, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. January 1931.

154) _____ Waste from Variation in Sawing Precision. Report No. R899-2, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. October 1932.

155) _____ Items of Cost Usually Ignored. Report No. R899, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

156) _____ Layouts and Sheds for Small Mills. Report No. R899-10, Forest Products Laboratory, United States Forest Service, Madison, Wisconsin. November 1933.

157) _____ "Energy Requirements for Insert-point Circular Head Saws." Proceedings Forest Products Research Society. 1949.

158) _____ Small Sawmill Operator's Manual. Superintendent of Documents, Washington 25, D.C. January 1952.

159) Useful Facts -- Sawmills and Saws. R. Hoe and Company, New York.