OREGON HARDWOOD SAWTIMBER

By James L. Overholser

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Forest Research Laboratory
School of Forestry
OREGON STATE UNIVERSITY
Corvallis 97331

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COVER PHOTOGRAPH: Large tanoaks near Pistol River

PREFACE

Growing interest in Oregon's hardwoods led to publication in 1953 of Basic Data for Oregon Hardwoods, Report G-2, by Jack R. Pfeiffer. This popular report, a compilation of information from many sources, was soon exhausted. But even though it has been out of print for several years, Pfeiffer's summary was so valuable that requests continue to arrive.

The present report is, in part, a revision of Pfeiffer's work, but it includes much new information from investigations made during the 15 years since Basic Data was printed.

ACKNOWLEDGMENTS

This review would have been impossible without the work of the four dozen authors whose reports I have referenced. In total, an immense volume of valuable research has been done by these men.

The photographs of wood cross sections were of microscope slides loaned by R. L. Krahmer.

Several reviewers made valuable suggestions on content and style of this report. They included Ralph K. Peter, U.S. Forest Service, Division of State and Private Forestry; John H. Grobey, Humboldt State College; K. R. Michel, past president of the Northwest Hardwood Association; and Everett L. Ellis, William I. West, Leif D. Espenas, Robert D. Graham, and Raymond A. Currier of the School of Forestry, Oregon State University.

OREGON HARDWOOD SAWTIMBER

Western Oregon has extensive stands of native hardwoods of such qualities that they are suitable raw material for making a wide selection of products. Processors and users of these woods need to know their properties so that the wood from them will provide greatest service.

Several organizations and many individuals have published valuable information about these woods, but the numerous reports need to be combined for ready access to that information. This report is aimed at providing for that need.

Several Oregon hardwoods supply logs for a growing industry. A dozen other species, limited in volume or without developed markets, are used little now but may be potentially valuable. Foremost in volume of lumber produced is red alder; second in production is bigleaf maple.

Information presented here is largely about physical properties of the wood from these trees and about considerations important in their manufacture and use. Economics of the industry are not easily measured, and comments made should be taken as indications, not as definitive statements of fact.

This report is divided into three major sections: status of the industry, information about the trees, and properties of the woods.

THE INDUSTRY

In recent years, increased acceptance of these woods has brought new stability to the industry.

History

The volume of hardwoods harvested annually for lumber in Oregon has varied greatly. For example, for western Oregon the West Coast Lumbermen's Association (now Western Wood Products Association) estimated a cut of more than 28 million board feet of lumber in 1936. For 1949 the estimated cut was not much more than 2 million, and had grown again to more than 28 million feet in 1960. John Grobey (23)* found that in the Northwest the volume of hardwoods cut for lumber varied inversely with the cut of softwoods; many mill operators turned to sawing hardwoods when demand for softwoods decreased.

Most mills where hardwoods were sawed intermittently were poorly equipped for such manufacturing. Milling and drying practices suited to softwoods resulted in producing hardwood lumber of low quality, which caused losses in manufacturing finished products and gave rise to the prevalent belief that western hardwoods were inferior to similar woods from other regions. The widely ranging volume cut annually resulted in an undependable supply of lumber. This factor led to disappointed customers and cancelled orders.

Producers of hardwood lumber in the Northwest have needed a stable market, trained workers, reliable information to teach to prospective workers, and increased acceptance of their product.

The situation has improved, however. Producers, wholesalers, and manufacturers joined together in September 1955 to form the Northwest Hardwood Association so that they could pool their efforts to arrive at workable grades for lumber and logs, to gain favorable freight rates and to achieve a uniformly high-quality product that would merit demand. Furthermore, several laboratories developed information on physical properties and processing characteristics of western hardwoods to aid in efficiently making high-quality products.

Status in 1968

Red alder lumber was in reasonably steady demand for several years before 1968, and well-manufactured lumber was available most of each year to fill that demand--<u>most</u> of the year, because some mills could not stockpile enough logs to produce lumber steadily during late winter when logging slowed or stopped. Several other factors also contributed to difficulty in accumulating logs.

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*Numbers in parentheses refer to references cited.

Steady demand for lumber was accompanied by rise in cost of stumpage. Trees that might have sold at $2 for a thousand board feet 20 years ago contrast with similar trees that might sell now for more than five times as much. Even so, prices paid for hardwood stumpage in 1967 were low when compared to prices for softwoods.

Loggers and log haulers usually are more familiar with handling softwoods than with handling hardwoods. Their equipment is also likely to be best suited for softwoods. Frequently, the result is that loggers are reluctant to work with hardwoods when they can keep busy with softwoods.

Sales of timber on National Forest land may include hardwoods along with predominant softwoods. The logging operator may contract to cut the hardwoods, but he may refrain from selling them because his equipment is not efficient with hardwoods, or because he cannot schedule his operation to haul out the hardwoods immediately after felling them, as is desirable to forestall the rapid staining that may occur in warm weather with species such as red alder and bigleaf maple. Also there may not be a mill within economical trucking range, or the mill may not have financial or productive capacity to handle the peak production of logs.

Sales of hardwood timber alone are difficult to make because the local stands usually have value too small to bear the expense of building roads, especially if they must be heavy-duty all-weather roads such as are needed for efficient hauling of softwoods or to meet minimal governmental standards.

There are problems associated with marketing, also. By far the largest market for good grades of lumber is for making furniture and cabinets. About one-half of the cut is in low grades of lumber that have been difficult to process at other than a loss because they were not suitable for exposed parts of furniture. New sorting and sizing for unexposed pieces of wood in upholstered furniture have developed some demand for grades of red alder lumber that formerly were restricted in use.

Increased use of red alder for pulp could serve to raise the quality of lumber produced, if logs are segregated by grade. As it is now, sawdust from softwoods is added to some pulp mixtures in preference to red alder chips.

Western producers of hardwood lumber have local advantage over other regions because of favorable freight rates west of a line running from Arizona through North Dakota, according to Ivan Bloch and Associates (4). West of this line lies a domestic market estimated at 110 million board feet in 1964--a market that has been increasing somewhat more rapidly than has population.

Much of this potential market for northwestern hardwoods has been supplied by similar hardwoods from other regions (4). But this situation could change. The forests of the Northwest probably grow enough sawtimber to supply all of the western market.

Metcalf (34) estimated that Oregon and Washington had about equal volumes of red alder, totalling 18, 603, 000. 000 board feet. On reasonably good sites, the species adds volume annually at close to 500 board feet an acre (54).

A realistic way to estimate the potential annual harvest might be to look only at those lands now occupied by red alder of sawtimber size. At 25, 000 board feet to the acre, the more than 18 billion board feet of timber would occupy 744, 000 acres. At 500 board feet of annual growth to an acre, this area would produce 372 million board feet a year. Not all acres will produce this well, of course. This estimated annual growth is more than three times greater than the western market for such lumber estimated by Bloch (4). By this analysis, growing stock appears ample to supply the western market for lumber and to provide a huge surplus for local use in pulping or lumber for other regional markets, which are expanding rapidly. And these other regions are being explored. Members of the Northwest Hardwood Association have reported sales of red alder lumber as far away as Florida and New York.

Species other than red alder are not being harvested in large volume except for bigleaf maple, which reportedly is cut into lumber in about 10 percent of the volume of red alder lumber.

There is considerable diversity in local use of hardwoods. Greatest volumes go to pulp and furniture; lesser amounts of sawtimber go to mills making such items as brush handles, water skis, paper roll plugs, and saddle stirrup bows. Burls from several species and figured wood from California-laurel support an impressive trade in bowls, trays, lamp stands, and tables. Some veneer is peeled from black cottonwood for boxes, and decorative veneer is peeled from several species. Huge burls that form at the base of bigleaf maple are sold by the pound for export to Europe.

THE TREES

Of the 15 species mentioned here. 12 are numerous enough so that their volumes have been estimated by the U. S. Forest Service; the remaining 3 species are in low volume mixed among stands of other trees. All are listed below according to their common and generic names (32).

Primary Species

Red alder	*Alnus rubra* Bong.
Oregon ash	*Fraxinus latifolia* Benth.
Golden chinkapin	*Castanopsis chrysophylla* (Dougl.) A. DC.
Black cottonwood	*Populus trichocarpa* Torr. & Gray
California-laurel*	*Umbellularia californica* (Hook. & Arn.) Nutt.
Pacific madrone	*Arbutus menziesii* Pursh
Bigleaf maple	*Acer macrophyllum* Pursh
California black oak	*Quercus kelloggii* Newb.
Canyon live oak	*Quercus chrysolepis* Liebm.
Oregon white oak	*Quercus garryana* Dougl.
Tanoak	*Lithocarpus densiflorus* (Hook & Arn.) Rehd.

Secondary Species

Bitter cherry	*Prunus emarginata* Dougl.
California white oak	*Quercus lobata* Neé
Pacific dogwood	*Cornus nuttallii* Audubon
Scouler willow	*Salix scouleriana* Barratt

Send to the Bulletin Clerk, Oregon State University, for a copy of *Trees to Know in Oregon* (44) if you need to know about these trees. C. H. Ross, Extension Forestry Specialist, has brought together clear descriptions of appearance, size. range, and uses of Oregon's trees, along with pictures and drawings to identify them.

Characteristics for these trees, listed in Table 1, are not rated closely, but are generally indicative of each species where growing in an ordinary stand. When the trees are open-grown, heights are lessened but diameters may be increased. This is especially true for bigleaf maple and canyon live oak. Open-grown trees of Oregon white oak and Pacific madrone frequently have crooked stems.

Information on managing Oregon hardwoods is scarce; the industry is still largely engaged in developing markets for naturally grown stands. Several publications are available, however, on red alder (46, 53. 54). This species is important in forest management because

*Also known as Oregon-myrtle.

Table 1. Description of Average Mature Hardwood Trees in Oregon.

Species	Height	Diam-eter	Age at maturity	Principal range	Best habitat
	Feet	Inches	Years		
			PRINCIPAL SPECIES		
Red alder	70	18	60	Coast range	Along streams
Oregon ash	70	24	100	Western Ore.	Wet bottomlands
Golden chinkapin	70	20	--	S.W. Ore.	Slopes
Black cottonwood	80	36	150	Western Ore.	Along streams
California-laurel	50	24	60	S. W. Ore.	Near streams
Pacific madrone	40	18	50	S. W. Ore.	Low slopes
Bigleaf maple	80	30	100	Western Ore.	Moist, rich soils
California black oak	60	24	--	S. W. Ore.	Sheltered valleys
Canyon live oak	70	36	--	S. W. Ore.	Sheltered canyons
Oregon white oak	55	24	--	Willamette valley	Valley slopes
Tanoak	80	24	70	S. W. Ore.	Valleys, low slopes
			SECONDARY SPECIES		
Bitter cherry	40	10	40	Western Ore.	Moist slopes
California white oak	100	48	--	S. W. Ore.	Low valleys
Pacific dogwood	25	10	--	Western Ore.	Porous soils
Scouler willow	30	10	30	Western Ore.	Moist areas

it adds considerable nitrogen to the soil, acts as a fire break, and has a ready market, but may crowd out high-value conifers.

Estimated volumes of commercially important hardwoods are listed in Table 2 (34-37), and potentially important species are listed in Table 3. Areas where hardwoods are present in notable volume are shown in Figure 1.

Volumes in Table 2 are based on trees with at least one 12-foot log to a top diameter of at least 8 inches inside bark and with diameter outside bark at breast height of 11 inches or more. Logs that barely meet these limits will yield such a high percentage of low-grade lumber that the sawmill operator probably will not recover costs of production and logs. A diameter of 12 inches at the small end of the log might allow the operator to recover his costs, but would reduce the volumes listed in Table 2.

Table 2. Estimated Net Volume[1] in 1963 of Principal Commercial Live Hardwood Sawtimber[2] Trees on Commercial Forest Land in Western Oregon by County and Species, in Millions of Board Feet, Scribner Log Rule(34-37).

County	Red alder	Bigleaf maple	Black cotton-wood	All three species
Northwest Oregon				
Clackamas	222	156	1-[3]	378
Clatsop	701	144	--	845
Columbia	514	115	--	629
Hood River	10	8	1-[3]	18
Marion	19	199	63	281
Multnomah	209	88	--	297
Polk	86	--	--	86
Tillamook	1,141	12	--	1,153
Washington	102	35	--	137
Yamhill	362	92	15	469
	3,366	849	78	4,293
West-central Oregon				
Benton	148	194	1-[3]	342
Lane	1,402	499	155	2,056
Lincoln	1,942	24	--	1,966
Linn	98	252	40	390
	3,590	969	195+	4,754
Southwest Oregon				
Coos	1,231	448	--	1,679
Curry	405	103	--	508
Douglas	860	717	115	1,692
Jackson	28	65	--	93
Josephine	62	15	--	77
	2,586	1,348	115	4,049
Totals	9,542	3,166	388	13,096

[1] Volumes for a species in a single county are subject to high errors by nature of the extensive sampling. These estimates should be considered indicative of relative amounts and dispersion, but should not be taken as absolute volumes.

[2] At least one 12-foot log to top diameter of not less than 8 inches inside bark and with diameter breast high 11 inches or larger.

[3] Sampling error may be especially large for these small volumes.

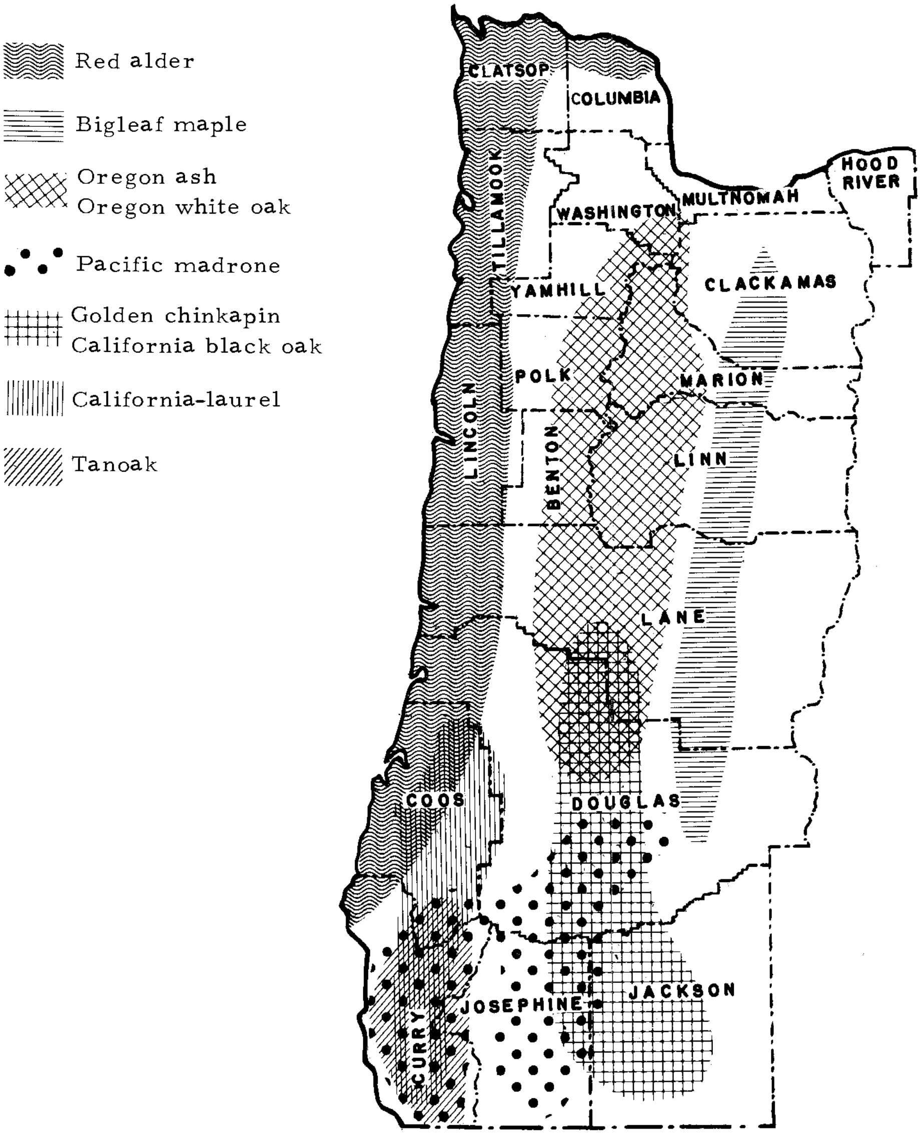


Figure 1. Principal stands of hardwood sawtimber in western Oregon. Several species are not shown; among them is black cottonwood, which grows along the rivers--especially the Willamette and Columbia.

Table 3. Estimated Net Volume[1] in 1963 of Additional Live Hardwood Sawtimber[2] on Commercial Forest Land in Western Oregon, in Millions of Board Feet, Scribner Log Scale (34-37).

County	Oregon ash	California-laurel	Golden chinkapin	Pacific madrone	California white oak	Canyon live oak	California black oak	Oregon white oak	Tanoak	All
Northwest Oregon										
Clackamas	12	--	--	--	--	--	--	--	--	12
Clatsop	--	--	--	--	--	--	--	--	--	--
Columbia	--	--	--	--	--	--	--	--	--	--
Hood River	--	--	--	--	--	--	--	17	--	17
Marion	41	--	--	--	--	--	--	--	--	41
Multnomah	--	--	--	--	--	--	--	--	--	--
Polk	48	--	--	--	--	--	--	168	--	216
Tillamook	--	--	--	--	--	--	--	--	--	--
Washington	--	--	--	--	--	--	--	11	--	11
Yamhill	21	--	--	--	--	--	--	206	--	227
	122	--	--	--	--	--	--	402	--	524
West-central Oregon										
Benton	30	--	9	--	--	--	--	258	--	297
Lane	22	--	9	45	--	--	52	98	--	226
Lincoln	--	--	--	--	--	--	--	--	--	--
Linn	17	--	20	--	--	--	--	--	--	37
	69	--	38	45	--	--	52	356	--	560

Southwest Oregon										
Coos	1	157	1	2	--	--	--	13	72	246
Curry	--	196	--	283	--	22	6	27	1,416	1,950
Douglas	--	--	138	489	--	--	196	261	--	1,084
Jackson	3	--	13	375	--	1	530	53	1	976
Josephine	3	--	20	302	17	77	463	66	28	976
	7	353	172	1,451	17	100	1,195	420	1,517	5,232
Totals	198	353	210	1,496	17	100	1,247	1,178	1,517	6,316

[1] Volumes for a species in a single county are subject to high errors by nature of the extensive sampling. These estimates should be considered indicative of relative amounts and dispersion, but should not be taken as absolute volumes.

[2] At least one 12-foot log to top diameter of not less than 8 inches inside bark and with diameter breast high 11 inches or larger.

THE WOODS

Oregon hardwoods should have those qualities that are needed in wooden parts of furniture, because furniture manufacturing offers a high-volume market at favorable prices. Handsome appearance with ability to take stains and finishes, strength to hold reasonable loads, ease in machining, ability to form strong joints with glues, lack of splitting when fastenings are inserted, and sufficient hardness to resist abrasion or denting are desirable qualities. The various species are graded for these qualities in following pages.

Values cited are indicative of what you might expect from wood of a particular species, but most are averages from tests of wood from a few trees cut in a restricted area. No two trees are alike, and no two stands are alike, either. Most of the values for strength and related properties in Table 4 are from trees grown in Oregon. The red alder, black cottonwood, and bigleaf maple were from Washington; the canyon live oak, some of the California black oak, and some of the Pacific madrone were from California. Only by chance will a piece of lumber test just like the values reported--but it probably will not be greatly different.

Information on gluability and machinability is summarized in Tables 5 and 6; texture (or grain) and color are described for each species individually. Advice on seasoning is extensive and important enough to merit an extended section.

Strength properties

The chief product sawed from Oregon hardwoods is factory lumber, most of which is ultimately made into cabinets and furniture. Desirable strength properties for such lumber are different from those of softwood structural lumber. For furniture, strength in bending is important for such pieces as rails in beds and davenports, but resistance to indentation and abrasion is important for exposed pieces. Wood in upholstered furniture should hold tacks well, and exposed pieces must take a desirable finish.

Modulus of rupture (MOR) is a useful measure of strength in bending. For red alder, the hardwood cut in greatest volume, MOR averages 9800 psi (pounds per square inch) at 12 percent moisture content. In Table 4, there are 4 other Oregon hardwoods listed with MOR less than that of red alder and 8 with MOR more than that of red alder.

For the country as a whole, Markwardt and Wilson (33) found that of 53 softwoods, slightly more than half had MOR less than that of red alder. Among 113 hardwoods, 30 had MOR less than for red alder. Oaks, hickories, and ashes are most numerous among species that are

Table 4. Strength and Related Properties of Oregon Hardwoods.[1]

Species	Moisture content	Specific gravity, oven dry, based on volume-- At test	Specific gravity, oven dry, based on volume-- When oven dry	Weight per cubic foot	Shrinkage from green to oven dry, based on green size: Volumetric	Radial	Tangential
	Per cent			Lb	Per cent	Per cent	Per cent
Alder,	98	0.37	0.43	46	12.6	4.4	7.3
red	12	.41	---	28	---	---	---
Ash,	48	.50	.58	48	13.2	4.1	8.1
Oregon	12	.55	---	38	---	---	---
Chinkapin,	134	.42	.48	61	13.2	4.6	7.4
golden	12	.46	---	32	---	---	---
Cottonwood,	132	.32	.37	46	12.4	3.6	8.6
black	12	.35	---	24	---	---	---
California-	70	.51	.59	54	11.9	2.8	8.1
laurel	12	.55	---	39	---	---	---
Dogwood,	52	.58	.70	55	17.2	6.4	9.6
Pacific	12	.64	---	45	---	---	---
Madrone,	68	.58	.69	60	17.4	5.4	11.9
Pacific	12	.65	---	45	---	---	---
Maple,	72	.44	.51	47	11.6	3.7	7.1
bigleaf	12	.48	---	34	---	---	---
Oak,	106	.51	.58	66	12.1	3.6	6.6
Calif. black	12	.57	---	40	---	---	---
Oak,	62	.70	.84	71	16.2	5.4	9.5
canyon live	12	.77	---	54	---	---	---
Oak,	72	.64	.75	69	13.4	4.2	9.0
Ore. white	12	.72	---	50	---	---	---
Tanoak[3]	115	.54	.66	62	14.9	5.5	10
"	11	.66	---	41	---	---	---
Willow,	105	.39	.47	50	13.8	2.9	9.0
black	12	.44	---	31	---	---	---

[1] Markwardt, L.C., and T.R.C. Wilson. Strength and Related Properties of Woods Grown in the United States. Tech. Bul. 479, U.S. Dept. of Agri. 1935.

Table 4. (Continued)

Species	Static bending: Fiber stress at pl[2]	Modulus of--: Rupture	Modulus of--: Elasticity	Work to--: Pl[2]	Work to--: Maximum load	Work to--: Total
	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.
Alder,	3,800	6,500	1,170	0.70	8.0	15.3
red	6,900	9,800	1,380	1.85	8.4	10.7
Ash,	4,200	7,600	1,130	0.92	12.2	33.3
Oregon	7,000	12,700	1,360	2.08	14.4	22.3
Chinkapin,	4,200	7,000	1,020	1.09	9.5	20.4
golden	7,900	10,700	1,240	3.11	9.5	19.1
Cottonwood,	2,900	4,800	1,070	0.44	5.0	12.7
black	5,300	8,300	1,260	1.25	6.7	10.8
California-	3,900	6,600	720	1.23	16.8	45.6
laurel	5,400	8,000	940	1.85	8.2	12.8
Dogwood,	4,200	8,200	1,090	0.92	17.0	38.7
Pacific	7,200	10,500	1,470	2.02	11.0	46.8
Madrone,	4,700	7,600	880	1.43	11.2	22.0
Pacific	7,300	10,400	1,230	2.46	8.8	12.4
Maple,	4,400	7,400	1,100	1.02	8.7	14.2
bigleaf	6,600	10,700	1,450	1.66	7.8	11.8
Oak,	3,400	6,200	740	1.03	8.8	16.0
Calif. black	6,100	8,700	990	2.28	6.5	10.0
Oak,	6,300	10,600	1,340	1.70	14.4	30.9
canyon live	9,300	12,900	1,610	3.15	9.9	21.5
Oak,	4,600	7,700	790	1.51	13.7	29.8
Ore. white	6,600	10,300	1,100	2.28	9.8	18.2
Tanoak[3]	4,421	8,866	1,321	0.95	11.19	---
"	6,963	16,300	1,800	1.58	17.91	---
Willow,	3,100	5,600	1,020	0.58	10.8	27.6
black	5,500	8,500	1,310	1.37	9.3	23.4

[2]Proportional limit or limit of elasticity.

Table 4. (Continued)

Species	Impact bending: Fiber stress at pl[2]	Impact bending: Work to pl[2]	Impact bending: Height to fail; 50-lb hammer	Comp. // to grain: Fiber stress at pl[2]	Comp. // to grain: Maximum crushing strength	Comp. ⊥ to grain; stress at pl[2]
	Lb per sq in.	In.-lb per cu in.	In.	Lb per sq in.	Lb per sq in.	Lb per sq in.
Alder,	8,000	2.6	22	2,620	2,960	310
red	11,600	4.8	20	4,530	5,820	540
Ash,	8,900	3.0	39	2,760	3,510	650
Oregon	13,300	5.2	33	4,100	6,040	1,540
Chinkapin,	8,800	3.4	31	2,030	3,020	490
golden	10,900	4.8	30	4,150	5,540	680
Cottonwood,	6,800	2.2	20	1,760	2,160	200
black	9,800	3.8	22	3,270	4,420	370
California-	8,300	4.1	57	1,980	3,020	800
laurel	10,700	5.3	31	3,520	5,640	1,400
Dogwood,	9,800	3.6	56	2,410	3,640	870
Pacific	10,500	3.7	34	4,300	7,540	1,650
Madrone,	10,200	4.7	40	2,430	3,320	780
Pacific	10,400	4.3	23	4,040	6,880	1,620
Maple,	8,500	2.8	23	2,510	3,240	550
bigleaf	---	---	28	4,790	5,950	930
Oak,	8,200	3.4	30	1,880	2,800	890
Calif. black	8,800	4.0	16	3,330	5,640	1,440
Oak,	11,200	3.9	47	3,940	4,690	1,480
canyon live	13,000	5.5	37	6,110	9,080	2,260
Oak,	10,300	4.8	49	2,480	3,570	1,380
Ore. white	11,900	5.4	29	3,960	6,530	2,110
Tanoak[3]	---	---	---	2,420	4,029	694
"	---	---	---	4,453	7,584	1,078
Willow,	7,600	2.5	33	1,810	2,340	330
black	11,000	4.7	31	3,120	4,560	630

[3] Randall, C.A. "Strength and Related Properties of Tanoak." J. of For. 54(7):458-462. July 1956.

Table 4. (Continued)

Species	Hardness; load to half-embed a ball 0.444-in. diam		Shear // to grain; maximum	Cleavage; load to split	Tension ⊥ to grain; maximum
	End	Side			
	Lb	Lb	Lb per sq in.	Lb per in. width	Lb per sq in.
Alder,	550	440	770	220	390
red	980	590	1,080	270	420
Ash,	850	790	1,190	310	590
Oregon	1,430	1,160	1,790	410	720
Chinkapin,	730	600	1,010	230	480
golden	840	730	1,260	---	---
Cottonwood,	280	250	600	170	270
black	540	350	1,020	220	330
California-	1,020	1,000	1,270	430	780
laurel	1,540	1,270	1,860	420	870
Dogwood,	1,140	980	1,300	340	740
Pacific	1,870	1,350	1,720	410	1,040
Madrone,	1,120	940	1,420	430	770
Pacific	1,890	1,460	1,810	490	1,360[4]
Maple,	760	620	1,110	320	600
bigleaf	1,330	850	1,730	400	540
Oak,	910	850	1,140	350	700
Calif. black	1,180	1,100	1,470	360	770
Oak,	1,590	1,570	1,700	520	970
canyon live	2,530	2,420	2,290	640	---
Oak,	1,430	1,390	1,630	450	940
Ore. white	1,880	1,660	2,020	380	830
Tanoak[4]	957	947	1,249	503	731
"	1,639	1,406	2,184	467	645
Willow,	490	500	870	210	360
black	850	630	1,160	290	530

[4] Schniewind, A.P. Strength and Related Properties of Pacific Madrone. II. In Air-Dry Condition. Calif. Forestry and For. Prod. No. 20. Calif. Agri. Exp. Sta. 1960.

stronger than red alder. Red alder compares favorably in properties with yellow poplar, a well-known wood in much demand. Red alder, however, resists indentation more than does yellow poplar.

Oregon hardwoods rank differently from one strength property to another. They are compared with well-known eastern and southern hardwoods in the Appendix (pages 51-52).

<u>Appearance</u>

To report the physical properties of Oregon hardwoods is not enough, because much of their value lies not only in such qualities as strength, but also in color and pattern of grain. No two pieces of wood are identical in appearance; the endless diversity of pattern in wood helps to give it that fascinating attractiveness from which we gain continuing delight. But wood of a particular species has attributes common throughout that species. These attributes can be described. Some can be photographed.

In the next few pages, brief descriptions of the general appearance of wood from ten of our hardwoods and two pictures of each species will help you recognize their wood.

One view is of the end grain across the annual rings. It is a slight magnification so you can see cross sections of the cells somewhat as you could see them with a hand lens of about 10-power. There are two notable differences. Black ink will give no hint of the color of the wood, and I took the pictures by light passing through thin sections, so cell openings are brightly lighted where they would be shadowed when viewed with a hand lens by reflected light.

The other view is of a flat-grain surface of lumber, sanded and coated with a transparent finish. This view is a reduction from an area that was about 8 inches long in the direction of the grain. Most hardwood lumber is flat grain and so is rotary-cut veneer, so this view will give you some idea of the grain pattern you are most likely to see when the wood is exposed in a finished product--except for those species that have several different patterns.

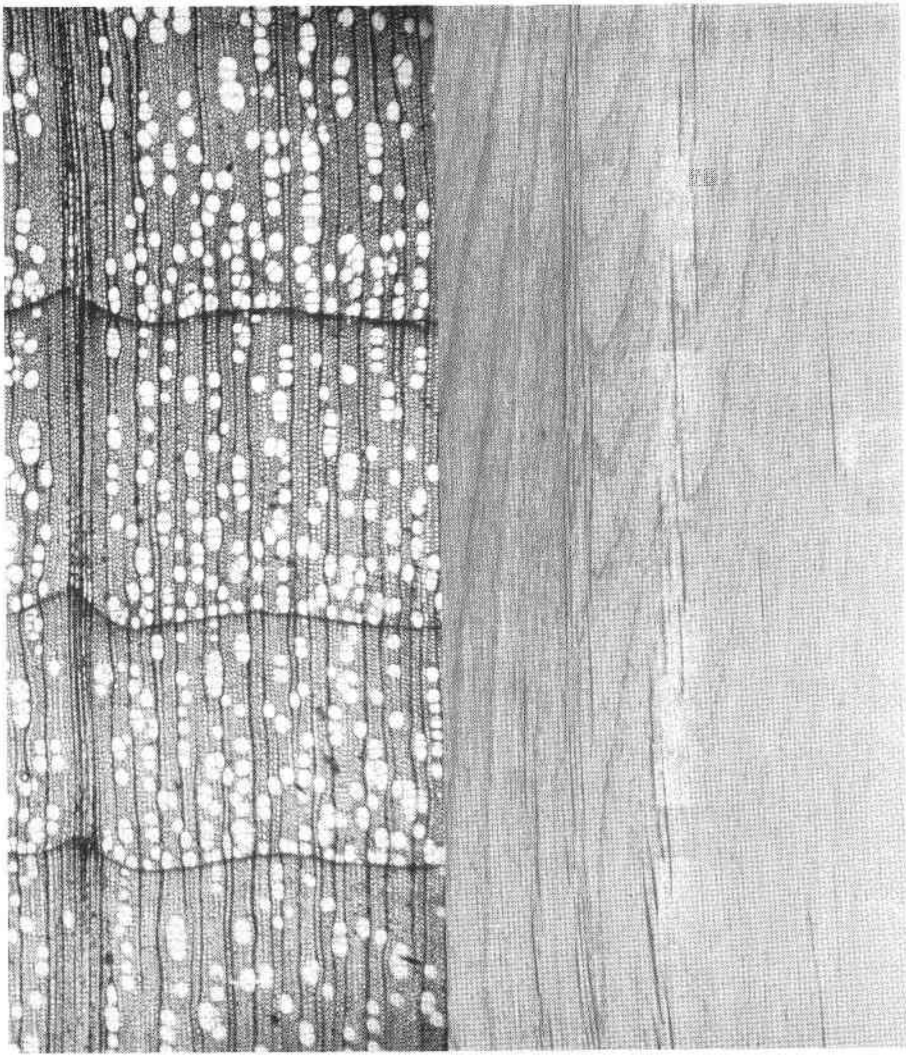
In the end-grain cross sections, the few dark lines extending more or less from left to right across each picture are annual rings; wood between two such lines was formed in one growing season. These same lines contribute to the patterns seen on the flat-grain surface.

In some of the species, all of the large cells, or vessels, are about the same size and are evenly distributed; these woods are called diffuse-porous. In other species, some of the first vessels that form at the beginning of the growing season are much larger than any of those formed later; these woods are called ring-porous. In some species, such as tanoak, early vessels are only slightly larger than those formed toward the end of the growing season, so they might be classed as semi-ring porous. The evenly distributed vessels of the diffuse-porous woods are usually considerably smaller than the large cells of the ring-porous species.

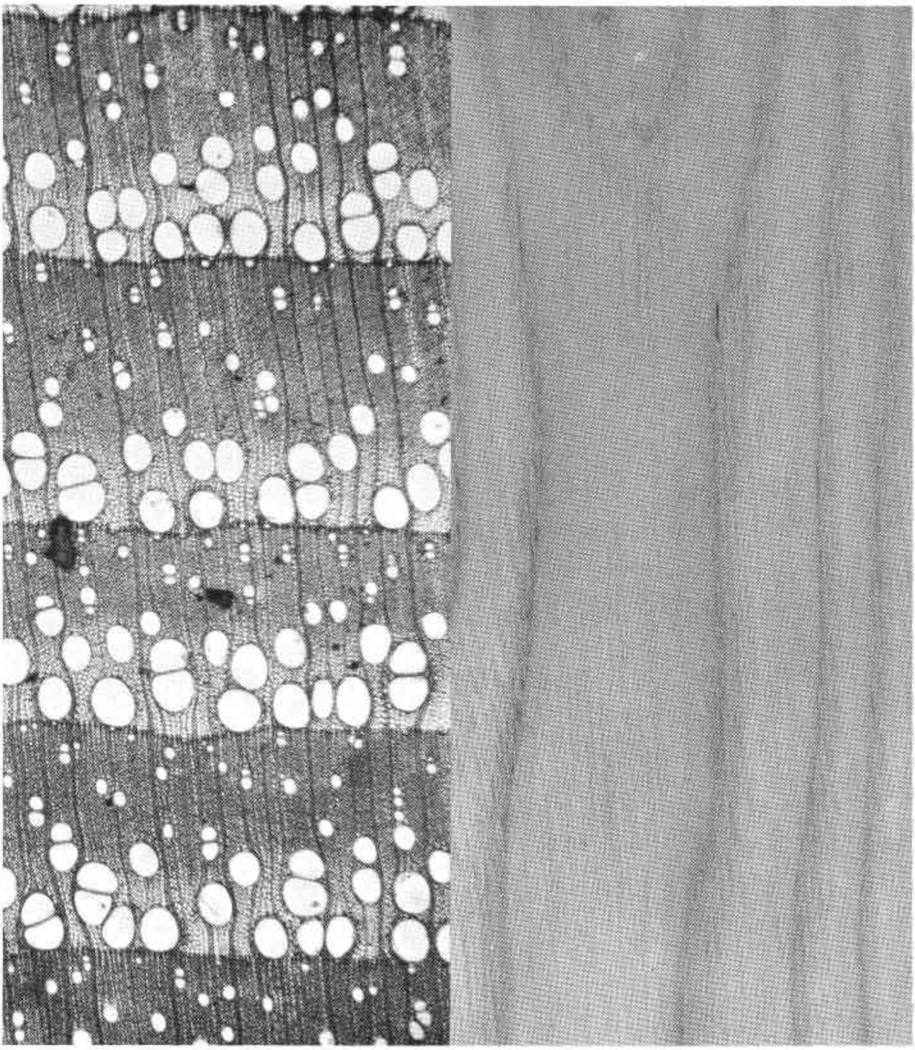
The numerous dark bands extending up and down on the cross sections are wood rays. They extend outward toward the bark and also extend vertically along the trunk for distances that vary with the species. The oaks, tanoak, and red alder have some very thick aggregations of rays that are wide enough to be seen in cross section on the views of flat-grain lumber. Such rays are numerous in the oaks, but are few in red alder. They vary considerably in height.

In the cross sections of Oregon white oak and California black oak, traces of the balloon-like membranes called tyloses are visible in the vessels, or pores.

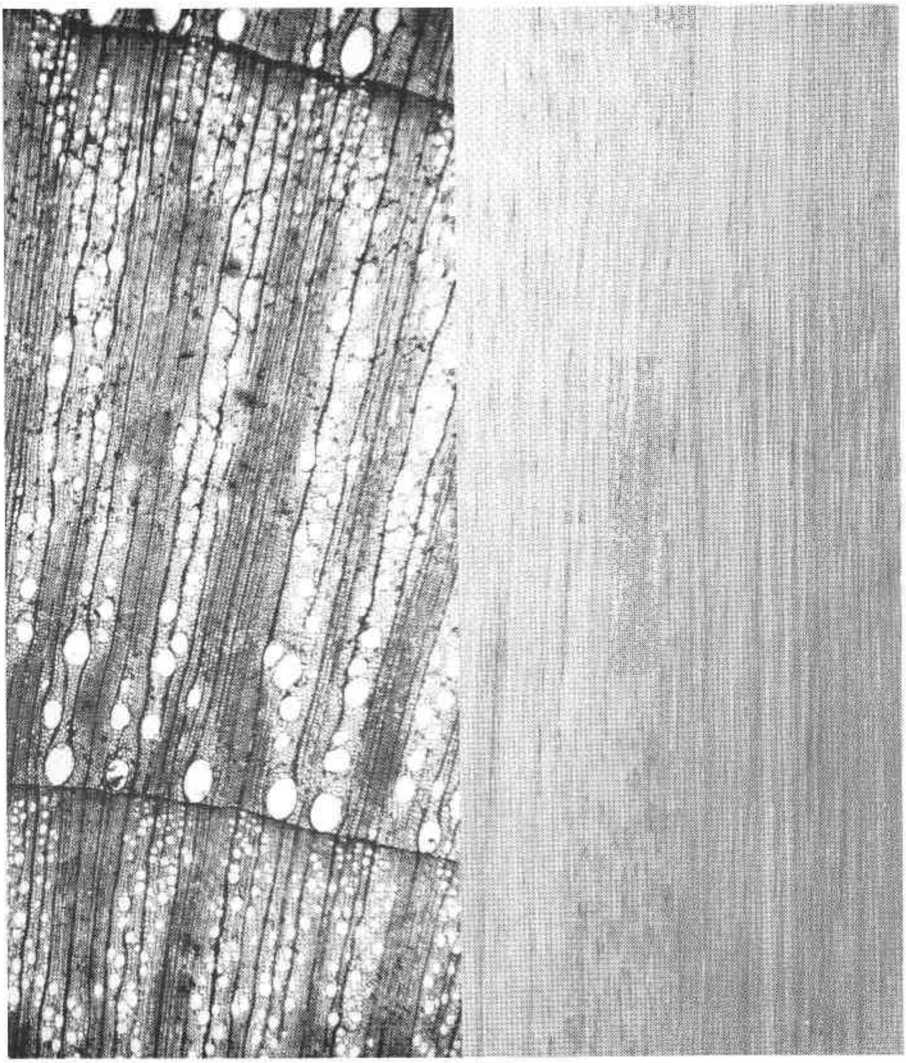
The size of pores, their groupings, and the size of rays help in recognizing particular species more than do color or flat-grain pattern. For definitive descriptions, I advise that you consult one of the good references available (40).



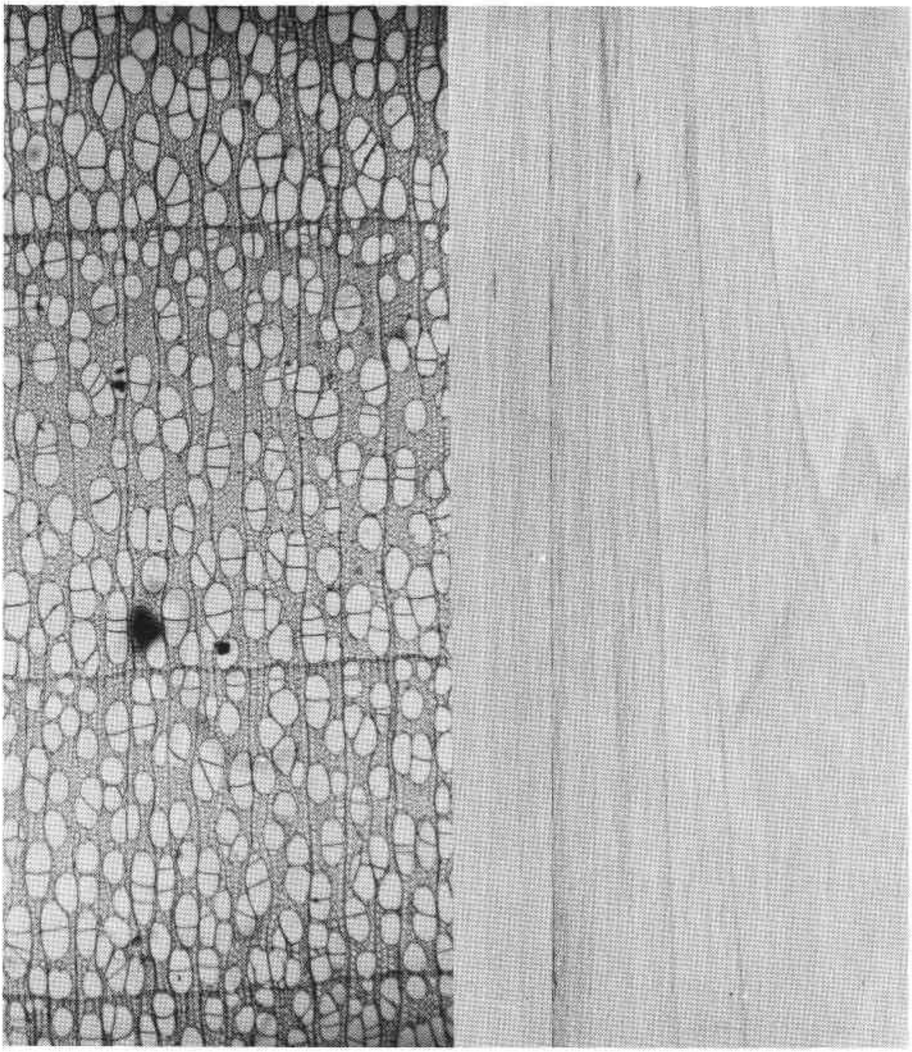
RED ALDER is light colored when first sawed, reddens on exposure to air, and can be dried to various shades of brown and reddish brown as desired. It can be finished to resemble many popular woods. The heartwood is indistinct, and the grain pattern is subdued. Growth rings are distinct; the wood is diffuse porous. Wide aggregate rays are spaced irregularly, often at wide intervals. It has no characteristic taste or odor.



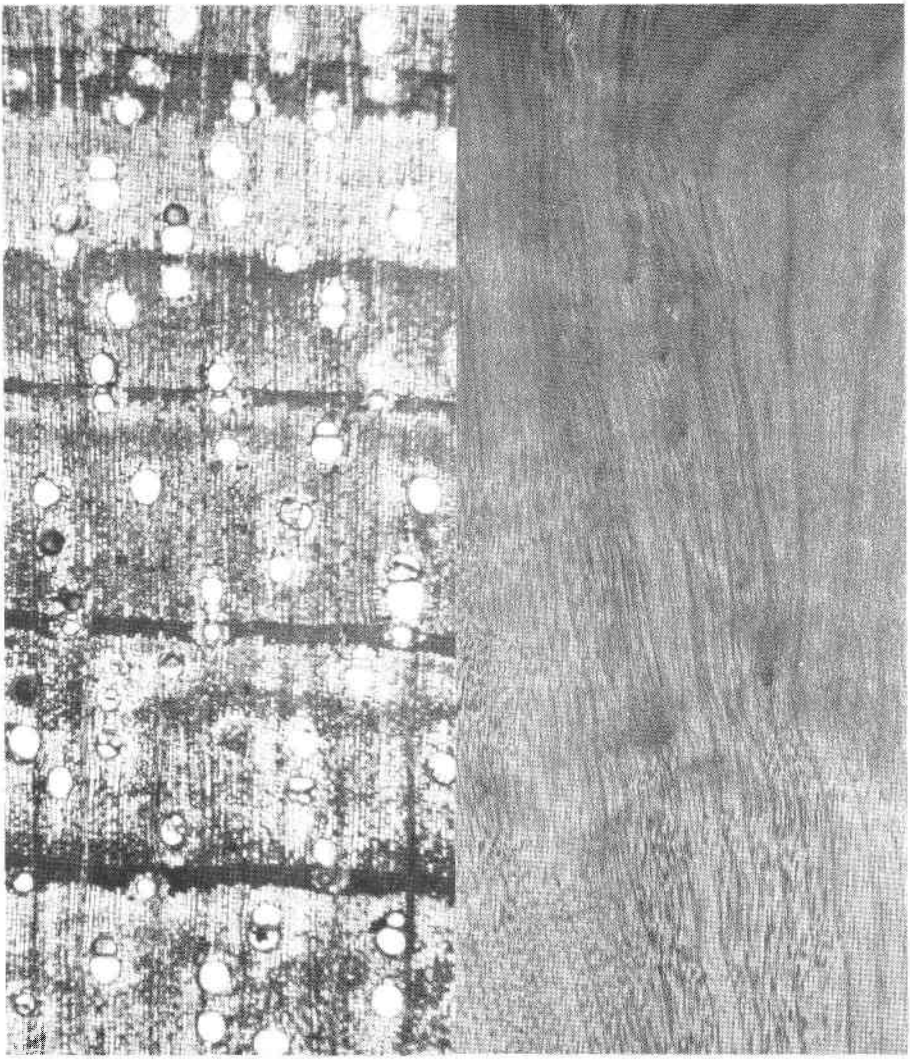
OREGON ASH has thick, nearly white sapwood; the heartwood is grayish or yellowish brown. The wood is somewhat lustrous. It is ring porous, and growth rings are distinct in a strong pattern. It has no characteristic odor or taste and is straight grained.



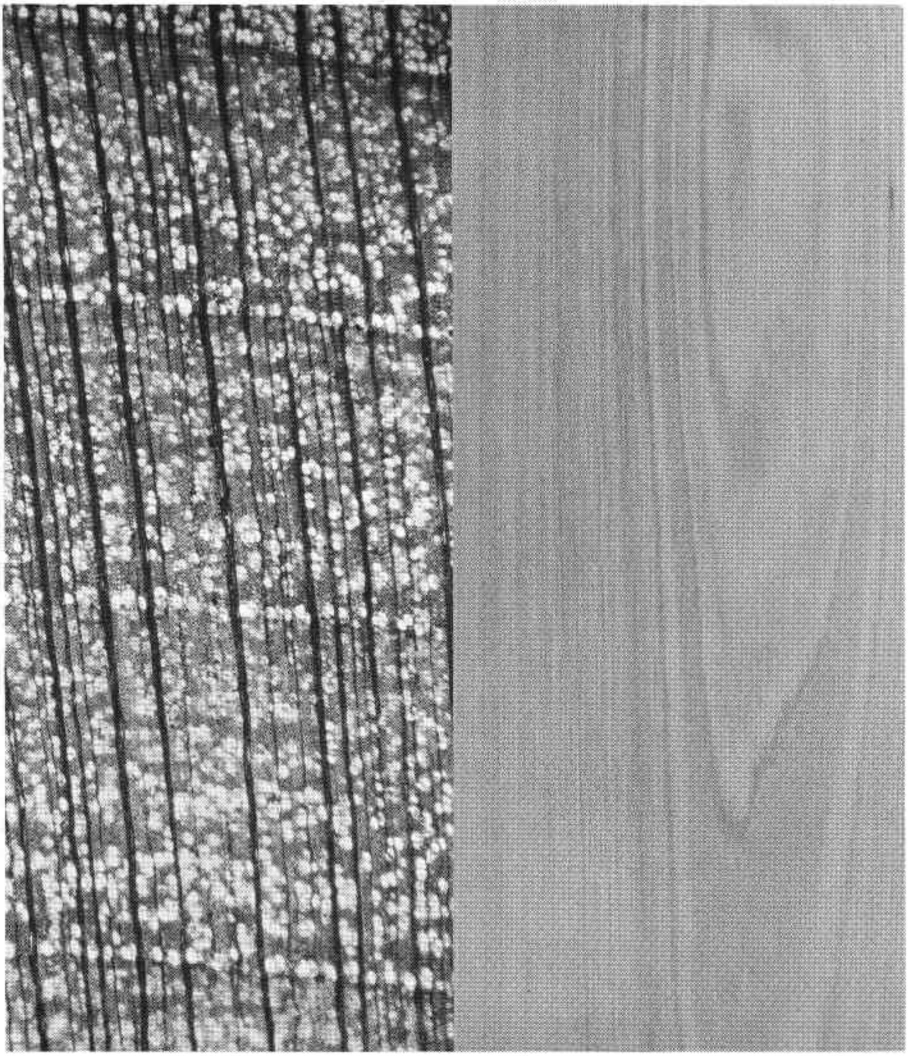
GOLDEN CHINKAPIN has thin sapwood much the same color as the heartwood, light brown with a pinkish tinge. It is ring porous, and the growth rings are distinct. The small vessels form flame-shaped patterns radially on the cross section. The wood has no characteristic odor or taste.



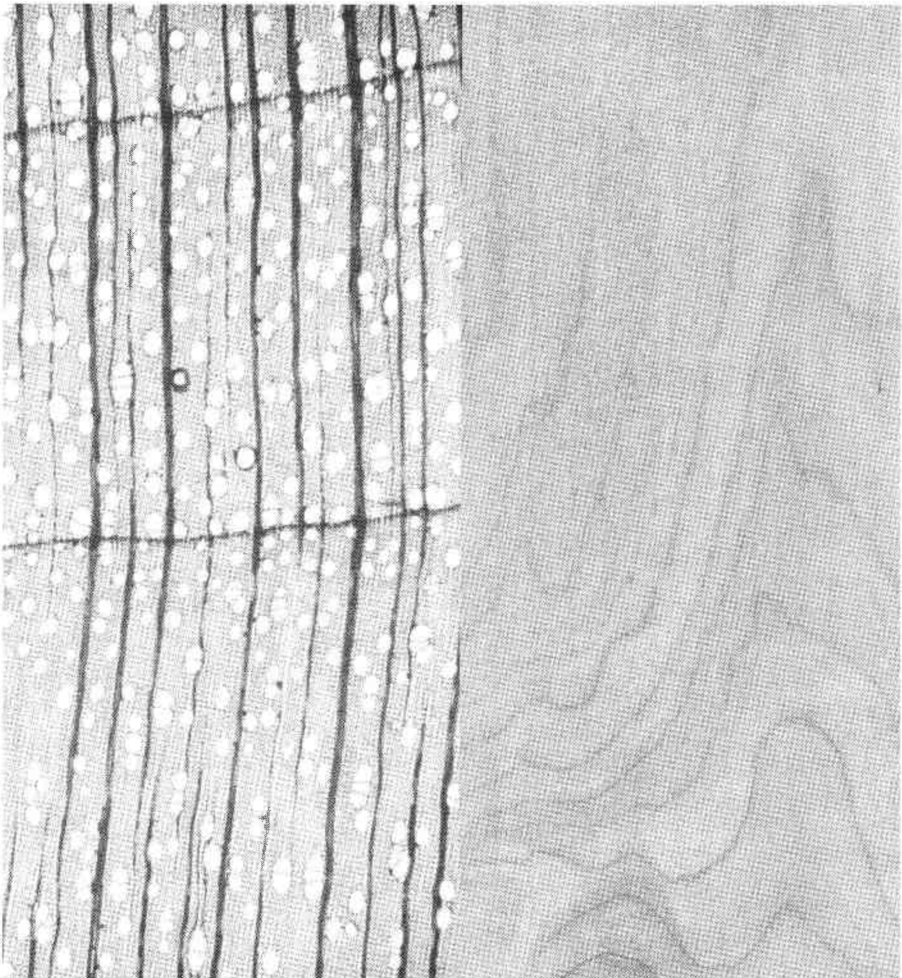
BLACK COTTONWOOD has almost white sapwood that often merges into the light gray or grayish brown heartwood that may have some dark streaks. Growth rings are distinct but inconspicuous; the wood is semi-ring porous, so the pattern is subdued. It has no odor when dry, but is disagreeable when wet. It is straight grained.



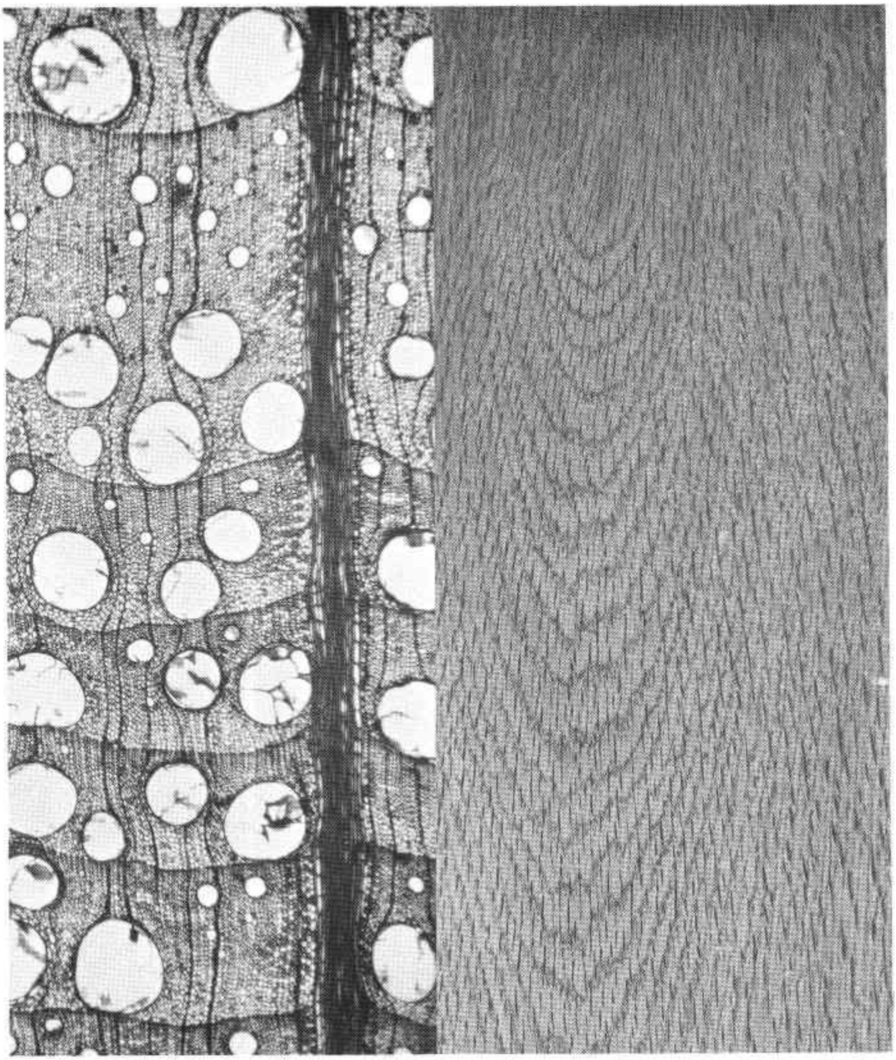
CALIFORNIA-LAUREL has thick whitish-to-light-brown sapwood and heartwood that is light rich-brown to grayish brown, often with dark streaks that make it prized for bowls and lamps. The growth rings are distinct, and the wood is diffuse porous with a strong grain pattern. It has a characteristic spicy odor, but no taste. The wood can be straight or interlocked grain in different trees.



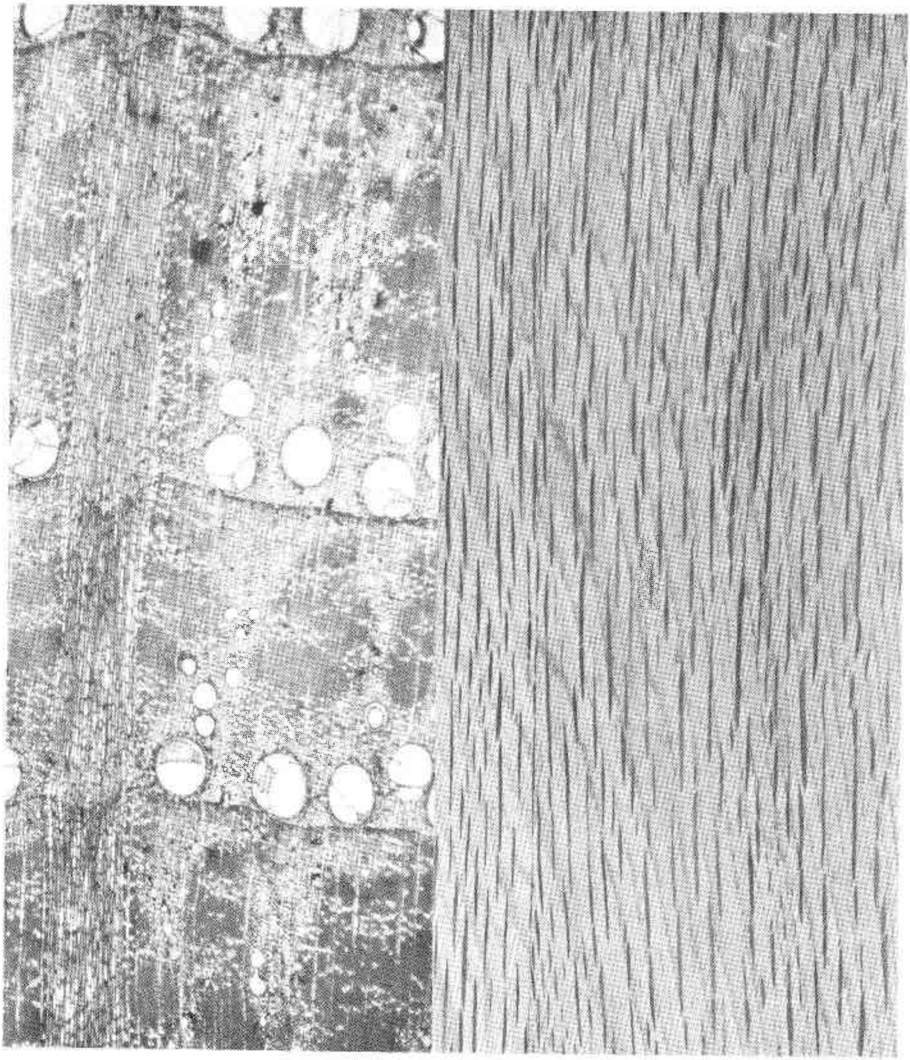
PACIFIC MADRONE has thin, whitish sapwood and pale, reddish brown heartwood with a well-figured pattern that resembles black cherry and is especially handsome in rotary-cut veneer. Growth rings are barely visible in the fine-grained, diffuse-porous wood. It has no characteristic taste or odor.



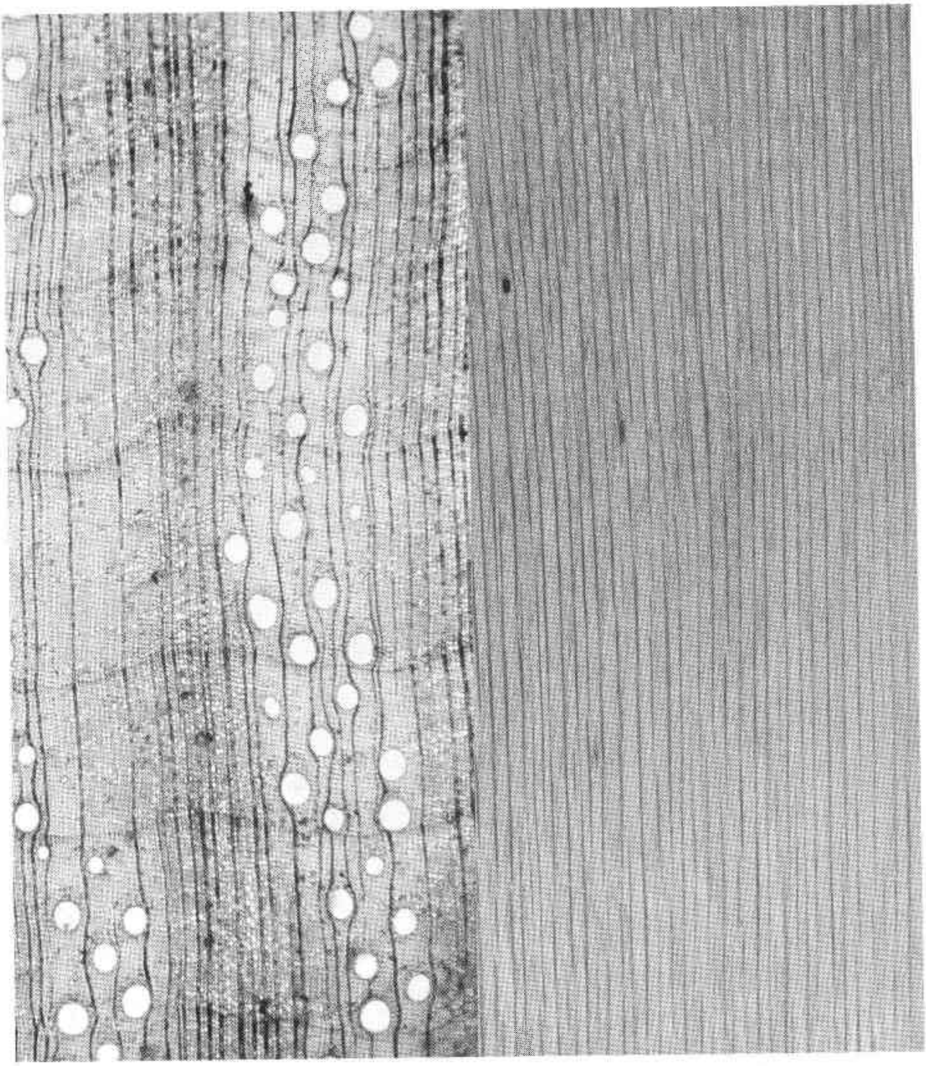
BIGLEAF MAPLE has reddish white sapwood and pinkish brown heartwood. The wood is usually straight grained, but also can be wavy grained, with quilted, fiddle-back, burl, and blister patterns that provide face veneer or inlays for expensive furniture. Growth rings are not distinct, and the fine-grained wood is essentially diffuse porous. It has no characteristic taste or odor.



CALIFORNIA BLACK OAK is pale reddish brown in color and fairly fine grained for an oak. The heavy rays are numerous and short vertically. The ring-porous wood with distinct growth rings is classified as a red oak in character, although the heartwood is difficult to penetrate with liquids and there are traces of membranes like tyloses in the sections I have seen. It has no characteristic taste or odor.



OREGON WHITE OAK is pale yellowish brown, with a greenish cast to the heartwood, which is darker than the sapwood. The ring-porous wood has very distinct growth rings and rays that are perhaps not so numerous as in California black oak, but are somewhat taller vertically. Tyloses are distinct in the vessels. It has no characteristic taste or odor.



TANOAK has very thick sapwood that is difficult to distinguish from the light reddish brown heartwood when freshly cut and cannot be separated visually when the wood darkens from exposure. Growth rings are scarcely visible in the almost diffuse-porous wood. The numerous very tall rays give rotary-cut veneer the appearance of rift-sawed oak. It has no characteristic taste or odor.

Gluability

Laboratory studies have demonstrated that joints satisfactory for most purposes can be glued with all Oregon species tested, but there is a range in ease of gluing (Table 5).

Red alder, along with 14 species from other regions, was tested by the U.S. Forest Products Laboratory in 1929 with casein, starch, and animal glues (52). In 1955, the same laboratory reported results of tests on golden chinkapin, tanoak, California-laurel, and Pacific madrone (39). These latter tests also included casein, starch, and animal glues, but added urea and resorcinol resins.

In 1964, the Forest Products Laboratory of the University of California reported tests of California black oak, golden chinkapin, Pacific madrone, and tanoak that had been glued with a phenolic resin and with polyvinyl acetate (8). The tests included Pacific madrone that had been reconditioned after collapse and tanoak that had been solvent-seasoned.

Results were reported as percentage of wood that failed when a glued joint was separated and as load required to separate the joint in the block-shear test. The early tests of red alder were made on more than 30 joints for each glue; the later tests included fewer joints of each species and glue, but nevertheless indicate results that could be expected from similar joints.

A rough ranking by ease of gluing would place red alder in the lead, with golden chinkapin as a close second; Pacific madrone, tanoak, California black oak, and California-laurel lag in gluability, but none presents unusual problems when gluing conditions are controlled moderately well. The ease of gluing red alder is known in industry (30).

Neither reconditioning madrone to correct collapse from drying nor solvent seasoning tanoak appeared to hinder gluing.

In all species tested, glued joints were stronger with dense wood than with light wood.

Oregon hardwoods do not contain oily extractives that weaken glue bonds, so ought to bond well with other modern glues.

Table 5. Gluability of Several Hardwoods as Measured by Shear-Block Tests.
A. Reported by U.S. Forest Products Laboratory (39, 52).

Species	Specific gravity	Glue or resin									
		Casein		Starch		Animal		Urea		Resorcinol	
		Shear strength	Wood failure	Shear strength	Wood failure	Shear strength	Wood failure	Shear strength	Wood failure	Shear strength	Wood failure
		Psi	Per cent	Psi	Per cent	Psi	Per cent	Psi	Per cent	Psi	Per cent
Red alder[1]	0.44	1,650	91	1,600	97	1,650	96	--	--	--	--
Golden chinkapin[2]	.52	2,044	88	1,740	68	1,952	92	2,199	98	2,130	88
Calif.-laurel[3]	.67	2,574	28	2,726	17	2,929	50	3,044	83	2,942	77
Pacific madrone[2]	.67	2,855	78	2,630	87	2,675	84	2,714	86	2,976	86
Tanoak[2]	.69	2,714	49	2,712	64	3,042	74	3,020	90	3,132	65

[1]Each value is average of more than 30 tests.

[2]Each value is average of 20 tests.

[3]Each value is average of 15 tests.

Table 5. (Continued)

B. Reported by California Forest Products Laboratory (8).

Species	Phenolic resin			Polyvinyl acetate		
	Specific gravity	Shear strength	Wood failure	Specific gravity	Shear strength	Wood failure
		Psi	Per cent		Psi	Per cent
Calif. black oak	0.48	2,005	65	0.55	2,018	35
Golden chinkapin	.52	1,724	95	.55	1,973	99
Pac. madrone, reconditioned	.67	2,247	70	.66	2,527	90
Pac. madrone, mod. collapse	.80	2,552	95	.76	2,740	55
Pac. madrone, severe collapse	.76	1,917	50	.84	2,991	7
Tanoak, kiln dried	.66	2,251	75	.68	2,425	45
Tanoak, solvent seasoned	.60	2,155	69	.62	2,205	70
Tanoak, extracted[1]	.56	2,062	70	.59	2,215	75

[1] By water-acetone cycling.

Machinability

Woods differ in machinability, but the differences may be of no importance in some uses. In products such as furniture, however, smoothness and ease of working may be highly important.

Most hardwood lumber is planed. After planing, much of it is machined further by shaping, turning, boring, mortising, or sanding. Davis (6, 7) found that moisture content affected the machining qualities of wood. Planing, boring, and mortising were done with best results when the wood was at about 6 percent moisture content, based on the dry weight of the wood. Shaping and turning were done equally well over a range of from 6 to 12 percent moisture content.

Among the species that Davis tested, Oregon hardwoods displayed a wide range of machinability. Ranking of the six Oregon species in Table 6 often places them among the best species for a given operation. Other Oregon species sometimes rank even higher than red alder, which had gained an enviable reputation for ease of machining(30).

Planed pieces were rated for occurrence of raised grain, fuzzy grain, chipped grain, and chip marks. California-laurel suffered chipped grain because of interlocked grain and small burls; bigleaf maple had some chipped grain and chip marks. The pieces were planed at a rate of 20 cuts to the inch, because close cutting minimizes chipped grain and aids in subsequent sanding.

Pacific madrone ranked at the top in planing and also in shaping. In the trials, the shaper operated at 7200 revolutions a minute and had two spindles turning in opposite directions so that one or the other spindle could always cut with the grain except when the cut was at right angles to the grain. With such end-grain cuts, some torn grain occurred in red alder and golden chinkapin.

All Oregon hardwoods turned well; fair-to-excellent pieces ranged from 77 to 88 percent of the 50 pieces tested for each species. Turning was done by a milled-to-pattern knife with considerable detail. The pieces, which were small, were turned at 3300 revolutions a minute.

Five Oregon hardwoods produced smooth cuts when bored; over 90 percent were good to excellent. The same woods produced fair-to-excellent smoothness of cut in 80 percent or more of mortises.

Davis made limited tests of the sanding qualities of four Oregon hardwoods (6). He concluded that tanoak, golden chinkapin, and California-laurel had only slight tendencies to show scratches with 2/0 grit on a small drum sander. Pacific madrone, because of its fine texture, would require 3/0 or 4/0 grit for equivalent results. Golden

Table 6. Machining Properties of Six Western Hardwoods (6.7).

	Planing		Shaping		Turning		Boring		Mortising	
	Rank[1]	Percent[2]	Rank	Percent[3]	Rank	Percent[4]	Rank	Percent[3]	Rank	Percent[4]
Alder, red	21	61	24	20	6	88	32	64	25	52
Chinkapin, golden	12	75	19	25	24	77	22	90	16	90
Laurel, California-	29	40	5	60	10	86	1	100	1	100
Madrone, Pacific	2	90	2	75	8	88	4	100	13	95
Maple, bigleaf	23	52	7	56	20	80	6	100	17	80
Tanoak	9	80	11	39	17	81	9	100	4	100

[1] Among 32-35 popular hardwoods.

[2] Based on perfect pieces.

[3] Based on good to excellent pieces.

[4] Based on fair to excellent pieces.

chinkapin produced some fuzz when sanded, but the other three species ranked in the top third of 29 woods tested.

Steam bending

Many parts of furniture are made of pieces of wood that must be bent permanently into a desired shape. The bending is done while the wood is flexible from heating or steaming. It is then clamped in the desired shape until it cools. After cooling, the wood keeps most of the curvature impressed on it while hot. Species differ in their response to this important treatment.

In 1964, Resch of the California Forest Products Laboratory reported bending qualities of five hardwoods native to Oregon as well as to California (43).

He tested 40 pieces 1 inch square and 30 inches long of each species in free bending to a 20-inch radius around pegs and 40 in restrained bending around a form 8 inches in radius. Half of the pieces, undried, were prepared for bending by steaming at 212 F for 45 minutes. The rest of the pieces were dried to 12-13.5 percent moisture content, then boiled for 45 minutes before bending.

California black oak and Pacific madrone rated in the top group of bending woods when compared with eastern and southern species. California white oak gave fair results when restrained, but a high percentage of the pieces tested in free bending broke on the tension side. Tanoak performed poorly in free bending with deformations in compression, possibly because of its resistance to penetration of moisture, but it gave better results when restrained. Golden chinkapin suffered much wrinkling and buckling on the concave side, especially in restrained bending, but produced 33 successful bends out of 40 attempts in free bending.

Seasoning

Each Oregon hardwood has its own requirements for care in drying to conditions suitable for a particular use. Factory lumber usually must be dried to 8 percent moisture content (based on dry weight of the wood), and stresses in the wood must be relieved so pieces will hold their shape during subsequent machining and use.

Not all of the species have been studied enough to provide precise recommendations, but the present state of knowledge does allow grouping into those that can be kiln-dried economically without previous air drying, those that probably would require too much time in the kiln if not air-dried, and those that need air drying before kiln drying to forestall excessive drying defects in addition to keeping down the cost of kiln drying.

For one-inch lumber, red alder and black cottonwood are kiln-dried from the green condition in about 4 days without any air drying. With some care, bigleaf maple and Oregon ash also can be kiln-dried from the sawmill in about a week. California-laurel and Pacific madrone require considerable care in seasoning, but with such care, have been kiln-dried in no more than 2 weeks (51). Oregon white oak apparently requires close care and possibly excessive time in the kiln (13). Even with careful attention during 3 weeks in the kiln, tanoak and golden chinkapin suffered considerable collapse and checking (51). Ellwood (9, 10) kiln-dried 1-inch California black oak lumber in 25 days, but with considerable degrade in the best lumber because of checking and collapse. Several other studies have been made in California (47-50).

For 1-inch lumber, then, air drying before kiln drying appears needed for the oaks, tanoak, and golden chinkapin. The same treatment may be economically desirable for California-laurel and Pacific madrone. Kiln drying alone is enough for 1-inch red alder, Oregon ash, black cottonwood, and bigleaf maple, although thick pieces for turning squares likely should be air-dried first.

To establish schedules for kiln drying most of those woods, I advise starting with directions for these, or similar species in Rasmussen's Dry Kiln Operator's Manual (42), or in Espenas' report on Seasoning of Oregon Hardwoods (13) and on tanoak (12).

Enough red alder and bigleaf maple have been kiln-dried to define fairly close schedules for them. On request, we can send you a copy of Kozlik's report on red alder (27) or bigleaf maple (29). The color of red alder is influenced by drying conditions, so you might like to have a copy of Kozlik's findings (28), or of earlier tests by Anderson and Frashour (2).

Briefly, Kozlik recommends five steps for drying 1-inch red alder lumber to 8 percent moisture content and seven steps for bigleaf maple:

Red Alder

1. Warm at 200 F for 4-6 hours;
2. Presteam at 190-200 F with 5 F wet-bulb depression for 12 hours;
3. Dry at 200 F dry bulb with wet-bulb depression for 10-12 percent EMC (equilibrium moisture content) for at least 12 hours--lower wet bulb to EMC condition of 6 percent until wettest piece is 14 percent moisture content;
4. Equalize at conditions for 5 percent EMC for 14 hours;
5. Condition at 190-200 F dry bulb with wet-bulb depressed enough for 13 percent EMC for 12 hours.

Bigleaf Maple

1.	Warm to 140 F for 4 hours, with wet bulb depressed not more than 4 F;
2.	Dry bulb at 140 F, wet bulb at 130 F for EMC of 12 percent for 24 hours;
3.	Dry bulb at 150 F, wet bulb at 136 F for EMC of 10 percent for 48 hours;
4.	Dry bulb at 170 F, wet bulb at 157 F for EMC of 10 percent for 15 hours;
5.	Dry bulb at 170 F, wet bulb at 146 F for EMC of 7 percent for 9 hours;
6.	Dry bulb at 170 F, wet bulb at 135 F for EMC of 5 percent for 48 hours;
7.	Dry bulb at 180 F, wet bulb at 174 F for EMC of 13.7 percent for 12 hours.

Several of the hardwoods may lose much otherwise good lumber because they collapse severely during drying. Pacific madrone is especially susceptible to this condition, but California black oak, tanoak, and golden chinkapin also suffer from it. A treatment for collapse has been developed in Australia, where it is applied to native hardwoods.

The treatment is simple as explained by Ellwood (11). After air drying to 20 percent moisture content, the lumber is exposed to saturated steam near 212 F for about 6 hours for 1-inch thickness and about 14 hours for 2-inch thickness. Moisture absorbed in the steaming is driven off later by residual heat. This reconditioning removes most of the distortion from collapsed wood. The treatment is especially effective with Pacific madrone, which collapses seriously but is not subject to severe checking. Pacific madrone can be reconditioned successfully after kiln drying to 8 percent moisture content; the other species should be only air dried first.

An unconventional method of drying, called solvent seasoning, has some promise for tanoak. Solvent seasoning, first tried by the Western Pine Association (now Western Wood Products Association) for drying ponderosa pine, includes removing moisture from wood by means of a water-miscible organic solvent that is easily removed from the wood when the desired moisture content has been reached. Espenas tested this method of seasoning with acetone on Oregon tanoak in 1952; the unpublished results were inconclusive, because some areas on the tanoak lumber dried rapidly with little defect while other contiguous areas dried slowly and with collapse. Anderson and Fearing (1) dried

1-inch tanoak lumber from northwestern California in about 30 hours from green to 10 percent moisture content. They found that defect, mostly collapse, was confined to small areas or streaks that probably were heartwood.

Treatability and durability

Little information is available on treating Oregon hardwoods with preservatives to guard against decay and insects. Actually, most products made from hardwood factory lumber are kept dry in use, so are protected against rot, and ordinary finishes protect against infestation by borers.

Dry sapwood of hardwoods may be attacked by powder post beetles during seasoning and storage, and even in use if unfinished. Larvae of these small beetles reduce the interior of sapwood to a fine powder. These larvae can be killed by heating infested wood in a kiln or oven, by fumigating with penetrating insecticidal gases, or by flooding their burrows with a volatile oil containing a poison such as pentachlorophenol. Soaking green lumber in a solution of borax or applying insecticides has prevented attack by these beetles, according to Glenn R. Esenther (For. Prod. J. 14(10): 477-480. 1964).

Wood for products such as fence posts or railway ties and lumber for use in boats either must be naturally resistant to decay or must have qualities that permit it to be injected with preservatives.

Oregon hardwoods have sapwood that is sufficiently penetrable to be treated, but the heartwood varies greatly in treatability among the species. Although the sapwood of all Oregon species decays readily, some of them have heartwood that is resistant to decay.

White oaks are noted for durable heartwood; Oregon white oak is no exception. The vessels in heartwood of white oaks are closed by balloon-like membranes called tyloses; these probably delay the penetration of fungi. California black oak, although classified as a member of the red oak group, has some of the characteristics of white oak in that the heartwood is difficult to penetrate.* This quality may help California black oak in resisting decay; it certainly adds to the difficulty of injecting a preservative. Resistance to penetration does not necessarily ensure natural durability, however. For example, some zones of tanoak are practically impenetrable, but nevertheless the wood decays readily.

Graham and Miller of this laboratory have tested eight Oregon hardwoods for natural durability as posts and have applied several

*Panek, Edward. Unpublished report. For. Prod. Lab., For. Service, U.S. Dept. of Agric. 1952.

nonpressure preservative treatments to three species (21). They found that untreated posts of red alder, Oregon ash, cascara buckthorn, black cottonwood, Pacific madrone, bigleaf maple, and tanoak averaged from 3 to 7 years in the ground before a moderate push would break them. Oregon white oak posts that were about one-fifth sapwood averaged 18 years in the same location. Posts sawed from Oregon white oak heartwood have been in a fence at Oregon State University for more than 50 years.

Red alder posts averaged 6 years' life after a double-diffusion treatment with copper sulfate followed by sodium chromate. Black cottonwood posts lasted 22 years after hot-and-cold baths in coal-tar creosote. Bigleaf maple is in test after soaking in diesel oil containing 5 percent by weight of pentachlorophenol (21); 92 percent of the posts had not failed after 16 years.

Miller and Graham have pressure-treated tanoak lumber with water-borne preservative to test its suitability for boat construction (38). Penetration and retention of preservative were satisfactory for the thick sapwood that had been dried to moisture contents below 40 percent, but were unsatisfactory for the heartwood, which was difficult to penetrate. They also dried crossties of two species, tanoak (19) and Oregon white oak (unpublished), and treated them with oil-type preservatives. Sapwood was penetrated readily in Oregon white oak, and some tanoak crossties were completely penetrated.

After 11 years in service, the tanoak crossties were performing about the same as were those of Douglas fir (20). The Oregon white oak crossties were placed in main line tracks of the Southern Pacific Company near Eugene, Oregon. Records are not yet available on their service. One would, however, expect Oregon white oak to perform about as do other white oaks with similar properties.

Commercial and do-it-yourself methods of applying preservatives to western woods have been described by Graham and Miller in a report that is available on request (22).

Special products

Three products that might well be made of Oregon hardwoods are discussed here as examples of how properties of a wood fit it for certain uses. Other products, such as flooring and cut stock, also are probable future outlets as the industry grows.

Pulp and paper. Hardwoods yield desirable pulps, most processes are suitable for pulping them, their use is economical, and they are abundantly available (5). Their pulps do not have the same properties as softwood pulps; hardwood pulp makes paper that tears easily but has desirable appearance, texture, and printing qualities.

Dense hardwoods may offer an economic advantage when bought by the cord, but black cottonwood has been a desired species for pulping, even though its density is low. Red alder also has gained acceptance, but other Oregon hardwoods have not, although laboratory tests suggest that some of them are suitable for pulping.

In tests, red alder produced sulfate pulp suitable for corrugating medium when mixed with Douglas fir pulp (45) and gave neutral sulfite pulps with promise for use in container boards and bleached-paper products (26). Red alder semibleached groundwood, chemiground, or neutral sulfite semichemical pulp produced satisfactory magazine book papers when mixed with Douglas fir pulp (3). Bleached red alder neutral sulfite semichemical pulp was suitable for milk-carton paperboard when mixed with Douglas fir sulfate pulp (3).

Cold soda pulps from red alder, tanoak, and bigleaf maple produced corrugating board with very good values for Concora and ring compression, but pulp from Pacific madrone was unsatisfactory (31).

Satisfactory duplicating and offset printing papers were made from mixtures of commercial Douglas fir pulps and sulfate pulps of black cottonwood, red alder, bigleaf maple, Pacific madrone, and tanoak. Tanoak and Pacific madrone gave more favorable air resistance and oil receptivity than did black cottonwood and red alder, but the madrone pulp caused a loss in strength (14).

Veneer. Bolts of three species native to Oregon--tanoak, red alder, and Pacific madrone--have been made into veneer by the U.S. Forest Products Laboratory. The red alder was rotary-cut, but the other two species were sliced in addition to peeling on a lathe. The bolts came from Sonoma County, California, but results ought to be indicative of characteristics of Oregon species.

The tanoak bolts heated at 150 F produced rotary-cut veneer of good quality, and flitches heated to 180 F yielded good-quality sliced veneer (16). The red alder produced good-quality rotary-cut veneer after heating to 140 F (15). Pacific madrone produced good-qualtiy rotary-cut veneer from bolts heated to 160 F, and good-quality sliced veneer from flitches heated to 180 F (17). The red alder veneer had small, tight knots--as one would expect from most small logs of this species. Red alder is easily glued and holds its shape well, which make it excellent for core and crossbands. Veneer is produced commercially in Oregon from red alder.

Other species also have been tried for veneer. Oregon ash, for example, is rotary cut at Sheridan, Oregon, for assembly into plywood at Tillamook.

Pfeiffer collected information on plywood from Oregon hardwoods (41). The U.S. Forest Products Laboratory has printed a note on use of small logs for veneer that applies well to Oregon timber (18).

Pallets. Huge volumes of lumber are made into pallets to aid in mechanized transportation. Nailability and moderate strength are desirable in such lumber, but appearance is not important, so low grades may be satisfactory (25).

In tests of pallets, red alder and black cottonwood performed better than Douglas fir when dropped on a corner or tumbled in a drum. Tanoak, however, did not perform so well as Douglas fir (24).

Pallets could become an outlet for some grades of hardwood lumber. There is, of course, the disadvantage that hardwood lumber usually is cut to random widths. For pallets, the lumber must be cut to stated widths and lengths because the western pallet industry is based on nominal sizes of softwoods. Although this requirement could lead to considerable loss in volume of lumber, it might not be prohibitive, because vast quantities of random-width lumber are made into pallets in the South.

REMARKS

Some statements about Oregon hardwoods do not fit appropriately into any of the previous sections of this review, so are clustered here simply for convenience. They are arranged according to the species as listed on page 8.

Hardwood sawdust has found ready sale in some areas for agricultural mulch.

Some mills cutting red alder bark their logs, then chip the slabs and edgings to sell for pulping. Red alder also is a favorite for commercial smoking of meat and fish.

There is strong competition for high-quality logs of Oregon ash. It is in demand for making furniture, water skis, and veneer. Oregon ash might also provide raw material for baseball bats. Heart rot is common in old-growth trees.

Golden chinkapin, where it grows well, has a long straight bole without branches up to a considerable height. Its form for sawtimber is perhaps equalled in Oregon only by tanoak.

Black cottonwood is the largest of our hardwoods. Although used principally for pulp and rough veneer, it can yield handsome light-colored panelling enhanced by dark zones.

California-laurel is tested for the burly grain and dark figure prized by novelty makers by chopping a notch into the boles of large trees. Such trees should provide exceedingly attractive veneer for panelling. Trees with straight-grained, evenly colored wood are not taken, but remain a potential source of wood suitable for making into furniture.

Pacific madrone, apparently our most easily worked wood, has not been used much because it warps readily and collapses seriously during drying. Weighting it heavily during drying, then steaming the collapsed pieces, might be sufficient to allow economic production of valuable lumber from this species.

Bigleaf maple is spread widely in mixture with softwoods, so can be difficult to log alone. Trees from the Cascade mountains are in greater demand than are those from wet areas in the Coast range, because wood from trees grown in boggy locations is reputed to be fuzzy when machined. This possibility has not been confirmed or refuted as yet.

Oregon white oak has been used mostly for fence posts and firewood. Although it serves well in these two uses, the tall, straight trees grown in closed stands should yield much more valuable products. On the other hand, open-grown individuals are prized for their distinctive, angular appearance. Sawlogs from them would be short between bends.

Tanoak presents a problem in drying, because, although it needs air drying before kiln drying, conditions are unfavorable for air drying along the coast for so much of each year that the wood is likely to decay. Transportation inland to a drier climate is not practical. Yet these trees represent a potential source of high-quality, handsome, strong lumber that would be suitable for many products. The ease with which preservatives, fire retardants, and plastics may be injected into its thick sapwood should extend the use of tanoak.

Bitter cherry yields green-tinted wood as handsome as that from the popular black cherry of the eastern United States. The trees are small, but usually are concentrated in clumps that should lessen the difficulty of logging them from among the surrounding softwoods.

California white oak may grow into a huge tree, but the information I have indicates that the larger the tree, the more likely that the trunk is decayed. If true, then the few million feet of this tree in southwest Oregon may be more valuable for scenery than for sawtimber.

Pacific dogwood, in addition to its colorful touches on our foothills in spring and fall, offers a supply of almost clear white, very fine-grained wood that might be as useful as flowering dogwood from the southeast for such products as shuttles and bobbins, which require a wood that wears smoother with use. This tree is short lived and may have much rot.

Scouler willow, like bitter cherry, is clustered in damp areas in the foothills. The light-colored wood offers no striking pattern of grain, but its light weight and ability to absorb shocks make it suitable for such specialty products as prosthetic devices.

SELECTED REFERENCES

In compiling this short list of references I tried to include only publications that are available. This was impossible, because some valuable reports are out of print.

Many of the references are available, fortunately. Most can be had as single copies without charge from the issuing agency. For those with a charge, the price is listed when known.

Several agencies are sources for most of the references. These are:

Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, Oregon 97331

Forest Products Laboratory
University of California
1301 South 46 Street
Richmond, California 94804

Pacific Southwest Forest and Range Experiment Station*
Forest Service
U.S. Department of Agriculture
Post Office Box 245
Berkeley, California 94701

Forest Products Laboratory
Forest Service
U. S. Department of Agriculture
Madison, Wisconsin 53705

Pacific Northwest Forest and Range Experiment Station
Forest Service
U. S. Department of Agriculture
Post Office Box 3141
Portland, Oregon 97200

Superintendent of Documents
U. S. Government Printing Office
Washington, D. C. 20402

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Table 7. Mechanical Properties[1] of Western Hardwoods Compared to Some Eastern Species.[2]

Species	Bending resistance	Shock resistance	Endwise compression	Breaking strength	Hardness
RED ALDER	100	100	100	100	100
Yellow poplar	109	117	91	94	76
OREGON ASH	99	108	104	130	197
Green ash	120	158	122	144	203
GOLDEN CHINKAPIN	90	100	95	109	124
American chestnut	89	96	91	88	92
BLACK COTTONWOOD	71	79	76	85	59
Eastern cottonwood	99	50	84	87	73
PACIFIC MADRONE	89	90	118	106	247
Black cherry	108	112	122	126	161
BIGLEAF MAPLE	105	---	102	109	144
Silver maple	83	144	90	91	119
CALIF. BLACK OAK	72	83	97	89	186
Northern red oak	132	177	116	146	219
OREGON WHITE OAK	80	112	112	105	281
White oak (Q. alba)	130	156	128	155	230
CALIFORNIA-LAUREL	68	110	97	82	215
Black walnut	122	171	130	149	171
TANOAK	120	---	130	166	238

[1]Strength values are percentages based on red alder as 100 percent (46).

[2]Pfeiffer, J. R. "Northwest Hardwood Industry." The Lumberman 87(3):44-46. March 1960.

Table 8. Physical Properties[1] of Western Hardwoods Compared to Some Eastern Species.[2]

Species	Specific gravity: green volume, oven-dry wt	Weight at 12% moisture content	Shrinkage: Volumetric	Shrinkage: Radial	Shrinkage: Tangential
		Lb/cu ft	Percent	Percent	Percent
RED ALDER	0.41	28	12.6	4.4	7.3
Yellow poplar	.40	28	12.3	4.0	7.1
OREGON ASH	.55	38	13.2	4.1	8.1
Green ash	.56	40	12.5	4.6	7.1
GOLDEN CHINKAPIN	.46	32	13.2	4.6	7.4
American chestnut	.43	30	11.6	3.4	6.7
BLACK COTTONWOOD	.35	24	12.4	3.6	8.6
Eastern cottonwood	.40	28	14.1	3.9	9.2
PACIFIC MADRONE	.65	45	17.4	5.4	11.9
Black cherry	.50	35	11.5	3.7	7.1
BIGLEAF MAPLE	.48	34	11.6	3.7	7.1
Silver maple	.47	33	12.0	3.0	7.2
CALIF. BLACK OAK	.57	40	12.1	3.6	6.6
Northern red oak	.63	44	13.5	4.0	8.2
OREGON WHITE OAK	.72	50	13.4	4.2	9.0
White oak (Q. alba)	.68	48	15.8	5.3	9.0
CALIFORNIA-LAUREL	.55	39	11.9	2.8	8.1
Black walnut	.55	38	11.3	5.2	7.1
TANOAK	.54	45	14.9	5.5	10.0

[1] Bar lengths are based on red alder; numbers are actual values for a species (46).

[2] Pfeiffer, J. R. "Northwest Hardwood Industry." *The Lumberman* 87(3):44-46. March 1960.