PROPERTIES OF PULPWOODS

Supplementary Volume

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INTRODUCTION

This supplement to Properties of Pulpwoods (published in September, 1943) includes many species of American woods which have only recently entered into pulp manufacture or which seem likely to do so in the future. For many of them there are few data available; of others, oldtimers in the other wood-using industries, much is known. Certain ones occur in large, readily accessible stands, whereas other species are found as scattered trees in forest or woodlot. The compiler hopes that any errors or omissions will be brought to his attention and also that additional information will be forthcoming, so that the usefulness of the work will be enhaneed. In order to facilitate use, the pagination has been continued from the first volume and an index, embodying all the species, is included at the end.

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EXPLANATION OF TERMS

Common Name. This appears at the head of each species description. In most cases, it is the name favored by the U. S. Forest Service.

Scientific Name. The technical name for the tree is given in italics (i.e., underscored), followed by the name of the person who first used the name in this combination and wrote the plant description. Sometimes another person's name is given in parentheses. If so, it means that person first applied the second or specific part of the name, but put it in a different combination, later found to be incorrect. Scientific names were originated because of the great confusion in common names, and their use is governed by a botanical code of nomenclature.

Synonyms. Some of the common names which are not so widely known or well chosen as the one used in the title are listed as synonyms. According to the U. S. Forest Service Check List (U. S. Dept. Agr., Misc. Circ. 92. 1927), a few species have as many as 30 common names.

Family Name. A family is a group of closely related genera just as a genus is composed of closely related species. The family name is given because experience has shown that it is convenient to think of woods in terms of Plant Families.

Range. This indicates the district or region where the species is indigenous. Certain localities within the range may not contain the tree because of environmental conditions, natural enemies, or removal by man.

Dimensions. Average measurements on mature trees are given.

Bark. A description of the appearance of the bark is given. Occasionally, in addition, data are available on the percentage of the total volume of the trunk occupied by the bark.

Silvics. This includes a general description of the tree, its environment, its associates, and other pertinent facts connected with its growth.

Gross Features of the Wood. This is a statement of the general characteristics and properties of the typical wood from the merchantable part of the tree. A hand lens (10X) is the greatest magnification used to obtain these data. In referring to the planes of section, x signifies cross, r signifies radial, and t signifies tangential.

Microscopic Structure. The minute anatomy of the wood is described by considering dimensions and characteristics of the wood elements normally present in the species. In the future, it is planned to illustrate this section with photomicrographs of the cross, radial, and tangential sections made from authentic wood samples.

Nonmechanical Physical Properties. These are the several common values which do not have to be determined by stress. The specific gravity is based on the oven-dry weight and the volume of the test piece when it was in a green, air-dry, or oven-dry condition. The density is given in pounds per cubic foot for various conditions of moisture. The moisture content is the average for green wood. It is the custom in wood industries to relate the loss in moisture from the original to the oven-dry condition to the weight of the oven-dry piece, whereas in the pulp and paper industry moisture is expressed as a percentage of the original weight as it is with chemicals. Both values are given. Most woods have their cell walls saturated and the cell cavities free from water (fiber-saturation point) at a moisture content of 25 to 30% (based on the oven-dry weight). When the moisture content decreases below the fiber-saturation point, shrinkage takes place. The shrinkage values for volume, radial direction, and tangential direction are figured on the loss in size to the oven-dry condition based on the dimension when green; the shrinkage to the air-dry condition will be less. The value for thermal expansion is a coefficient per degree Fahrenheit at ordinary temperatures. The coefficients along the grain and across the grain are given customarily. The thermal conductivity is expressed as B.t.u. per hour per square foot of material when the temperature gradient is one degree Fahrenheit per inch of thickness. The electrical resistance is expressed in megohms. The value is given at moisture contents of 7 and 12% (on the oven-dry basis), corresponding closely to the kiln-dry and air-dry moisture contents. This small difference in moisture content causes a several-fold difference in resistance.

Mechanical Properties. These values are included because it is felt that the pulp and paper engineer encounters considerable structural work and in many places wood might be a desirable constructional material. It must be remembered that wood is heterogeneous, unidirectional, and variable with moisture contents below the fiber-saturation point. Since the various properties listed are familiar to one versed in the testing of materials, they will not be expanded here. Toughness is given as the drop in inches of a 50-lb. hammer at complete failure, hardness as the load in pounds required to embed a 0.444-inch sphere to half of its diameter, and splitting strength or cleavability as the pounds necessary per inch of width when splitting; all other stress values are expressed as pounds per square inch. More complete information is available in publications of the U. S. Forest Products Laboratory or the Canadian Forest Products Laboratory.

Chemical Properties. The data on proximate analysis of many of the pulpwoods are surprisingly meager. All the information available has been given in the following pages. In general, the methods of the U. S. Forest Products Laboratory have been used by various investigators, although modifications have been made. Specific references are given when feasible, and any unusual methods have been noted.

Pathology. A knowledge of the durability of wood and its susceptibility to various diseases and insects should be helpful to woodyard and woodroom operators. Much of this information concerns the forest trees and far less the logs. Unfortunately, there is no direct relationship between the pathological resistance of a growing tree and the durability of the wood cut from it. Certain types of diseases do not interfere with the use of wood for chemical pulping; others cause so much decay that it is undesirable to take the log as far as the landing deck.

Utilization. All phases of utilization have been considered in this compilation. It is important to know the properties of wood and its uses other than as pulpwood because of the competition for raw material in certain localities. Usually an integrated or multiple-use program can be worked out with other utilizers, especially if all concerned are interested in keeping their industries going. The production figures are the latest and most reliable obtainable.

Supply. This information has been obtained from estimates of the U. S. Forest Service and the Canadian Forest Service. The data for certain species and regions are much more complete and detailed than for others.

WESTERN WHITE PINE

Scientific Name. Pinus monticola D. Don.

Synonyms. White pine, Idaho white pine.

Family Name. Pinaceae.

Range. Vancouver Island and southern British Columbia, northwestern Montana, northern Idaho, Washington and Oregon (Cascade and Blue Mountains), northern and central California (Sierra Nevada). Sea level to 3,000 feet west of the summit of the Cascade Mountains in British Columbia, Washington, and Oregon; 2,000 to 7,000 feet east of the Cascade summit and in Idaho and Montana; 5,000 to 10,000 feet in California.

Dimensions. 150 to 180 feet tall and 2 1/2 to 3 1/2 feet in diameter.

Bark. Smooth, gray green to light gray on young trees, thin (rarely more than 1 1/4 inches thick) even on old trunks where it breaks up into nearly square or rectangular, dark gray or purplish gray plates separated by deep fissures.

Silvics. The tree has a long, slightly tapered shaft, a short, generally symmetrical and somewhat open crown, and a deep, wide spreading system of lateral roots. This species is typically a mountain form, except in the northwestern portion of its range. It attains its best development in the Inland Empire region on rich, porous soils in moist valleys and on middle and upper slopes and flats of northerly exposure. Here it is very common and occasionally forms almost pure stands. Elsewhere, an occasional tree or small groves in mixture with other softwoods occur on poorer and drier soils. Its principal associates in the Rockies are grand fir, Douglas fir, western larch, ponderosa pine, Engelmann spruce, western red cedar, western hemlock, lodgepole pine, and alpine fir; Douglas fir, western hemlock, grand, noble and silver fir in Washington and Oregon; and red, Shasta and Douglas firs and lodgepole pine in California.

Gross Features of the Wood. The wood of western white pine is moderately soft, straight- and even-grained, medium textured, slightly resinous, without characteristic odor or taste. The sapwood is nearly white to pale yellowish white, narrow to medium wide. The heartwood is cream colored to light brown or reddish brown, darkening on exposure. The springwood zone is several times wider than the summerwood; the summerwood zone is distinct with the naked eye but not pronounced. The transition from springwood to summerwood is gradual. In the x-section the rays are very fine and are not distinct with the naked eye unless they include a horizontal resin canal; in the r-section they form a fine, close, inconspicuous fleck. Both longitudinal and horizontal resin canals are normally present. The numerous longitudinal canals, which appear as white flecks to the naked eye, are confined chiefly to the central and outer portions of

the annual ring. They are solitary or rarely 2 or 3 contiguous tangentially, forming more or less prominent streaks along the grain. The horizontal canals are smaller than the longitudinal ones and appear as white, rather prominent wood rays spaced irregularly on the x-section, scarcely visible with a hand lens on the tangential surface. Parenchyma are absent.

Microscopic Structure

Tracheids. Up to 60 mu (average, 40 mu) in diameter and 3.2 mm. in length; bordered pits in one row or occasionally in two on the radial walls; tangential pitting present in the last few rows of summerwood tracheids; pits leading to ray parenchyma large, window-like, 1 to 4 (generally 1 or 2) per ray crossing, those in the springwood more or less angled and occupying most of the back wall; ray tracheid pits present.

Resin canals. Longitudinal, up to 200 mu (average, 135 to 150 mu) in diameter; horizontal, less than 80 mu; thin-walled epithelial cells, tylosoids.

Rays. Two types, uniseriate and fusiform; the uniseriate rays are numerous, 1 to 12+ cells high; the fusiform rays are scattered, with a horizontal resin canal, 2- to 4-seriate in the central portion, tapering to uniseriate margins, up to 20+ cells high; ray tracheids are present in all types of rays, marginal and interspersed, with nondentate inner walls.

Longitudinal parenchyma. Absent.

Nonmechanical Physical Properties

Specific gravity,	green volume	0.36
	air-dry volume	0.38
	oven-dry volume	0.42
Density, lb./cu. ft.	green	35
	air-dry	27
	oven-dry	23

Moisture content, when green: 54% based on oven-dry weight (35% on green basis).

Shrinkage, from green condition: v, 11.8%; r, 2.6%; t, 5.3%.

Mechanical Properties

	Green	Air-dry
Tensile, /, lb./sq. in.	260	--
Compressive stress at p.l. //, lb./sq. in.	2430	4480
Compressive stress at p. l. /, lb./sq. in.	290	540
Shear, maximum stress //, lb./sq. in.	640	850

	Green	Air-dry
Static bending FSPL, lb./sq. in.	3400	6200
Static bending E, lb./sq. in.	1.17×10^6	1.51×10^6
Static bending, R, lb./sq. in.	5200	9500
Toughness, in.	19	23
Hardness, //, lb.	310	440
Hardness, ⊥, lb.	310	370
Cleavability, lb./in. width	160	160

Chemical Properties

Calorific value: 18.6×10^6 B.t.u. per air-dry cord.

Proximate analysis:

			Ritter and Fleck(2)		Anderson(3)	
	F.P.L.	Martin and Bray(1)	Heartwood Spring	Heartwood Summer	Sap	Heart
Ash, %	0.20				0.2	0.2
Hot-water soly., %	4.49	3.4	5.16	5.42	4.1	4.5
Cold-water soly., %	3.16		3.76	4.29	2.3	2.7
Ether soly.,%	4.26	1.6			3.4	3.6
Alcohol-benzene soly., %		3.4			3.4	5.7
1% NaOH soly., %	14.8	11.6	22.1	21.5		
Acetic acid,%	1.03		1.42	1.40		
Methoxyl, %	4.56		3.68	3.85		
Pentosans, %	8.86	10.7	10.1	9.82	9.2	9.5
Mannan, %	6.93					
Lignin, %	26.4	24.8	26.3	25.3	25.6	25.4
C.& B.cellulose, %	59.7	61.1	57.6	60.0	59.0	57.7
Pentosans,%	6.69	8.7	7.27	6.94		
Alpha-cellulose, %	38.6	41.7				
Holocellulose, %					68.5	66.0

(1) Paper Trade J. 111, no. 25:36 (Dec. 19, 1940); average of data taken at three heights in tree.

(2) Ind. Eng. Chem. 18:608 (1926).

(3) Ind. Eng. Chem. 36:662 (1944).

Pathology

Resistance to decay: intermediate.

Red ring rot caused by ring scale fungus (Fomes pini); red-brown butt rot caused by velvet top fungus (Polyporus schweinitzii); dwarf mistletoe (Arceuthobium campylopodum); white pine blister rust (Cronartium ribicola); spongy sap rot caused by pine root fungus (Fomes annosus); shoestring rot caused by honey mushroom (Armillaria mellea).

Mountain pine beetle (Dendroctonus monticolae); engraver beetles (Ips species).

Utilization

Use properties. Soft textured, inconspicuous figure, straight-, close-, and uniform-grained, nails easily without splitting, easy to work, low shrinkage, stays in place well, subject to blue stain, takes and holds paint well, glues easily, easy to season.

Pulping. Sulfate process. Reduces readily; yield, 49%.

Lumber. 458 million bd. ft. annual production from 1933 to 1942, 78% from Idaho and 17% from Washington; matches (50%), general millwork, boxes and crates, patterns and flasks.

Supply.

17.5 billion bd. ft. in the United States, about two-thirds of which is in Idaho (1942 estimate).
910 million bd. ft. and 500 thousand cords in Canada (1935).
10.4 billion bd. ft. in northern Idaho (1937).
1.9 billion bd. ft. in Washington (1936).
1.7 billion bd. ft. in Oregon (1936).
893 million cu. ft. in Washington and Oregon (1936).

SUGAR PINE

Scientific Name. Pinus lambertiana Douglas.

Synonym. California sugar pine.

Family name. Pinaceae.

Range. From the Cascade and Siskiyou Mountains in southern Oregon south in the Sierra Nevada and coast ranges of California to Lower California.

Dimensions. 175 to 180 feet tall and 2 to 3 feet in diameter.

Bark. Dark green, thin, and smooth on young stems, grayish brown to cinnamon red on old trunks, 1 1/2 to 4 inches thick, and broken into irregular, superficially scaly ridges separated by deep fissures. A sweet substance, pinite, exudes from bark wounds.

Silvics. The forest tree has a long, massive, clear, cylindrical bole, a short crown composed of several large, horizontal branches and a well-developed lateral root system. This tree is typical of the transition zone and reaches its best development on the west slope of the Sierra Nevada in northern and central California at 4500 to 5500 feet elevation. It is always found in mixture, principally with ponderosa pine, Douglas fir, white fir, incense cedar, and bigtree. Farther north it is often found with digger pine, ponderosa pine, Douglas fir, tanbark oak, California black oak, bigleaf maple, and dogwood usually below 4000 feet elevation. In the southern portion of its range it becomes alpine in habit.

Gross Features of the Wood. The wood of sugar pine is moderately soft, straight- and even-grained, relatively coarse-textured, slightly resinous, a faint noncharacteristic odor, often exuding a sugary substance when green, but without characteristic taste when dry. The sapwood is nearly white to pale yellow-white and narrow to medium in width. The heartwood is light brown to pale red-brown, frequently discolored with sap stain. The springwood zone is several times wider than the summerwood zone; the transition between them is gradual. The growth ring is distinct because of the darker summerwood. In the x-section the rays are very fine and are not distinct with the naked eye unless they include a horizontal resin canal; in the r-section they form a fine, close, inconspicuous fleck. Both longitudinal and horizontal resin canals are normally present. The numerous longitudinal canals are conspicuous, confined largely to the central and outer portions of the ring, solitary or rarely 2 to 3 contiguous tangentially, and appear as prominent dark streaks along the grain. The horizontal canals appear as rather prominent wood rays spaced at irregular intervals on the x-section and are visible with a hand lens as brownish specks on the t-section. Parenchyma are absent.

Microscopic Structure

Tracheids. Up to 65 mu (average, 45 mu) in diameter and 5.2 mm. in length; bordered pits in one to two rows on the radial walls; tangential pitting present in the last few rows of summerwood tracheids; pits leading to ray parenchyma large, windowlike, 1 to 4 (generally 2 or 3) per ray crossing, those in the springwood rounded and more or less widely spaced. Volume occupied, 94.0%.

Resin canals. Longitudinal, up to 300 mu (average, 175 to 225 mu) in diameter; horizontal, less than 80 mu; thin-walled epithelial cells, tylosoids. Volume occupied, 0.5%.

Rays. Two types, uniseriate and fusiform; the uniseriate rays are numerous, 1 to 12+ cells high; the fusiform rays are scattered, with a horizontal resin canal, 2- to 4-seriate in the central portion, tapering to uniseriate margins, up to 20+ cells high: ray tracheids are present in all types of rays, marginal and interspersed, with nondentate inner walls. Volume occupied, 5.5%.

Longitudinal Parenchyma. Absent.

Nonmechanical Physical Properties

Specific gravity	green volume	0.35
	air-dry volume	0.36
	oven-dry volume	0.38
Density, lb./cu. ft.	green	52
	air-dry	25
	oven-dry	23

Moisture content, when green: 137% based on oven-dry weight (58% on green basis).

Shrinkage, from green condition: v, 7.9%; r, 2.9%; t, 5.6%.

Thermal conductivity: 0.69 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance: 22,900 megohms at 7% moisture content.
140 megohms at 12% moisture content.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	270	350
Compressive stress at p.l. //, lb./sq. in.	2330	4140
Compressive stress at p.l. ⊥, lb./sq. in.	350	590
Shear, maximum stress //, lb./sq. in.	680	1050
Static bending FSPL, lb./sq. in.	3400	5700
Static bending, E, lb./sq. in.	0.94×10^6	1.20×10^6
Static bending, R, lb./sq. in.	5100	8000
Toughness, in.	17	18

	Green	Air-dry
Mechanical Properties (Continued)		
Hardness //, lb.	320	530
Hardness ⊥, lb.	310	380
Cleavability, lb./in. width	180	190

Chemical Properties

Mannan content: 4.67% (Schorger), 6.63% (Dore).

Proximate analysis:	Anderson (1) Sap	Anderson (1) Heart	Dore (2)
Ash, %	0.2	0.2	
Cold-water soly., %	1.7	8.4	
Hot-water soly., %	3.1	10.3	
Ether soly., %	3.1	4.5	
Alcohol-benzene soly., %	3.8	12.0	
Benzene soly., %			2.84
Alcohol soly., %			1.90
Pentosan, %	10.4	9.5	
Galactan, %			0.50
Lignin, %	26.8	24.8	29.5
C. & B. cellulose, %	58.7	54.1	59.2
Holocellulose, %	68.5	62.5	

(1) Ind. Eng. Chem. 36:662(1944).
(2) J. Ind. Eng. Chem. 12:476(1920).

Pathology

Resistance to decay: intermediate.

Brown trunk rot caused by chalky quinine fungus (Fomes laricis); dwarf mistletoe (Arceuthobium campylopodum); white pine blister rust (Cronartium ribicola).

Mountain pine beetle (Dendroctonus monticolae); various engraver beetles (Ips species); flat-headed borer.

Utilization

Use properties. Soft-textured, inconspicuous figure, straight-, close-, and uniform-grained, nails easily without splitting, easy to work, low shrinkage, stays in place well, subject to blue stain, takes and holds paint well, glues easily.

Pulping

Sulfite process. Reduces readily but unevenly, fair strength, dull greenish-brown color, shivy and harsh; yield, 47%.

Sulfate process. Reduces readily, very strong; yield, 48%.

Lumber. 264 million bd. ft. annual production from 1933 to 1942, 81% from California and 19% from Oregon; general millwork, boxes and crates, patterns and flasks, rollers, boot and shoe findings.

Supply.

24.7 billion bd. ft. in the United States (1938 estimate), of which 4.3 billion bd. ft. occur in Oregon and rest in California.

850 million cu. ft. in Oregon (1936).

PONDEROSA PINE

Scientific name. Pinus ponderosa Lawson.

Synonyms. Western yellow pine, yellow pine, pondosa pine, bull pine.

Family name. Pinaceae.

Range. This species covers a wide territory in the west. From southern British Columbia southeastward to north central Nebraska and in the Rockies to northern Mexico. It is absent or sparse in the Great Basin region. From British Columbia it occurs southward in the mountains of the Pacific Coast states to Lower California. In the Pacific Northwest it is found from sea level to 6000 feet, in northern Idaho and central California from 2000 to 7000 feet, and in Arizona from 4000 to 8000 feet in elevation.

Dimensions. 150 to 180 feet tall and 3 to 4 feet in diameter.

Bark. Brown to black and deeply furrowed on vigorous or young trees; yellowish brown to cinnamon red and broken up into large flat, superficially scaly plates separated by deep irregular fissures on slow-growing and old trunks; very thick on old trees.

Silvics. The tree has a long, symmetrical bole, clear for at least half of its length, a short, conical or flat-topped crown in old trees, and a taproot with a well-developed system of moderately deep, wide-spreading lateral roots. Ponderosa pine is not exacting in its site requirements but responds best on relatively moist, well-drained soils found on the western slopes of the Siskiyou and Sierra Nevada ranges. It occurs in many parts of its range in pure stands and is also commonly the most abundant tree in mixed coniferous stands. In eastern Washington and Oregon its associates are western larch, Douglas fir and, occasionally, lodgepole pine. In the central Rockies it occurs principally with Douglas fir and in California with Jeffrey and sugar pines, white fir, incense cedar, and Douglas fir.

Gross Features of the Wood. The wood of ponderosa pine is moderately soft, generally straight- and quite even- to very uneven-grained, medium coarse-textured, resinous, without characteristic taste but with a distinct, noncharacteristic resinous odor. The relationship between summerwood and springwood zones is variable; in slow, even growth the summerwood zone is very narrow but in fast, young stock it is broad and conspicuous. This causes variation in appearance of the grain. The ring is always distinct and the transition from springwood to summerwood abrupt. In the x-section the rays are very fine and are not distinct with the naked eye unless they include a horizontal resin canal; in the r-section they form a fine, close, inconspicuous fleck. Both longitudinal and horizontal resin canals are normally present. The numerous longitudinal canals are conspicuous, confined largely to the central and outer portions of the ring, solitary or rarely 2 to 3 contiguous tangentially and appear as relatively

prominent dark streaks along the grain. The horizontal canals are whitish, relatively inconspicuous wood rays spaced irregularly on the x-section, and barely visible with a hand lens as brown specks on the t-section. Parenchyma are absent. The split tangential surface is frequently dimpled but the dimples are less conspicuous than in lodgepole pine.

Microscopic Structure

Tracheids. Up to 60 mu (average, 40 mu) in diameter and 3.7 mm. in length; bordered pits in one row (occasionally in two) on the radial walls; tangential pitting absent; pits leading to ray parenchyma variable in shape and size, 1 to 7 (generally 4 or 5) per ray crossing. Volume occupied, 93.0%.

Resin Canals. Longitudinal, up to 230 mu (average, 160 to 185 mu) in diameter; horizontal, less than 70 mu; thin-walled epithelial cells, tylosoids. Volume occupied, 0.3%.

Rays. Two types, uniseriate and fusiform; the uniseriate rays are numerous, 1 to 12+ cells high; the fusiform rays are scattered, with a horizontal resin canal, 3- to 5-seriate in the central portion, tapering to uniseriate margins, up to 16+ cells in height; ray tracheids present in all types of rays, marginal (often in several rows) and occasionally interspersed, with prominent dentate walls. Low rays frequently consist entirely of ray tracheids. Volume occupied, 6.7%.

Longitudinal Parenchyma. Absent.

Nonmechanical Physical Properties

Specific gravity	green volume	0.38
	air-dry volume	0.40
	oven-dry volume	0.42
Density, lb./cu. ft.	green	45
	air-dry	28
	oven-dry	24

Moisture content, when green: 91% based on oven-dry weight (48% on green basis).

Shrinkage, from green condition: v, 9.6%; r, 3.9%; t, 6.3%.

Thermal conductivity: 0.85 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance: 39,800 megohms at 7% moisture content.
300 megohms at 12% moisture content.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	290	400
Compressive stress at p.l. //, lb./sq. in.	2070	4060
Compressive stress at p.l. ⊥, lb./sq. in.	360	740
Shear, maximum stress //, lb./sq. in.	680	1160
Static bending FSPL, lb./sq. in.	3100	6300
Static bending E, lb./sq. in.	0.97×10^6	1.26×10^6
Static bending R, lb./sq. in.	5000	9200
Toughness, in.	20	17
Hardness //, lb.	300	550
Hardness ⊥, lb.	310	450
Cleavability, lb./in. width	170	220

Chemical Properties

Calorific value: 22.1×10^6 B.t.u. per air-dry cord.
Tannin content: in wood, 8.9%; in bark, 10.9%.
Proximate analyses:

	F.P.L.	F.P.L.	Anderson(1) Sap	Anderson(1) Heart	Dore (2)
Ash, %	0.46		0.3	0.2	
Hot-water soly., %	5.05	4.8	4.3	6.2	
Cold-water soly., %	4.09		1.0	3.3	
Ether soly., %	8.52	6.8	4.8	5.0	
1% NaOH soly., %	20.3	19.0			
Acetic acid, %	1.09				
Methoxyl, %	4.49				
Pentosan, %	7.35	8.4	10.5	10.4	
Lignin, %	26.7	27.2	22.8	22.9	29.5
C.& B. cellulose, %	57.4	58.0	59.9	58.1	57.7
Pentosan, %	6.82				
Alpha-cellulose, %	35.7	37.4			
Alcohol-benzene soly.,%		4.4	5.1	7.2	
Benzene soly., %					2.22
Alcohol soly., %					1.49
Mannan, %	4.64				6.37
Galactan, %					0.78
Holocellulose, %			69.9	66.3	

(1) Ind. Eng. Chem. 36:662(1944).
(2) J. Ind. Eng. Chem. 12:476(1920).

Pathology

Resistance to decay: low +.

Western red rot (Polyporus ellisianus); dwarf mistletoe (Arceuthobium campylopodum); western gall rust (Cronartium harknessii); lodgepole blister rust (Cronartium filamentosum).

Western pine beetle (Dendroctonus brevicomis); Black Hills beetle (D. ponderosae); mountain pine beetle (D. monticolae); southwestern pine beetle (D. barberi); engraver beetles (Ips species); pine butterfly (Neophasia menapia); pandora moth (Coloradia pandora).

Utilization

Use properties. Soft-textured, delicately figured, straight-, close-, and uniform-grained, nails easily without splitting but has low nail-holding power, easy to work, low shrinkage, stays in place well, subject to blue stain, takes and holds paint well, glues easily, slightly resinous, easily treated with preservatives.

Pulping

Sulfite process. Reduces fairly readily but unevenly, dark, shivy; yield 47%.

Sulfate process. Reduces readily, very strong; yield, 48%.

Soda process. Yield, 41%.

Lumber. 3.0 billion bd. ft. average annual production from 1933 to 1942, 43% from Oregon, 25% from California, 11% from Washington, and 6% from Idaho; boxes and crates, general millwork, caskets and coffins, furniture, toys, rollers, laundry appliances.

Other uses. Fuel, fence posts.

Supply

218 billion bd. ft. in the United States (1943 estimate).
1 billion bd. ft. and 500 thousand cords in Canada (1935).
70 billion bd. ft. in Oregon (1936).
16.5 billion bd. ft. in Washington (1936).
5.7 billion bd. ft. in northern Idaho (1937).

LODGEPOLE PINE

Scientific Name. Pinus contorta Loudon.

(Some botanists insist that the two forms, coastal and mountain, of lodgepole pine are distinct species or at least varieties and designate the coast form as Pinus contorta Douglas and the mountain form as Pinus contorta var. latifolia Engelmann.)

Synonyms. "Tamarack," black pine, spruce pine, jack pine.

Family Name. Pinaceae.

Range. From eastern Alaska south on the coast to northern California, in the interior south in the mountains to Lower California, and in the Rocky Mountains to Colorado. Also in the Black Hills. Sea level to 2000 feet in north, to 6000 feet in Washington and Oregon, to 11,500 feet in California, and 6,000 to 11,000 feet in the Rockies.

Dimensions. Coast form--25 to 30 feet tall and 12 to 18 inches in diameter. Mountain form--70 to 80 feet tall and 15 to 30 inches in diameter.

Bark. Coast form--3/4 to 1 inch thick, deeply furrowed and transversely fissured, reddish brown to black and superficially scaly. Mountain form--1/4 inch thick, orange brown to gray covered by thin, loosely appressed scales.

Silvics. Because of their small size and poorly formed boles, the trees of the coastal form contribute little or nothing to the timber supply. In the mountains the tree has a long, clear, slender, cylindrical bole, a short, narrow, open crown and shallow root system. The trees reach commercial size on a variety of soil types but attain their best development on a moist, well-drained sandy loam. This species is very aggressive and hardy. Thus, in many areas it is found in pure, dense, even-aged stands but also occurs in mixture with other conifers. At lower elevations it associates with ponderosa and western white pines, Douglas fir, and western larch. At higher altitudes, it occurs chiefly with Engelmann spruce, alpine fir, and limber pine in the Rockies and limber and Jeffrey pines and California red fir in the Sierra Nevada. In pure dense stands the trees are prone to stagnate.

Gross Features of the Wood. The wood of lodgepole pine is moderately soft, generally straight- but somewhat uneven-grained, medium fine-textured, resinous, without characteristic taste, but with a distinct noncharacteristic, resinous odor (especially when green). The sapwood is nearly white to pale yellow and narrow. The heartwood is light yellow to pale yellow-brown, often scarcely darker than the sapwood and not clearly distinct. The springwood zone is usually much wider than the narrow, distinct summerwood zone except in the outer rings of mature trees. The transition from springwood to summerwood is more or less abrupt. In the x-section the rays are very fine and are not

distinct with the naked eye even when they enclose a horizontal resin canal; in the r-section they form a fine, close, inconspicuous fleck. Both longitudinal and horizontal resin canals are normally present. The longitudinal canals, which are relatively inconspicuous or not visible with the naked eye, are numerous, confined largely to the central and outer portions of the ring, solitary for the most part, and forming fairly conspicuous, brownish streaks along the grain. The smaller horizontal canals, which appear as brown radial lines spaced irregularly on the transverse surface, are barely visible with a hand lens on the tangential surface. Parenchyma are absent. A split tangential section shows prominent dimpling effect.

Microscopic Structure

Tracheids. Up to 55 mu (average, 40 mu) in diameter and 3.2 mm. in length; bordered pits in one row or occasionally paired on the radial walls; tangential pitting absent; pits leading to ray parenchyma variable in size and shape, 1 to 6 (generally 2 to 4) per ray crossing; ray tracheid pits present.

Resin canals. Longitudinal, up to 110 mu (average, 80 to 90 mu) in diameter; horizontal, less than 50 mu; thin-walled epithelial cells, tylosoids.

Rays. Two types, uniseriate and fusiform; the uniseriate rays are numerous 1 to 8+ cells in height; biseriate rays frequent in the areas of whirled tissue; the fusiform rays are scattered, with a horizontal resin canal, 2- to 3-seriate in the central portion, tapering to uniseriate margins, up to 10+ cells high; ray tracheids are present in all types of rays, marginal and interspersed, with prominently dentate walls. The marginal tracheids are often in several rows and in low rays the ray tracheids frequently compose the entire ray.

Longitudinal Parenchyma. Absent.

Nonmechanical Physical Properties.

Specific gravity	green volume	0.38
	air-dry volume	0.41
	oven-dry volume	0.43
Density, lb./cu. ft.	green	39
	air-dry	29
	oven-dry	24

Moisture content, when green: 65% based on oven-dry weight (39% on green basis).

Shrinkage, from green condition: v, 11.5%; r, 4.5%; t, 6.7%.

Mechanical Properties

	Green	Air-dry
Tensile /, lb./sq. in.	220	290
Compressive stress at p.l. //, lb./sq. in.	2110	4310
Compressive stress at p.l. /, lb./sq. in.	310	750
Shear, maximum stress //, lb./sq. in.	680	880
Static bending FSPL, lb./sq. in.	3000	6700
Static bending E, lb./sq. in.	1.08×10^6	1.34×10^6
Static bending R, lb./sq. in.	5500	9400
Toughness, in.	20	20
Hardness //, lb.	320	530
Hardness /, lb.	330	480
Cleavability, lb./inch width	150	180

Chemical Properties

Calorific value: 20.1×10^6 B.t.u. per air-dry cord.

Pathology

Resistance to decay: low+

Dwarf mistletoe (Arceuthobium Americanum); western gall rust (Cronartium harknessii); lodgepole blister rust (Cronartium filamentosum).

Mountain pine beetle (Dendroctonus monticolae); Black Hills beetle (D. ponderosae); lodgepole needle tier (Argyrotaenia species); sawfly.

Utilization

Use properties. Generally straight- but somewhat uneven-grained, medium fine-textured, moderately light, moderately soft, easy to work, glues well, average in paint-holding ability, holds nails and screws poorly, appreciable shrinkage, stays in place well, seasons easily, conspicuous figure, heartwood difficult to penetrate with preservatives, takes a good finish.

Pulping

Sulfite process. Reduces readily, excellent color, fine fibered, very strong, somewhat pitchy, easily bleached; yield, 47%.

Sulfate process. Reduces readily, very strong; yield, 48%.

Mechanical process. Reduces readily, excellent color and standard strength, power requirement 15 to 25% more than white spruce.

Lumber. 39 million bd. ft. average annual production from 1931 to 1940, 83% from Wyoming and Colorado. Used locally for rough construction, siding, finish, and flooring.

Other uses. Mine timbers, railroad ties, poles, posts, fuel.

Supply

38.6 billion bd. ft. in the United States (1939 estimate).
963 million bd. ft. in northern Idaho (1937).
700 million bd. ft. in Oregon (1936).
480 million bd. ft. in Washington (1936).

SAND PINE

Scientific Name. Pinus clausa (Engelmann) Sargent.

Synonyms. Oldfield pine, spruce pine, scrub pine.

Family Name. Pinaceae.

Range. Alabama coast and Florida (except the extreme northeastern and southwestern portions).

Bark. Comparatively smooth, forming plates only on larger branches.

Silvics. A small tree, of poor form, commonly found on sterile sandy soils. Because of its habit of retaining many of its cones unopened for several years it is able to seed in large numbers following fire. The type with sand pine predominant occurs on very dry, high sand ridges and coastal dunes. Its chief associates are myrtle oak, Florida hickory and Chapman white oak. On ground intermittently wet this species is found in mixture with longleaf, slash and loblolly pines, southern and pond cypresses, and black and tupelo gums.

Gross Features of the Wood. The wood cannot be separated from that of the other southern yellow pines; see longleaf pine, page 26.

Nonmechanical Physical Properties

Specific gravity	green volume	0.45
	air-dry volume	0.48
	oven-dry volume	0.51
Density, lb./cu. ft.	green	38
	air-dry	34
	oven-dry	29

Moisture content, when green: 36% based on oven-dry weight (26% on green basis).

Shrinkage, from green condition: v, 10.0%; r, 3.9%; t, 7.3%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	380	300
Compressive stress at p.l. //, lb./sq. in.	2670	3900
Compressive stress at p.l. ⊥, lb./sq. in.	560	1030
Shear, maximum stress //, lb./sq. in.	1140	1100
Static bending FSPL, lb./sq. in.	4100	6700
Static bending E, lb./sq. in.	1.02×10^6	1.41×10^6
Static bending R, lb./sq. in.	7500	11,600
Toughness, in.	25	19
Hardness //, lb.	460	950
Hardness ⊥, lb.	480	730

Chemical Properties

Proximate analysis:	F.P.L.
Hot-water soly., %	2.5
Alcohol-benzene soly., %	2.2
Ether soly., %	1.1
1% NaOH soly., %	11.8
Pentosan, %	6.9
Lignin, %	27.1
C. & B. cellulose, %	61.0
Alpha-cellulose, %	42.9

Pathology

Resistance to decay: intermediate.

Utilization

Used locally or in mixture with other southern pines.

Pulping. Sulfate process. Reduces readily, fair strength; yield, 42%.

Supply

According to the U. S. Forest Service, an extensive stand of young sand pine covers about 150,000 acres of sandy upland on the Ocala National Forest in northeastern Florida. The management plans provide for pulpwood production on a 40-year rotation. When mature, the stands will average 10 inches in diameter and 30 to 40 feet in height. This stand should yield about 35 thousand cords annually.

POND PINE

Scientific Name. Pinus rigida var. serotina (Michaux) Loudon

Synonym. Pocosin pine, bay pine, marsh pine, bull pine, bastard pine, black pine.

Family Name. Pinaceae.

Range. Coastal plain from southern tip of New Jersey to western tip of Florida. Not in southern half of Florida peninsula.

Dimensions. Occasionally 80 feet high and 30 inches in diameter as a maximum.

Bark. Grayish brown, very wide, irregular ridges or patches composed of many loose irregular friable scales.

Silvics. This species occurs extensively on flatwoods near the coast or in bays and ponds. It is found in small pure stands or predominant in mixture with slash pine, loblolly pine, pond cypress, red gum, sweet bay, loblolly bay, red bay, and swamp black gum.

Gross Features of the Wood. See description under longleaf pine, page 26.

Microscopic Structure

Tracheids. Length, 2.7 mm.

Nonmechanical Physical Properties

Specific gravity	green volume	0.50
	air-dry volume	0.54
	oven-dry volume	0.58
Density, lb./cu. ft.	green	49
	air-dry	38
	oven-dry	31

Moisture content, when green: 56% based on oven-dry weight (36% on green basis).

Shrinkage, from green condition: v, 11.2%; r, 5.1%; t, 7.1%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	280	360
Compressive stress at p.l. //, lb./sq.in.	2940	6300
Compressive stress at p.l. ⊥, lb. sq. in.	540	1120
Shear, maximum stress //, lb./sq. in.	940	1380
Static bending FSPL, lb./sq. in.	4500	8300
Static bending E, lb./sq. in.	1.28×10^6	1.75×10^6

Mechanical Properties, continued

	Green	Air-dry
Static bending R, lb./sq. in.	7400	11,600
Toughness, in.	33	28
Hardness //, lb.	460	780
Hardness ⊥, lb.	510	740
Cleavability, lb./in. width	190	240

Pathology

Resistance to decay: intermediate.

Turpentine borer (Buprestis apricans); southern pine beetle (Dendroctonus frontalis); engraver beetles (Ips species).

Utilization. See longleaf pine, page 29. Not suitable for turpentining.

Pulping. Sulfate process. Reduces readily, strong; yield, 48%.

Supply.

1.8 billion bd. ft. in North Carolina (1938).
8.8 million cords in North Carolina (1938).

WESTERN LARCH

Scientific Name. Larix occidentalis Nuttall.

Synonym. Larch, mountain larch, tamarack, Montana larch.

Family Name. Pinaceae.

Range. Southern British Columbia and south in the east slope of the Cascade Mountains to north central Oregon; east through the Blue Mountains to northern Idaho and western Montana.

Dimensions. 140 to 180 feet tall and 3 to 4 feet in diameter.

Bark. Reddish brown to cinnamon red, scaly on young stems; up to 4 to 6 inches thick on old trunks and then with flat-plated ridges separated by deep irregular fissures.

Silvics. The tree has a clear, tapered bole (often swollen-butted), a short, open, pyramidal crown and a deep, wide-spreading root system. It grows best on deep, moist, porous soils in high valleys and on mountain slopes of northern and western exposure. Nearly pure open stands of this species occur in the Inland Empire. It is often the most abundant species in the larch-Douglas fir forests of the northern Rockies, where it is also associated with western white pine and, at higher elevations, with lodgepole pine, Engelmann spruce, and alpine fir. Other associates are western hemlock, grand fir, ponderosa pine and, occasionally, western red cedar. Western larch is very intolerant throughout life and is dominant in old-growth mixed stands.

Gross Features of the Wood. The wood of western larch is moderately hard, slightly resinous, straight-grained, coarse-textured, with a characteristic oily appearance and greasy feel, but without characteristic odor or taste. The sapwood is white to pale straw brown and very narrow. The heartwood is russet or reddish brown. The summerwood zone is normally very narrow, sharply delineated and conspicuous to the naked eye which makes the growth ring quite distinct. The springwood zone usually constitutes at least 70% of the ring. The transition from springwood to summerwood is very abrupt. In the x-section the rays are very fine, not distinct to the naked eye, and form a fine, close, inconspicuous fleck on the radial surface. Both longitudinal and horizontal resin canals are present. The longitudinal canals are small, inconspicuous, not visible to the naked eye or appearing as whitish or dark flecks, sparse, confined mostly to the summerwood, solitary or 2 or more contiguous tangentially. The smaller horizontal canals appear, with a hand lens, as somewhat broader, whitish rays spaced irregularly on the x-section and are invisible or barely visible with a hand lens on the tangential surface. Parenchyma not visible.

Microscopic Structure

Tracheids. Up to 60 mu (average, 40 to 50 mu) in diameter and 3.2 mm. in length. Those in the summerwood occasionally have spiral thickening. Bordered pits in 1 to 2 rows on the radial walls; tangential pitting present on the last few rows of summerwood tracheids; pits leading to ray parenchyma small, quite uniform in size, with distinct border, 1 to 10 (generally 4 to 6) per ray crossing; ray tracheid pits present. Volume occupied, 89.0%.

Resin canals. Longitudinal, up to 135 mu (average, 60 to 90 mu) in diameter; horizontal, less than 25 mu. Thick-walled epithelial cells and no tylosoids. Volume occupied, 0.1%.

Rays. Two types, uniseriate or rarely in part biseriate, and fusiform. The uniseriate rays are numerous and 1 to 20+ cells in height; the biseriate rays are very sparse and scattered, or absent. The scattered fusiform rays, which include a horizontal resin canal, are 2- to 3-seriate in the central portion, tapering to uniseriate margins, up to 20+ cells in height. Ray tracheids are present in all types of rays, marginal and very rarely interspersed, nondentate inner walls; marginal usually in one row. Volume occupied, 10.0%.

Longitudinal Parenchyma. Terminal and very sparse, or absent. Volume occupied, 0.9%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.48
	air-dry volume	0.52
	oven-dry volume	0.59
Density, lb./cu. ft.	green	48
	air-dry	36
	oven-dry	28

Moisture content, when green: 58% based on oven-dry weight (37% on green basis).

Shrinkage, from green condition: v, 13.2%; r, 4.2%; t, 8.1%.

Thermal conductivity: 0.99 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance: 39,800 megohms at 7% moisture content
250 megohms at 12% moisture content

Mechanical Properties

	Green	Air-dry
Tensile /, lb./sq. in.	230	310
Compressive stress at p.l. //, lb./sq.in.	3250	5950
Compressive stress at p.l. /, lb./sq.in.	560	1080

Mechanical Properties (continued)	Green	Air-dry
Shear, maximum stress //, lb./sq. in.	920	1360
Static bending FSPL, lb./sq. in.	4600	7900
Static bending E, lb./sq. in.	1350	1710
Static bending R, lb./sq. in.	7500	11,900
Toughness, in.	24	32
Hardness //, lb.	470	1110
Hardness ⊥, lb.	450	760
Cleavability, lb./in. width	160	160

Chemical Properties

Calorific value: 26.5×10^6 B.t.u. per air-dry cord.

Tannin content: in wood, 6.7%; in bark, 10.6%.

There is a water-soluble gum (arabogalactan) in western larch amounting to 8 to 25%. Several papers have been published on this material--e.g., Wise and Peterson, Ind. Eng. Chem. 22:362(1930).

Proximate analysis:

	F.P.L.
Ash, %	0.23
Hot-water soly., %	12.6
Cold-water soly., %	10.6
Ether soly., %	0.81
1% NaOH soly., %	22.1
Acetic acid, %	0.71
Methoxyl, %	5.03
Pentosan, %	12.5
C. & B. cellulose, %	57.8
Pentosans, %	8.94
Mannan, %	5.13

Pathology

Resistance to decay: intermediate.

Red ring rot caused by ring scale fungus (Fomes pini); brown trunk rot caused by quinine fungus (Fomes officinalis); red-brown butt rot caused by velvet top fungus (Polyporus schweinitzii); dwarf mistletoe (Arceuthobium campylopodum); white pocket rot by black line fungus (Fomes nigrolimitatus); red root rot (Polyporus circinatus); string and ray rot (Polyporus berkeleyi).

Bark beetles (Melanophila drummondi).

Utilization

Use properties. Moderately heavy, strong, moderately hard, moderately high in shock resistance, stiff, moderately high shrinkage, slightly resinous, growth extremely narrow and uniform, exceptionally slow in reacting to moisture, very little sapwood, high percentage of

summerwood, pronounced figure, straight-grained, does not mar, dent, or scratch easily, stays in place well, high nail-holding power, tendency to split in seasoning and handling, glues easily, does not hold paint well, difficult to penetrate with liquids, exudes galactans.

Pulping. Sulfate process. Reduces readily, very strong; yield, 47%.

Lumber. 93 million bd. ft. average annual production from 1931 to 1940, 58% from Montana; building construction, interior trim, flooring, tanks, crates.

Other uses. Mine timbers, railroad ties, piling. Mucic acid can be prepared from the galactan and used as substitute for tartaric acid.

Supply

25 billion bd. ft. in the United States, 50% in Montana (1939 estimate).
4.8 billion bd. ft. in northern Idaho (1937).
3.8 billion bd. ft. in Washington (1936).
3.0 billion bd. ft. in Oregon (1936).
1.5 billion cu. ft. in northern Idaho (1937).
1.9 billion cu. ft. in Washington and Oregon (1936).

ENGELMANN SPRUCE

Scientific Name. Picea engelmannii (Parry) Engelmann.

Synonym. White spruce, silver spruce, mountain spruce.

Family Name. Pinaceae.

Range. From central British Columbia south in the upper slopes of the Cascade and Blue Mountains of Washington and Oregon; in the Rockies south to Arizona and New Mexico. Found at 1500 to 12,000 feet in the northern part of its range, 9,000 to 11,000 feet in the central Rockies, and 10,000 to 12,000 feet in the southern Rockies.

Dimensions. 100 to 120 feet tall and 18 to 30 inches in diameter.

Bark. Very thin, broken into large purplish-brown to russet-red, thin, loosely attached scales.

Silvics. In dense stands, Engelmann spruce has a straight, clean trunk with a close, very short, narrowly pyramidal crown of small branches and a shallow root system. It reaches its best development on deep, rich, loamy soils of high moisture content. This species is quite tolerant, as are other spruces. Pure stands of considerable extent are common, although the tree occurs abundantly in mixture with other conifers. At lower altitudes it is often associated with white, alpine, silver and noble firs, Douglas fir, western larch, western hemlock, lodgepole, and western white pine. At higher altitudes the chief associates are alpine fir, mountain hemlock, alpine larch, whitebark, limber and bristlecone pines, and Alaska cedar. Engelmann spruce occasionally shares new burns with lodgepole pine but is usually the less agressive species.

Gross Features of the Wood. The wood of the eastern spruces is usually slightly heavier and stronger than Engelmann spruce; see description under white spruce, page 11. In some samples of Engelmann spruce the transition from springwood to summerwood is more abrupt than in eastern spruce, and the summerwood is then usually appreciably denser than the springwood.

Microscopic Structure. Similar to white spruce, page 11.

Tracheids. Length, 3.0 mm.

Nonmechanical Physical Properties

Specific gravity	green volume	0.31
	air-dry volume	0.33
	oven-dry volume	0.35
Density, lb./cu. ft.	green	39
	air-dry	23
	oven-dry	21

Moisture content, when green: 100% based on oven-dry weight (50% on green basis).

Shrinkage, from green condition: v, 10.4%; r, 3.4%; t, 6.6%.

Mechanical Properties

	Green	Air-dry
Compressive stress at p.l. //, lb./sq. in.	1680	3580
Compressive stress at p.l. ⊥, lb./sq. in.	290	640
Shear, maximum stress //, lb./sq. in.	590	1010
Static bending FSPL, lb./sq. in.	2500	6000
Static bending E, lb./sq. in.	0.83×10^6	1.16×10^6
Static bending R, lb./sq. in.	4200	8500
Toughness, in.	14	15
Hardness //, lb.	250	450
Hardness ⊥, lb.	240	310
Cleavability, lb./in. width	130	200

Chemical Properties. Calorific value: 17.6×10^6 B.t.u. per air-dry cord.

Pathology

Resistance to decay: low +

Western red rot (Polyporus ellisianus); dwarf mistletoe (Arceuthobium campylopodum); brown stringy rot caused by Indian paint fungus (Echinodontium tinctorium); red root rot (Polyporus circinatus); Engelmann spruce beetle (Dendroctonus engelmannii); spruce budworm (Cacoecia fumiferana).

Utilization

Use properties. Very similar to white spruce, page 14.

Pulping

Sulfite process. Reduces readily, strong, fine texture, excellent color bleaches easily; yield, 47%.

Sulfate process. Reduces readily, strong, fine texture; yield, 48%.

Mechanical process. Reduces readily, excellent color, standard strength, power requirement comparable with that for white spruce.

Lumber. Local use; chiefly building construction and boxes. The average annual production from 1931 to 1940 was 36 million bd. ft.; principal sources were Colorado, Montana, and Idaho.

Other uses. Mine timbers, poles, railroad ties, fuel.

Supply

58 billion bd. ft. in British Columbia (1923 estimate).
49 billion bd. ft. in the United States, of which 22 billion bd. ft. are in Colorado (1937 estimate).
1.8 billion bd. ft. in Washington (1936).
2.5 billion bd. ft. in north Idaho (1937).
200 million bd. ft. in Oregon (1936).
834 million cu. ft. in Washington and Oregon (1936).
600 million cu. ft. in north Idaho (1937).

MOUNTAIN HEMLOCK

Scientific Name. Tsuga mertensiana (Bongard) Sargent.

Synonym. Alpine hemlock.

Family Name. Pinaceae.

Range. Alaska (Cook's Inlet) and southward in the coastal mountains of British Columbia, Cascade and Blue Mountains of Washington and Oregon, and Siskiyou and Sierra Nevada of California; also in southeastern British Columbia, northwestern Montana, and northern Idaho. Found from sea level (Alaska) to 10,000 feet elevations.

Dimensions. 75 to 100 feet tall and 2.5-3.5 feet in diameter.

Bark. Dull purplish brown to reddish brown, divided into narrow flattened ridges by deep, narrow fissures and up to 1 1/4 inches thick in old trees.

Silvics. This tree, although one of the largest of the alpine species, is often low and sprawling near timberline. The large forest trees have a long, clear or limby bole with a narrow pyramidal crown of drooping or even pendulous branches. The root system is shallow. The best stands are found on moist slopes, flats, and heads of ravines with northerly exposure. Best development is in southern Oregon. In certain coniferous forests, mountain hemlock constitutes more than 75% of the stand. In parklike stands, the excessively tapered boles are the only species or are mingled with alpine fir, alpine larch, Engelmann spruce, and whitebark pine.

Gross Features of the Wood. The wood of mountain hemlock is moderately hard, fine- and uniformly-textured. The heartwood is a pale reddish brown and is usually not distinguishable from the moderately thin sapwood. The summerwood is quite pronounced, and is distinguishable from the lighter springwood. In the x-section the rays are very fine, not distinct with the naked eye, and form a fine, close, inconspicuous fleck on the radial surface. Resin canals are normally absent. Longitudinal parenchyma are not visible.

Microscopic Structure. Probably similar to western hemlock, page 53.

Nonmechanical Physical Properties

Specific gravity	green volume	0.43
	air-dry volume	0.47
	oven-dry volume	0.51
Density, lb./cu. ft.	green	44
	air-dry	33
	oven-dry	31

Moisture content, when green: 62% based on oven-dry weight (38% on green basis).

Shrinkage, from green condition: v, 11.4%; r, 4.4%; t, 7.4%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	330	320
Compressive stress at p.l. //, lb./sq. in.	2540	4620
Compressive stress at p.l. ⊥, lb./sq. in.	470	1030
Shear, maximum stress //, lb./sq. in.	910	1230
Static bending FSPL, lb./sq. in.	3800	7400
Static bending E, lb./sq. in.	1.08×10^6	1.32×10^6
Static bending R, lb./sq. in.	6600	11,200
Toughness, in.	32	32
Hardness //, lb.	600	1170
Hardness ⊥, lb.	500	740
Cleavability, lb./in.	200	170

Chemical Properties

Tannin content: bark contains "large amounts."

Pathology

Resistance to decay: low +

Utilization

No specific information could be found. Probably small amounts are used in admixture with western hemlock for lumber and pulp.

Supply

6 billion bd. ft. in Oregon (1936).
2.1 billion bd. ft. in Washington (1936).
1.9 billion cu. ft. in Washington and Oregon (1936).
Approximately 70% of these stands are west of the summit of the Cascade Mountains.

WHITE FIR

Scientific Name. Abies concolor Lindley and Gordon.

Synonyms. Balsam fir, California white fir.

Family Name. Pinaceae.

Range. Oregon to southern California; northern and southeastern Arizona, and New Mexico to Colorado and Utah; Nevada; southern Idaho; northern Mexico and Lower California. At elevations of 6,000 to 11,000 feet.

Dimensions. Sierra--130 to 150 feet tall and 3 to 4 feet in diameter. Rockies--80 to 100 feet tall and 15 to 30 inches in diameter.

Bark. 4 to 7 inches thick on old trunks, ash gray and divided by deep irregular furrows into thick, horny flattened ridges; young stems with conspicuous resin blisters.

Silvics. The tree has a long, clear, slightly tapering bole and a shallow root system. The crown is elongated in youth but frequently broken and malformed in old trees. Best development is on deep, rich, moist, well-drained sandy loam slopes and benches with a northerly exposure but this species will exist on dry, barren sites. White fir is usually in admixture with other conifers, principally sugar, ponderosa, Jeffrey and limber pines, incense cedar, Douglas fir, alpine fir, and Engelmann spruce, and sometimes constitutes as much as 80% of the stand in parts of the Sierra Nevada. This species is moderately tolerant.

Gross Features of the Wood. The wood of white fir cannot be distinguished from that of the other true firs. For description see lowland white fir, page 69.

Microscopic Structure. See description of lowland white fir, page 69.

Tracheids. Length, 3.6 mm. Volume occupied, 90.5%.

Rays. Volume occupied, 9.5%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.35
	air-dry volume	0.37
	oven-dry volume	0.40
Density, lb./cu. ft.	green	47
	air-dry	26
	oven-dry	22

Moisture content, when green: 115% based on oven-dry weight (53% on green basis).

Shrinkage, from green condition: v, 9.4%; r, 3.2%; t, 7.0%.

Thermal conductivity: 0.65 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance: 57,600 megohms at 7% moisture content.
180 megohms at 12% moisture content.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	290	260
Compressive stress at p.l. //, lb./sq. in.	2390	3590
Compressive stress at p.l. ⊥, lb./sq. in.	370	930
Shear, maximum stress //, lb./sq. in.	750	930
Static bending FSPL, lb./sq. in.	3800	6500
Static bending E, lb./sq. in.	1.03×10^6	1.38×10^6
Static bending R, lb./sq. in.	5700	9300
Toughness, in.	22	17
Hardness //, lb.	380	730
Hardness ⊥, lb.	330	440
Cleavability, lb./in. width	170	160

Chemical Properties

Proximate analysis:

	Isenberg (1)
Ash, %	0.43
Hot-water soly., %	1.89
Cold-water soly., %	1.12
Ether soly., %	0.23
Alcohol-benzene soly., %	1.43
Acetic acid, %	1.64
Methoxyl, %	4.57
Pentosan, %	8.86
Lignin, %	27.4
C. & B. cellulose, %	64.5
Pentosan, %	7.31
1% NaOH soly., %	11.4

(1) J. Am. Chem. Soc. 58:2231(1936); data also given for several parts of the stem at one height.

Pathology

Resistance to decay: low

Brown stringy rot caused by Indian paint fungus (Echinodontium tinctorium); dwarf mistletoe (Arceuthobium campylopodum).

Bark beetles (Melanophila drummondi); spruce budworm (Cacoecia fumiferana).

Utilization

Use properties. Straight-grained, fine-textured, distinct but not pronounced figure, light colored, tendency to check and split, soft, works easily with tools, splits easily, low nail-holding power, not durable, very resistant to the penetration of preservatives, low shrinkage, glues easily, holds paint well, nonresinous.

Pulping. Similar to lowland white fir, see page 71. [Correction: power requirement is about 20% more than that for spruce.]

Lumber. Similar to lowland white fir, see page 71. Principally from California.

Supply. 44 billion bd. ft. in the U. S. (1941 estimate); makes up about 36% of total stand of western true firs.

ALPINE FIR

Scientific Name. Abies lasiocarpa (Hooker) Nuttall.

Synonyms. Balsam, white fir.

Family Name. Pinaceae.

Range. Yukon Territory, south along the coast ranges to southern Oregon; inland along the mountains through British Columbia, Idaho, Montana, Utah, Colorado to Arizona and New Mexico; 2,000 to 8,000 feet in Washington and Oregon, 3,500 to 9,500 feet in the Rockies.

Dimensions. 60 to 100 feet tall and 18 to 24 inches in diameter.

Bark. Thin, at most about 1-1/4 inches thick, hard, flinty, and but little broken on fairly large trees, except occasional shallow, narrow cracks near the base of the trunk. The unbroken smooth parts are ashy gray--often chalky white. Even in old trunks, always irregularly and shallowly seamed, the flat ridges are whitish, but pale brownish on the broken edges and red-brown on the inside.

Silvics. Alpine fir is largely restricted to higher elevations and on exposed timberline sites is of sprawling habit. Open grown trees have excessively tapered trunks and dense spirelike crowns but forest trees have dense, narrowly pyramidal crowns, and symmetrical, clear, moderately tapering boles. Best growth is on moist porous soils, although dry sterile sites support moderately sized trees. This species forms restricted pure stands but also occurs in mixed forests. The principal associate is Engelmann spruce but it is found with the other alpine species. In northern Idaho it reaches large size in admixture with grand fir, western white pine, Engelmann spruce, and western larch. In the Pacific region its chief associates are mountain hemlock, whitebark pine, and Alaska cedar. Alpine fir is quite tolerant.

Gross Features of the Wood. Similar to white fir but the growth rings are usually narrower. The wood has a mild but distinct rank odor, noticeable when fresh cuts are made. See description of lowland white fir, page 69.

Microscopic Structure. See description of lowland white fir, page 69.

Nonmechanical Physical Properties

Specific gravity	green volume	0.31
	air-dry volume	0.33
	oven-dry volume	0.35
Density, lb./cu. ft.	green	28
	air-dry	23
	oven-dry	21

Moisture content, when green: 47% based on oven-dry weight (32% on green basis).

Shrinkage, from green condition: v, 9.0%; r, 2.5%; t, 7.1%.

Mechanical Properties

	Green	Air-dry
Compressive stress at p.l. //, lb./sq. in.	1690	3740
Compressive stress at p.l. ⊥, lb./sq. in.	310	600
Shear, maximum stress //, lb./sq. in.	610	1020
Static bending FSPL, lb./sq. in.	2400	--
Static bending E, lb./sq. in.	0.86×10^6	0.90×10^6
Static bending R, lb./sq. in.	4400	7100
Toughness, in.	9	16
Hardness //, lb.	280	470
Hardness ⊥, lb.	220	400
Cleavability, lb./in. width	130	140

Pathology

Resistance to decay: low.

Brown stringy rot caused by Indian paint fungus (Echinodontium tinctorium); dwarf mistletoe (Arceuthobium campylopodum); branch canker (Phoma abietina).

Spruce budworm (Cacoecia fumiferana).

Utilization

Similar to lowland white fir, page 71. Apparently only a small amount enters the trade.

Supply

1.9 billion bd. ft. in the United States (1939 estimate).
600 million bd. ft. in Washington (1936).
200 million bd. ft. in Oregon (1936).
282 million cu. ft. in Washington and Oregon (1936).

NOBLE FIR

Scientific Name. Abies nobilis Lindley.

Synonyms. "Larch," red fir.

Family Name. Pinaceae.

Range. Coast range and Cascade Mountains of Washington and Oregon. 2,000 to 5,000 feet in elevation.

Dimensions. 90 to 120 feet tall and 20 to 24 inches in diameter but larger trees are not uncommon.

Bark. Gray and smooth for many years, with prominent resin blisters, eventually dark gray, often tinged with purple and broken up into thin, nearly rectangular plates separated by deep fissures on old trunks; about 1.5 inches thick.

Silvics. The tree has a long, clear, columnar bole, a domelike crown, and a moderately deep and spreading root system. Best growth is made on a deep, moist, cool site, although good growth is made on poor soils if abundant moisture is present. Noble fir occurs in mixture with other conifers either singly or in small groves. The principal associates are Douglas fir, western hemlock, silver, white and alpine firs, sugar and western white pines and western red cedar. This fir is intolerant.

Gross Features of the Wood. The wood of noble fir has the same general characteristics as the other firs but has somewhat of a reddish tinge, which is caused by the pale reddish springwood and the slow growth, which brings the darker bands of summerwood close together. It thus resembles western hemlock, and cannot be distinguished from this species without a compound microscope. Specimens of rapid growth resemble white and lowland white fir very closely. See description of lowland white fir, page 69.

Microscopic Structure. See description of lowland white fir, page 69.

Tracheids. Length, 3.6 mm.

Nonmechanical Physical Properties

Specific gravity	green volume	0.35
	air-dry volume	0.38
	oven-dry volume	0.40
Density, lb./cu. ft.	green	30
	air-dry	26
	oven-dry	22

Moisture content, when green: 36% based on oven-dry weight (26% on green basis).

Shrinkage, from green condition: v, 12.5%; r, 4.5%; t, 8.3%

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	230	220
Compressive stress at p.l. //, lb./sq. in.	2420	4960
Compressive stress at p.l. ⊥, lb./sq. in.	340	640
Shear, maximum stress //, lb./sq. in.	750	980
Static bending FSPL, lb./sq. in.	3600	6600
Static bending E, lb./sq. in.	1.27×10^6	1.58×10^6
Static bending R, lb./sq. in.	5800	10,100
Toughness, in.	19	23
Hardness //, lb.	330	690
Hardness ⊥, lb.	290	410
Cleavability, lb./in. width	150	150

Pathology

Resistance to decay: low.

Indian paint fungus (Echinodontium tinctorium) on overmature trees.

Utilization

Use properties. Similar to Sitka spruce in strength properties. Otherwise similar to other true firs, although color is usually redder.

Pulping

Sulfite process. Reduces readily, excellent color and strength, fibers fine and tough, easily bleached; yield, 47%.

Sulfate process. Reduces readily, strong; yield, 48%.

Mechanical process. Reduces readily, excellent color and standard strength; power requirement 20% less than spruce.

Lumber. Much larger pieces of clear, straight-grained material can be obtained from this species than from the other true firs.

Average annual production approximates 7.5 million bd. ft. Principal uses are planing mill products, boxes, Venetian blinds, ladder rails.

Supply

8.6 billion bd. ft. in the United States (1939 estimate).
5.6 billion bd. ft. in Oregon (1936 estimate).
3.0 billion bd. ft. in Washington (1936).

CALIFORNIA RED FIR

Scientific Name. Abies magnifica A. Murray.

Synonym. Red fir.

Family Name. Pinaceae.

Range. Southern Cascade Mountains in Oregon; coast range in northern California and western slope of the Sierra Nevada. Occurs at elevations from 5,000 to 10,000 feet.

Dimensions. 150 to 180 feet tall and 4 to 5 feet in diameter.

Bark. Smooth and chalky on young stems; 4 to 6 inches thick on old trunks and divided by deep furrows into rounded or plated reddish-colored ridges.

Silvics. The tree has a straight, clear, slightly tapering bole and a short, narrow, round topped cone crown. Best development is on cool, moist, gravelly or sandy soils in sheltered ravines or on protected slopes but commercial size is reached on much poorer sites. Red fir occurs in pure forests above the transition zone and in mixture. In the northern part of its range its associates include Douglas fir, sugar and ponderosa pines at lower elevations, and mountain hemlock and lodgepole pine at higher levels. In the Sierra Nevada its neighbors are white and Shasta firs, lodgepole, western white, ponderosa, Jeffrey and sugar pines, bigtree, and mountain hemlock. This species is intolerant.

Gross Features of the Wood. Resembles the wood of noble fir in having a more reddish tinge than the other species of western balsam firs. See description of lowland white fir, page 69.

Microscopic Structure. See description of lowland white fir, page 69.

Tracheids. Length 3.3 mm.

Nonmechanical Physical Properties

Specific gravity	green volume	0.37
	air-dry volume	0.39
	oven-dry volume	0.42
Density, lb./cu. ft.	green	48
	air-dry	27
	oven-dry	23

Moisture content, when green: 108% based on oven-dry weight (52% on green basis).

Shrinkage, from green condition: v, 11.8%; r, 3.8%; t, 6.9%.

Electrical resistance: 31,600 megohms at 7% moisture content.
150 megohms at 12% moisture content.

Mechanical Properties

	Green	Air-dry
Tensile /, lb./sq. in.	340	350
Compressive stress at p.l. /, lb./sq. in.	440	850
Shear, maximum stress //, lb. /sq. in.	920	1050
Static bending FSPL, lb./sq. in.	4100	7200
Static bending E, lb./sq. in.	1.06×10^6	1.59×10^6
Static bending R, lb./sq. in.	6000	11,200
Toughness, in.	22	23
Hardness //, lb.	390	1090
Hardness /, lb.	380	530
Cleavability, lb./in. width	190	190

Pathology

Resistance to decay: low.

Dwarf mistletoe (Arceuthobium campylopodum).

Utilization

Use properties. Similar to other balsam firs, although wood color most closely resembles noble fir.

Pulping

Sulfite process. Reduces fairly readily, very strong, fairly easily bleached; yield, 47%.

Sulfate process. Reduces readily, very strong; yield, 48%.

Mechanical process. Reduces readily, color slightly reddish, standard strength; power requirement 20% more than spruce.

Supply

10.5 billion bd. ft. in the U. S. (1939 estimate) includes Shasta red fir. Of this 8.0 billion bd. ft. in California and 2.5 billion bd. ft. in Oregon.

Scientific Name. Abies magnifica var. shastensis Lemmon.

Synonym. Shasta fir.

Family Name. Pinaceae.

Range. Coincides with California red fir.

All the properties of this variety correspond to those of the type species given in the preceding description, page 193.

Scientific Name. Sequoia sempervirens (Lambert) Endlicher.

Synonyms. Coast redwood, Sequoia.

Family Name. Taxodiaceae.

Range. From the southern borders of Oregon, southward in the coast region (20 to 30 miles inland) to Monterey County, California. From sea level to 2,500 feet in elevation.

Dimensions. 200 to 275 feet tall and 8 to 12 feet in diameter.

Bark. Reddish brown to cinnamon red, deeply furrowed, fibrous, 3 to 12 inches thick.

Silvics. The tree has a clear, tall, buttressed, and moderately tapering bole, a short, narrow, irregularly conical crown, and a moderately deep and wide-spreading root system. Redwood is restricted to the California fog belt and is the dominant species in this region. Areas with over 80% are extensive and, in the moist flats, 90% or more of the timber is of this species. The principal associates are Douglas fir, Sitka spruce, grand fir, western hemlock, tan oak, madrone, red alder, and California laurel. Vigorous stump sprouts arise from the old stump. Redwood is a very tolerant tree.

Gross Features of the Wood. The wood of redwood is soft to moderately hard, generally straight-grained, coarse-textured, and without characteristic odor or taste. The sapwood is almost white and very narrow in old trees. The heartwood is clear light red to deep reddish brown. The grain is even in old slow growth or uneven in second growth. The springwood zone is usually much wider than the summerwood zone. The transition from springwood to summerwood is generally abrupt. The darker summerwood is very narrow in old growth to very wide in sprout second growth. The growth rings are distinct. In the x-section the rays are coarse for a coniferous wood, generally visible with the naked eye because of their lighter color as compared with the background, and form a fine, close, relatively conspicuous fleck on the radial surface. Normal resin canals are absent, but traumatic (wound) canals are sometimes present; if so, they are sporadic and arranged in a tangential row, appearing as dark streaks along the grain. Longitudinal parenchyma are abundant, scattered, readily visible in the sapwood with a hand lens and sometimes with the naked eye because of their contents, inconspicuous in the dark-colored heartwood.

Microscopic Structure

Tracheids. Up to 80 mu (average, 50 to 65 mu) in diameter and 6.2 mm. in length; bordered pits in 1 to 3 (generally 2) rows on the radial walls; tangential pitting present in the last few rows of summerwood tracheids; pits leading to ray parenchyma fairly large, quite uniform in size, oval for the most part, 1 to 4 (generally 2 to 3) per ray crossing; ray tracheid pits absent. Volume occupied, 91.2%.

Rays. Uniseriate and rather frequently partly biseriate, consisting entirely of ray parenchyma, up to 40 cells (800 mu) in height. Volume occupied, 7.8%.

Longitudinal Parenchyma. Metatracheal-diffuse, solitary or occasionally 2 or more contiguous tangentially, conspicuous because of their dark resinous contents. Volume occupied, 1.0%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.38
	air-dry volume	0.40
	oven-dry volume	0.42
Density, lb./cu. ft.	green	50
	air-dry	28
	oven-dry	23

Moisture content, when green: 112% based on oven-dry weight (53% on green basis).

Shrinkage, from green condition: v, 6.8%; r, 2.6%; t, 4.4%.

Thermal conductivity: 0.76 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance: 22,400 megohms at 7% moisture content
100 megohms at 12% moisture content

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	260	240
Compressive stress at p.l. //, lb./sq. in.	3700	4560
Compressive stress at p.l. ⊥, lb./sq. in.	520	860
Shear, maximum stress //, lb./sq. in.	800	940
Static bending FSPL, lb./sq. in.	4800	6900
Static bending E, lb./sq. in.	1180	1340
Static bending R, lb./sq. in.	7500	10,000
Toughness, in.	21	19
Hardness //, lb.	570	790
Hardness ⊥, lb.	410	480
Cleavability, lb./in. width	170	150

Pathology

Resistance to decay: very durable.
Brown heart rot caused by Poria sequoiae.

Chemical Properties.

Tannin content: in heartwood, 12.2%; in sapwood, 1.15%; in bark, 0.86%.

Proximate analyses:

	F.P.L. Heartwood	Dore(1)	Lewis(2) Sap	Lewis(2) Heart
Ash, %	0.21			
Hot-water soly., %	9.86		2.8	11.3
Cold-water soly., %	7.36			
Ether soly., %	1.07			
1% NaOH soly., %	20.0			
Acetic acid, %	1.08			
Methoxyl, %	5.21			
Pentosan, %	9.43		12.9	12.0
Lignin, %	34.2	34.5	33.8	36.4
C. and B. cellulose, %	48.5	54.9	56.0	53.4
Pentosans, %	8.85			
Alpha-cellulose, %	38.2			
Benzene soly., %		0.34		
Alcohol soly., %		4.39	1.9	13.2
Mannan, %		3.21		
Galactan, %		0.50		
Alcohol-benzene soly., %			1.6	12.1

(1) J. Ind. Eng. Chem. 12:476(1920).
(2) Mech. Eng. 65:515(1943); pentosans, lignin and cellulose based on extractive-free wood.

The amount of hot-water solubles in various parts of a redwood tree were determined by Sherrard and Kurth, Ind. Eng. Chem. 25:300(1933).

Utilization

Use properties. Durable, low shrinkage, little tendency to warp and split, not difficult to work, good nail holding power, glues easily, holds paint well, good resistance to chemicals, even-textured, close-grained, resistance to fire good.

Pulping

Sulfite process. Reduces readily but unevenly, fairly strong but brash, shivy, dark in color; yield 50%.
Sulfate process. Reduces readily, fairly strong; yield, 40%.

Lumber. About 300 million bd. ft. average annual production from 1931 to 1940. Used for general millwork, caskets and coffins, tanks, boxes, furniture, bridges and trestles, shingles, stadium seats, siding, greenhouses, silos, vats.

Other uses. Shakes, stakes, bark insulation, bark fiber, plastics, novelties.

Supply

About 40 billion bd. ft. (1940 estimate), mostly in California.
57 million bd. ft. in Oregon (1933).
11 million cu. ft. in Oregon (1933).

SWEET BIRCH

Scientific Name. Betula lenta Linnaeus.

Synonyms. Birch, black birch, cherry birch, mahogany birch.

Family Name. Betulaceae.

Range. Southern Maine west to southern Michigan, south through eastern Ohio, eastern Kentucky and eastern Tennessee to northern Georgia, thence northeastward to the coast in southern New Jersey.

Dimensions. 50 to 60 ft. tall and 1 to 2 ft. in diameter.

Bark. On young trees reddish brown to nearly black, with prominent horizontal lenticels; on mature trees brownish black and breaking up into large, thin, irregular, scaly plates. Wintergreen oil in the inner bark of stems and roots.

Silvics. The tree develops a long, clear bole with a deep, wide-spreading root system. Deep, rich, moist, well-drained soils are preferred although the tree is also found on rocky sites. This species occurs as a scattered tree with maples, basswood, beech, oaks, and yellow poplar. It is moderately tolerant. Best development is reached in Kentucky and Tennessee.

Gross Features of the Wood. Similar to yellow birch, page 104.

Microscopic Structure. The wood of this species is not distinguishable from that of yellow birch, page 104.

Fibers. Length, 1.5 mm.

Rays. Volume occupied, 16.6%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.60
	air-dry volume	0.65
	oven-dry volume	0.71
Density, lb./cu. ft.	green	57
	air-dry	46
	oven-dry	44

Moisture content, when green: 53% based on oven-dry weight (35% on green basis).

Shrinkage, from green condition: v, 15.6%; r, 6.5%; t, 8.5%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	430	950
Compressive stress at p.l. //, lb./sq. in.	2680	6330
Compressive stress at p.l., ⊥, lb./sq. in.	580	1340
Shear, maximum stress //, lb./sq. in.	1240	2240
Static bending FSPL, lb./sq. in.	4800	10,100
Static bending E, lb./sq. in.	1.65×10^6	2.17×10^6
Static bending R, lb./sq. in.	9400	16,900
Toughness, in.	48	47
Hardness //, lb.	1070	1960
Hardness ⊥, lb.	970	1470
Cleavability, lb./in. width	300	640

Chemical Properties

Oil of wintergreen (containing 98 to 99% methyl salicylate) can be prepared from the bark. Most of the birch oil is produced in Connecticut and Tennessee.

Pathology

Resistance to decay: low +.
Brown cubical rot caused by birch conk (Polyporus betulinus).

Utilization

See yellow birch, page 106.

Use properties. A little higher in strength values than yellow birch and also with darker heartwood. Takes a beautiful polish.

Supply. See yellow birch, page 107.

RIVER BIRCH

Scientific Name. Betula nigra Linnaeus.

Synonyms. Red birch, birch, water birch, black birch.

Family Name. Betulaceae.

Range. Southern New Hampshire, northern Massachusetts, Long Island and southward east of the Alleghenies to western Florida; to east Texas, and north through eastern Oklahoma, eastern Kansas, central Iowa, southern Minnesota, southern Wisconsin, and eastward through northern Indiana, Ohio, and Pennsylvania, to southern New York. Not in the Appalachian or Ozark Mountains.

Dimensions. 70 to 80 feet tall and 2 to 3 feet in diameter; usually much smaller.

Bark. Salmon-pink, papery, later becoming coarsely scaly.

Silvics. This species is most common along stream banks throughout its range, and occurs mixed with sycamore, elm, soft maples, cottonwoods, and willows. The trunk often divides 15 or 20 feet from the ground into several arching branches.

Gross Features of the Wood. The wood of river birch is said to have abundant pith flecks but in other respects it is similar to yellow birch (page 104). It may be slightly softer, lighter, and weaker than yellow and sweet birch.

Microscopic Structure. Indistinguishable from yellow birch, page 104.

Rays. Volume occupied, 15.8%.

Pathology

Brown cubical rot caused by birch conk (Polyporus betulinus).

Utilization. Only small amount enters trade; turnery, woodenware, shoelasts.

Supply. No separate information; see yellow birch, page 107.

GRAY BIRCH

Scientific Name. Betula populifolia Marsh.

Synonyms. White birch, oldfield birch.

Family Name. Betulaceae.

Range. The Maritime provinces and the north bank of the St. Lawrence River to the eastern end of Lake Ontario, southward to northeastern West Virginia, and eastward to the coast.

Dimensions. 20 to 30 feet tall and 15 inches in diameter.

Bark. At first brownish, soon grayish white, exfoliating very little in comparison with that of paper birch; black triangular patches usually present on the trunk below the branch insertions.

Silvics. The root system is shallow and the bole usually poorly shaped and limby, with an irregular, open, pyramidal crown. It will grow on the poorest soils and has seeded in large areas, where it is associated with pitch pine and scrub oak. On better soils it occurs with oaks and white pine. It also associates widely with red maple.

Gross Features of the Wood. Similar to yellow birch (page 104) but usually softer, lighter, and weaker. Abundant pith flecks in evidence.

Microscopic Structure. The wood of this species is not distinguishable from yellow birch, page 104.

Fibers. Length, 1.3 mm.

Rays. Volume occupied, 9.3%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.45
	air-dry volume	0.51
	oven-dry volume	0.55
Density, lb./cu. ft.	green	46
	air-dry	35
	oven-dry	34

Shrinkage, from green condition: v, 14.7%; r, 5.2%.

Mechanical Properties

	Green	Air-dry
Compressive stress at p.l. //, lb./sq. in.	1080	2670
Compressive stress at p.l. ⊥, lb./sq. in.	250	920
Shear, maximum stress //, lb./sq. in.	-	1340
Static bending, FSPL, lb./sq. in.	1800	5500

Mechanical Properties (Continued)

	Green	Air-dry
Static bending E, lb./sq. in.	0.4×10^6	1.15×10^6
Static bending R, lb./sq. in.	4900	9800
Toughness, in.	59	35
Hardness //, lb.	430	680
Hardness ⊥, lb.	480	760

Pathology

Resistance to decay: low.

Brown cubical rot caused by birch conk (Polyporus betulinus); white mottled rot caused by tinder fungus (Fomes fomentarius).

Gray birch is highly favored by gypsy moth (Porthetria dispar).

Utilization. Fuel. Limited volume finds way into trade as substitute for paper birch; clothes pins, spools, shoe pegs, toothpicks.

Supply. No data available.

RED ALDER

Scientific Name. Alnus rubra Bongard.

Synonyms. Alder, Oregon alder, western alder.

Family Name. Betulaceae.

Range. Along coast from southeastern Alaska to Santa Barbara, California. In the island and coastal forests.

Dimensions. 80 to 130 feet tall and 10 to 36 inches in diameter.

Bark. Thin; grayish white, pale gray, or blue gray at the surface, smooth or covered with small warty excrescences; on large trees breaking up into large flat plates of irregular contour; inner bark bright reddish brown.

Silvics. The forest tree has a clear, symmetrical, slightly tapered bole, a narrow dome-like crown, and a shallow, spreading root system. Best growth is made on moist, rich bottom lands, slopes, and benches, although many trees are found on dry gravelly soils. This species occurs in pure stands or in mixture with Douglas fir, Sitka spruce, western hemlock, western red cedar, black cottonwood, and bigleaf maple. It is essentially a coastal species. Red alder is one of the first species to appear on burned and logged areas.

Gross Features of the Wood. The wood is flesh colored to light brown with a reddish tinge; the heartwood is not distinguishable from the sapwood. It is straight-grained, without characteristic odor or taste, diffuse-porous, and with distinct growth rings because of the whitish or brownish line at the outer margin. The pores are small, indistinct without a hand lens, solitary and in short radial groups of 2 or more. The longitudinal parenchyma are indistinct. The rays are of two types, narrow and broad. The narrow rays are closely spaced and not visible with the naked eye. The broad rays are at irregular intervals (often at wide intervals), not sharply delineated and relatively inconspicuous to the naked eye in the x-section, and as much as an inch along the grain on the t-surface.

Microscopic Structure

Vessels. 70 to 110 per sq. mm., the largest 70 to 100 mu in diameter; perforation plates scalariform with 15+ thin bars; intervessel pits orbicular to oval, quite widely spaced, fairly small (4 to 6 mu in diameter).

Fibers. Thin- to moderately thick-walled, 16 to 40 mu in diameter and 1.2 mm. long.

Rays. Unstoried, homogeneous; the narrow rays uniseriate or rarely in part biseriate; the aggregate rays consist of units similar to the narrow rays, and of included fibers and vessels.

Longitudinal Parenchyma. Paratracheal, metatracheal-diffuse, and occasionally terminal; the paratracheal parenchyma sparse, restricted to occasional cells; the metatracheal-diffuse parenchyma sparse to fairly abundant, the cells solitary or in short tangential rows of 2 or more; the terminal parenchyma, if present, form an interrupted uniseriate line.

Nonmechanical Physical Properties

Specific gravity	green volume	0.37
	air-dry volume	0.41
	oven-dry volume	0.43
Density, lb./cu. ft.	green	46
	air-dry	28
	oven-dry	23

Moisture content, when green: 98% based on oven-dry weight (49% on green basis).

Shrinkage, from green condition: v, 12.6%; r, 4.4%; t, 7.3%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	390	420
Compressive stress at p.l. //, lb./sq. in.	2620	4530
Compressive stress at p.l. ⊥, lb./sq. in.	310	540
Shear, maximum stress //, lb./sq. in.	770	1080
Static bending FSPL, lb./sq. in.	3800	6900
Static bending E, lb./sq. in.	1.16×10^6	1.38×10^6
Static bending R, lb./sq. in.	6500	9800
Toughness, in.	22	20
Hardness //, lb.	550	980
Hardness ⊥, lb.	440	590
Cleavability, lb./in. width	220	270

Chemical Properties

Calorific value: 17.4×10^6 B.t.u. per air-dry cord.

Proximate analysis:

	Rittor and Fleck (1) Heartwood	
	Spring	Summer
Cold-water soly., %	3.02	3.03
Hot-water soly., %	4.01	4.16
1% NaOH soly., %	20.5	21.2
Acetic acid, %	3.69	3.60
Methoxyl, %	5.18	5.55
Pentosans, %	22.4	23.4
Lignin, %	24.7	23.0
C. and B. cellulose, %	58.4	57.2
Pentosans, %	22.8	22.9

(1) Ind. Eng. Chem. 18:608(1926).

Pathology

Resistance to decay: low.
White trunk rot caused by the false tinder fungus (Fomes igniarius).

Utilization

Use properties. Straight-grained, close- and uniform-textured, easy to work, moderately light, moderately soft, little tendency to split in nailing, moderate nail-holding power, glues satisfactorily, takes and holds paint satisfactorily, moderately large shrinkage, difficult to bend.

Pulping

Soda process. Reduces readily, fairly easy to bleach; yield, 42%.
Sulfate process. Reduces readily, fairly easy to bleach; yield, 42%.

Lumber. Average annual production 23 million bd. ft. from 1931 to 1940; furniture.

Supply

1.5 billion bd. ft. in Oregon (1936).
0.5 billion bd. ft. in Washington (1936).
1.4 billion cu. ft. in Washington and Oregon (1936).

WHITE ALDER

Scientific Name. Alnus rhombifolia Nuttall.

Synonyms. Alder, mountain alder.

Family Name. Betulaceae.

Range. From northern Idaho to the eastern slope of the Cascade Mountains of Washington, then south through Oregon and California, especially in the mountains.

Dimensions. 50 to 80 feet tall and 18 to 36 inches in diameter.

Bark. Dark brown, divided into irregular plates covered by thin, appressed scales.

Silvics. The tree has a straight, clear bole, a rather broad, open, dome-like crown, and a shallow and spreading root system. Pure stands occur only along the stream banks and in canyon bottoms when moisture is plentiful but rarely where the stream flow is intermittent. Sycamore, bigleaf maple, dogwood, and ash are the chief associates when white alder occurs in mixed forests.

Gross Features of the Wood. Pale yellow brown; otherwise similar to red alder.

Nonmechanical Physical Properties

Specific gravity	air-dry volume	0.41
Density, lb./cu. ft.	air-dry	26

Utilization

Very little used; probably mixed with red alder.

Supply. No data available.

RED BAY

Scientific Name. Persea borbonia (Linnaeus) Sprengel.

Synonyms. Bay galls, laurel-tree.

Family Name. Lauraceae.

Range. Coast region from Virginia to Florida and the Gulf region to eastern Texas; northward through Louisiana to southern Arkansas.

Dimensions. 60 feet tall by 3 feet diameter, maximum size.

Bark. Grayish brown, fissured into flat, firm ridges.

Silvics. Evergreen. Occurs typically in swamp areas and on pine barrens. In swampy areas associates include pond, slash and loblolly pines, swamp black and red gums, pond cypress, southern white cedar, and loblolly bay; on beach dunes and calcareous hummocks, live oak, cabbage palmetto, southern red cedar, evergreen magnolia, laurel oak, red maple, and holly.

Gross Features of the Wood. Diffuse porous, moderately hard, moderately strong, takes beautiful polish, reddish-brown heartwood and lighter sapwood.

Nonmechanical Physical Properties

Specific gravity	air-dry volume	0.64
Density, lb./cu. ft.	air-dry	40

Utilization. Local use only; interior trim, cabinet work. Ornamental value.

SWAMP BAY

Scientific Name. Persea palustris (Rafinesque) Sargent.

Synonyms. Swamp red-bay, bay.

Family Name. Lauraceae.

Range. South Atlantic and Gulf region from North Carolina to southern Florida, Alabama, Mississippi, and eastern Louisiana.

Dimensions. 60 feet tall by 12 to 16 inches in diameter, maximum size.

Bark. Reddish brown, furrowed into prominent and rather firm ridges.

Silvics. A small evergreen with an irregular crown. This species is found typically in swamp areas and on pine barrens. Its associates are the same as those of red bay.

Gross Features of the Wood. Diffuse porous, hard, heavy, strong, close-grained, compact, takes a smooth polish, orange-brown heartwood and buff-white sapwood.

Nonmechanical Physical Properties

Specific gravity	air-dry volume	0.64
Density, lb./cu. ft.	air-dry	40

Utilization. Larger sizes used locally for interior trim, furniture, boat building.

BIGLEAF MAPLE

Scientific Name. Acer macrophyllum Pursh.

Synonym. Broadleaf maple, Oregon maple.

Family Name. Aceraceae.

Range. Coast of British Columbia and west slopes of the Cascade Mountains in Washington and Oregon to southern California in the coast range and Sierra Nevada.

Dimensions. 60 to 80 feet tall and 14 to 30 inches in diameter.

Bark. Light gray brown and smooth on young stems, but becoming darker and deeply furrowed on old trunks.

Silvics. The forest tree has a straight, clear bole, a rather narrow crown, and a shallow, widespreading root system. It is found on a variety of soils throughout its range but makes its best development on rich bottom lands. Usually it occurs in mixture with Douglas fir, western red cedar, western hemlock, red alder, black cottonwood, grand fir, and California laurel but in sections of southwestern Oregon it is the principal species. This species is tolerant.

Gross Features of the Wood. The sapwood is reddish white, sometimes with a grayish cast and the heartwood is pinkish brown. The wood is moderately hard, generally straight- but occasionally wavy-grained, without characteristic odor or taste. The rather indistinct growth rings are marked by a narrow light line of fibrous tissue. The wood is diffuse-porous with moderately small to medium-sized pores, indistinct without a hand lens, evenly distributed throughout the growth ring or somewhat more numerous in the early springwood, mostly solitary or in short radial groups of 2 or more. The rays are visible with the naked eye and intergrade in width, the broadest being about as wide as the largest pores. They form a pronounced close ray fleck on the r-surface and on the t-surface are visible with the naked eye as short crowded lines. The longitudinal parenchyma are not visible.

Microscopic Structure

Vessels. 30 to 80 per sq. mm., the largest 80 to 120 mu in diameter; perforation plates simple; spiral thickening present; intervessel pits orbicular or angled through crowding, 4 to 10 mu in diameter; gummy deposits not infrequent.

Fibers. Thin- to moderately thick-walled, 16 to 30 mu in diameter and 0.8 mm. in length.

Rays. Unstoried, 1 to 5 (mostly 3 to 5) seriate, essentially homogeneous. Volume occupied, 18.4%.

Longitudinal Parenchyma. Sparse, terminal, paratracheal, and metatracheal-diffuse.

Nonmechanical Physical Properties

Specific gravity	green volume	0.44
	air-dry volume	0.48
	oven-dry volume	0.51
Density, lb./cu. ft.	green	47
	air-dry	34
	oven-dry	32

Moisture content, when green: 72% based on oven-dry weight (42% on green basis).

Shrinkage, from green condition: v, 11.6%; r, 3.7%; t, 7.1%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	600	540
Compressive stress at p.l. //, lb./sq. in.	2510	4790
Compressive stress at p.l. ⊥, lb./sq. in.	550	930
Shear, maximum stress //, lb./sq. in.	1110	1730
Static bending FSPL, lb./sq. in.	4400	6600
Static bending E, lb./sq. in.	1100	1450
Static bending R, lb./sq. in.	7400	10,700
Toughness, in.	23	28
Hardness //, lb.	760	1330
Hardness ⊥, lb.	620	850
Cleavability, lb./in. width	320	400

Pathology

Resistance to decay: low +

Utilization

Use properties. Generally straight-grained but occasionally wavy-grained, moderately heavy, moderately hard, works moderately well with tools, polishes well, takes paints and stains readily, difficult to glue, shrinks moderately, growth rings not very distinct.

Pulping. No data.

Lumber. Furniture, handles, fixtures, woodenware, and novelties. Production in 1940 about 7 million bd. ft.

Other uses. Veneer (plain and figured).

Supply.

500 million bd. ft. in Oregon (1933).
235 million bd. ft. in Washington (1933).
455 million cu. ft. in Washington and Oregon (1933).

BLACK MAPLE

Scientific Name. Acer nigrum Michaux.

Synonym. Hard maple.

Family Name. Aceraceae.

Range. Southern Quebec southwest through southern Michigan to northeastern South Dakota; south to Missouri, and in the east through western Connecticut and southeastern Pennsylvania to Kentucky.

Dimensions. 60 to 80 feet tall and 2 feet in diameter.

Bark. More corrugated than that of sugar maple.

Nonmechanical Physical Properties

Specific gravity	green volume	0.52
	air-dry volume	0.57
	oven-dry volume	0.62
Density, lb./cu. ft.	green	54
	air-dry	40
	oven-dry	39

Moisture content, when green: 65% based on oven-dry weight (39% on green basis).

Shrinkage from green condition: v, 14.0%; r, 4.8%; t, 9.3%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	720	670
Compressive stress at p.l. //, lb./sq. in.	2800	4600
Compressive stress at p.l. ⊥, lb./sq. in.	740	1250
Shear, maximum stress //, lb./sq. in.	1130	1820
Static bending FSPL, lb./sq. in.	4100	8300
Static bending E, lb./sq. in.	1.33×10^6	1.62×10^6
Static bending R, lb./sq. in.	7900	13,300
Toughness, in.	48	40
Hardness //, lb.	940	1700
Hardness ⊥, lb.	840	1180
Cleavability, lb./in. width	430	420

Black maple is very similar to sugar maple in habit and wood properties. The woods are not separated in the trade, in fact, cannot be. For information not specifically given here the reader should consult sugar maple, page 133.

LOBLOLLY BAY

Scientific Name. Gordonia lasianthus (Linnaeus) Ellis.

Synonyms. Tan bay, black laurel.

Family Name. Theaceae.

Range. Coast region from southern Virginia to Florida and west in the Gulf Coast region to the Mississippi River; inland in Georgia to Augusta.

Dimensions. 75 feet tall by 18 inches in diameter, maximum size.

Bark. Reddish brown, deeply fissured into long, firm, rounded or narrow-topped ridges.

Silvics. A small evergreen tree of secondary importance, with rather upright branches and narrow top, found in wet situations in association with southern white cedar, pond pine, cypress, swamp black gum, sweet bay, red bay, slash pine, and similar moisture-loving species. Occurs as a shrub in unfavorable conditions.

Gross Features of the Wood. Light, soft, not strong, easily worked, diffuse-porous, reddish-brown heartwood and wide pinkish-white sapwood.

Nonmechanical Physical Properties

Specific gravity	air-dry volume	0.47
Density, lb./cu. ft.	air-dry	29

Utilization

Lumber. Small local use in cabinet making.

Other uses. Bark for tanning.

BLACK ASH

Scientific Name. Fraxinus nigra Marshall.

Synonyms. Brown ash, hoop ash, swamp ash, water ash.

Family Name. Oleaceae.

Range. From northern shores of Gulf of St. Lawrence west to southeastern Manitoba; southward to Delaware, Virginia, West Virginia, southern Illinois and Indiana, Iowa. Not in Maritime provinces.

Dimensions. 40 to 50 feet tall and 1.5 feet in diameter.

Bark. Grayish, relatively smooth, later shallowly furrowed or scaly.

Silvics. The tree has a rather poorly shaped bole, a small open crown, and a very shallow, fibrous root system. It occurs along stream banks or swamp borders in association with white cedar, balsam fir, red maple, yellow birch, American elm, and black gum. It reaches best development in northern Michigan and northern Wisconsin. Black ash is intolerant.

Gross Features of the Wood. The very narrow sapwood of black ash is whitish to light brown, and the heartwood is dull grayish brown to brown (darker than in white ash). The wood is medium hard, moderately strong, straight-grained, without characteristic odor or taste. The wood is ring porous with distinct growth rings which are frequently narrow. The springwood pores are large, distinct to the naked eye, and form a band 2 to 4 pores in width; the summerwood pores are small, barely visible to the naked eye, solitary and in radial groups of 2 or 3, rarely joined laterally by parenchyma in the late summerwood. The transition from springwood to summerwood is abrupt. The longitudinal parenchyma is visible with a hand lens, forming a narrow sheath around the pores in the summerwood, and rarely uniting them laterally. The rays are indistinct or barely visible to the naked eye.

Microscopic Structure

Vessels. In the summerwood 8 to 30 per sq. mm.; largest springwood vessels 160 to 260 mu in diameter; perforation plates simple; intervessel pits orbicular to short-oval or occasionally somewhat angular through crowding, 3 to 6 mu in diameter. Volume occupied, 11.6%.

Tracheids. Confined to the vicinity of the springwood vessels.

Fibers. Thin- to fairly thick-walled, 12 to 22 mu in diameter and 1.3 mm. long. Volume occupied, 69.4%.

Rays. Unstoried, 1 to 3 seriate, homogeneous. Volume occupied, 12.0%.

Longitudinal Parenchyma. Paratracheal, rarely paratracheal-confluent in the late summerwood, and terminal; sheath of paratracheal parenchyma around the summerwood vessels uniseriate for the most part; terminal parenchyma fairly abundant, grading into the tissue of the succeeding growth ring, not forming a distinct line. Volume occupied, 7.0%.

Nonmechanical Physical Properties

Specific gravity	green volume	0.45
	air-dry volume	0.49
	oven-dry volume	0.53
Density, lb./cu. ft.	green	52
	air-dry	34
	oven-dry	33

Moisture content, when green: 85% based on oven-dry weight (46% on green basis).

Shrinkage, from green condition: v, 15.2%; r, 5.0%; t, 7.8%.

Thermal expansion: 0.0000053.

Mechanical Properties

	Green	Air-dry
Tensile, ⊥, lb./sq. in.	490	700
Compressive stress at p.l. //, lb./sq. in.	1690	4520
Compressive stress at p.l. ⊥, lb./sq. in.	430	940
Shear, maximum stress //, lb./sq. in.	860	1570
Static bending FSPL, lb./sq. in.	2600	7200
Static bending E, lb./sq. in.	1.04×10^6	1.60×10^6
Static bending R, lb./sq. in.	6000	12,600
Toughness, in.	33	35
Hardness //, lb.	590	1150
Hardness ⊥, lb.	520	850
Cleavability, lb./in. width	280	380

Chemical Properties

Calorific value: 22.6×10^6 B.t.u. per air-dry cord.
Destructive distillation: pyroligneous acid, 34.6%; tar, 10.2%; charcoal, 39.3%.

Pathology

Resistance to decay: low+.
Sapwood attacked by powder post beetle (Lyctus species).

Utilization

Use properties. Dark colored heartwood, fine grain, pleasing figure, seasons well, holds shape well, excellent bending qualities, medium heavy,

medium hard, splits easily, shrinks considerably.

Lumber. About 15 million bd. ft. average annual production from 1931 to 1940, which was 20% of total ash cut; interior trim, cabinet work.

Other uses. Basket making by Indians.

Supply. Approximately 1 billion bd. ft. in the Lake States (1935).

NORTHERN CATALPA

Scientific Name. Catalpa speciosa Warder.

Synonyms. Catalpa, hardy catalpa, western catalpa, cigar tree.

Family Name. Bignoniaceae.

Range. Through southern Illinois and Indiana, western Kentucky and Tennessee, southeastern Missouri, and northeastern Arkansas. Naturalized in eastern U. S., especially in southern Arkansas, western Louisiana, and eastern Texas.

Silvics. The bole is well formed if grown on good sites but otherwise is liable to be crooked. The tree is an inhabitant of bottomlands, where it occurs scattered in mixture with other well-known bottomland species. This species is intolerant. Growth is rapid and close stocking necessary for good pruning.

Gross Features of the Wood. The very narrow sapwood is pale gray, and the heartwood is grayish brown, with a lavender tinge. The wood is moderately soft, moderately light, straight-grained, with a faint, non-characteristic odor and without characteristic taste. The growth rings are distinct as a result of the ring porousness, and generally wide. The springwood pores are large, distinct with the naked eye, arranged in a band 3 to 5 or more pores in width, somewhat lighter in color than the denser summerwood; the summerwood pores are small, arranged in small groups which are further aggregated into interrupted or continuous concentric bands toward the outer margin of the ring. The transition from springwood to summerwood is abrupt, or more or less gradual. The longitudinal parenchyma is not distinct, or associated with the pores and then distinct and zonate toward the outer margin of the ring. The rays are usually indistinct with the naked eye but are plainly visible with a hand lens.

Microscopic Structure

Vessels. In the summerwood 8 to 20 per sq. mm., the largest 160 to 210 mu in diameter; perforation plates simple; spiral thickening present in the small vessels in the summerwood; intervessel pits orbicular or nearly so, 6 to 8 mu in diameter. Volume occupied, 19.6%.

Fibers. Thin walled, 20 to 52 mu in diameter and 0.6 mm. in length. Volume occupied, 64.5%.

Rays. Unstoried, 1 to 6 (mostly 2 or 3) seriate, homogeneous to heterogeneous. Volume occupied 13.3%.

Longitudinal Parenchyma. Paratracheal and paratracheal-zonate, the zonate parenchyma more frequent near the outer margin of the ring and the outermost band not infrequently devoid of vessels. Volume occupied, 2.6%.

Nonmechanical Physical Properties

Specific gravity,	green volume	0.38
	air-dry volume	0.41
	oven-dry volume	0.42
Density, lb./cu. ft.	green	41
	air-dry	29
	oven-dry	26

Moisture content, when green: 72% based on oven-dry weight (42% on green basis).

Shrinkage, from green condition: v, 7.3%; r, 2.5%; t, 4.9%.

Mechanical Properties

	Green	Air-dry
Tensile ⊥, lb./sq. in.	430	570
Compressive stress at p.l. //, lb./sq. in.	1450	2740
Compressive stress at p.l. ⊥, lb./sq. in.	320	570
Shear, maximum stress //, lb./sq. in.	680	1130
Static bending FSPL, lb./sq. in.	2700	4700
Static bending E, lb./sq. in.	840	1210
Static bending R, lb./sq. in.	5200	9400
Toughness, in.	35	27
Hardness //, lb.	420	650
Hardness ⊥, lb.	410	550
Cleavability, lb./in. width	220	300

Chemical Properties

Proximate analysis:	Ritter and Fleck (1) Sapwood Spring	Sapwood Summer	Heartwood Spring	Heartwood Summer
Cold-water soly., %	9.12	7.29	7.51	2.69
Hot-water soly., %	12.4	10.1	11.7	5.26
1% NaOH soly., %	34.5	28.0	34.3	24.2
Acetic acid, %	3.33	4.45	3.39	4.07
Methoxyl, %	4.44	4.10	4.97	3.37
Pentosans, %	22.4	22.4	21.3	21.5
Lignin, %	23.6	18.7	24.3	19.4
C. & B. cellulose, %	50.4	56.5	50.4	58.5
Pentosans, %	25.9	22.1	24.8	21.2

(1) Ind. Eng. Chem. 18:608(1926).

Pathology

Resistance to decay: very durable.

White spongy rot caused by rainbow conk (*Polystictus versicolor*).

Catalpa sphinx moth (*Ceratomia catalpae*); catalpa midge (*Itonida catalpae*).

Utilization

Use properties. Straight-grained, moderately light, moderately soft, low shrinkage, figure distinct, very durable.

Pulping

Sulfite process. Reduces fairly readily, decidedly pinkish in color, frequently specky, very difficult to bleach; yield, 47%.

Soda process. Reduces readily, fairly easy to bleach; yield, 42%.

Lumber. Used locally in general construction, interior finish, cabinet work.

Other uses. Fence posts, rails, fuel.

Supply. No information available.

SOUTHERN CATALPA

Scientific Name. Catalpa bignonioides Walter.

Synonyms. Catalpa, Indian bean, beantree, catawba, cigar tree.

Family Name. Bignoniaceae.

Range. Southwestern Georgia, western Florida, central Alabama, Mississippi, and southwestern Missouri. Widely cultivated for ornament and naturalized in eastern U. S. as far north as southern New York.

This species is very similar to northern catalpa in habit and wood properties.

OAKS

The important oaks are listed according to a generalization of ranges. Note is made whether the species is a member of the red or white oak group. A white oak (chestnut oak) is described in detail on page 94.

South Atlantic and Gulf Coastal Plain in addition to varying distances north in the Mississippi Valley:

Overcup oak (Quercus lyrata Walter) - white
Swamp chestnut oak (Quercus prinus Linnaeus) - white
Live oak (Quercus virginiana Miller) - red
Shumard red oak (Quercus shumardii Buckley) - red
Southern red oak (Quercus rubra Linnaeus) - red
Swamp red oak (Quercus rubra pagodaefolia (Elliott) Ashe) - red
Cherrybark oak (Quercus rubra leucophylla Ashe) - red
Nuttall oak (Quercus nuttallii Palmer) - red
Turkey oak (Quercus catesbaei Michaux) - red
Water oak (Quercus nigra Linnaeus) - red
Laurel oak (Quercus laurifolia Michaux) - red
Willow oak (Quercus phellos Linnaeus) - red

The general region east of the Great Plains, including the Coastal Plains:

White oak (Quercus alba Linnaeus) and its variety, latiloba Sargent - white
Post oak (Quercus stellata Wangenheim) - white
Black oak (Quercus velutina La Marck) - red
Blackjack oak (Quercus marilandica Muenchhausen) - red

Not on the Coastal Plain; in general, north, east, or central:

Chinquapin oak (Quercus muehlenbergii Engelmann) - white
Bur oak (Quercus macrocarpa Michaux) - white
Chestnut oak (Quercus montana Willdenow) - white
Swamp white oak (Quercus bicolor Willdenow) - white
Northern red oak (Quercus borealis Michaux) and its variety maxima (Marshall) Ashe - red
Scarlet oak (Quercus coccinea Muenchhausen) - red
Pin oak (Quercus palustris Muenchhausen) - red
Jack oak (Quercus ellipsoidalis Hill) - red
Shingle oak (Quercus imbricaria Michaux) - red

Pacific Coast:

Oregon white oak (Quercus garryana Douglas) - white
California black oak (Quercus kelloggii Newberry) - red

Gross Features of the Wood. The wood of a white oak is described under chestnut oak (page 94). This description will suffice for all the white oaks. The following table shows how the red oaks differ from the white oaks without giving details.

White Oaks	Red Oaks
1. Heartwood rich light brown to dark brown, without flesh-colored cast.	1. Heartwood pinkish or pale reddish brown.
2. Transition from springwood to summerwood generally abrupt.	2. Transition from springwood to summerwood gradual to more or less abrupt.
3. Springwood pores in the heartwood usually occluded with tyloses.	3. Springwood pores in the heartwood usually open.
4. Summerwood pores barely distinct with a hand-lens, thin-walled, more or less angular.	4. Summerwood pores plainly visible with a hand lens, thick-walled, rounded.

Microscopic Structure

Fibers. Length, 1.4 mm.

Nonmechanical Physical Properties

Specific gravity, commercial white oak:	green volume	0.59
	air-dry volume	0.67
commercial red oak:	green volume	0.57
	air-dry volume	0.63
Density, lb./cu. ft., commercial white oak:	green	63
	air-dry	47
commercial red oak:	green	64
	air-dry	44

Moisture content, when green: Commercial white oak--70% based on oven-dry weight (41% on green basis); commercial red oak--80% based on oven-dry weight (44% on green basis).

Shrinkage, from green condition:

commercial white oak, v, 16.0%; r, 5.4%; t, 9.3%.
commercial red oak, v, 14.8%; r, 4.3%; t, 9.0%.

Thermal expansion: // 0.0000027; ⊥ 0.0000302

Thermal conductivity: 1.21 B.t.u./hr./sq. ft. with 1° F. gradient/inch thickness.

Electrical resistance:

commercial white oak: 17,400 megohms at 7% moisture content
80 megohms at 12% moisture content

commercial red oak: 14,400 megohms at 7% moisture content
125 megohms at 12% moisture content

Mechanical Properties

	Commercial White Oak		Commercial Red Oak	
	Green	Air-dry	Green	Air-dry
Tensile ⊥, lb./sq. in.	760	760	735	830
Compressive stress at p.l.//, lb./sq. in.	2940	4350	2590	4610
Compressive stress at p.l. ⊥, lb./sq. in.	850	1410	800	1260
Shear, maximum stress ⊥, lb./sq. in.	1270	1890	1220	1830
Static bending FSPL, lb./sq.in.	4700	7900	4400	8400
Static bending E, lb./sq. in.	1.20×10^6	1.62×10^6	1.36×10^6	1.81×10^6
Static bending R, lb./sq. in.	8100	13,900	8500	14,400
Toughness, in.	42	39	43	43
Hardness //, lb.	1110	1420	1050	1490
Hardness ⊥, lb.	1070	1330	1030	1300
Cleavability, lb./in. width	420	400	410	430

Chemical Properties

Calorific value: white oak, 30.6×10^6 B.t.u. per air-dry cord
red oak, 27.3×10^6 B.t.u. per air-dry cord

Proximate analysis: White oak.

	Ritter and Flock (1)				Bird and Ritter (2)
	Sap	Heart	Sap	Heart	
Ash, %	0.57	0.43	0.37	0.42	
Cold-water soly., %	2.55	7.33	4.27	4.76	
Hot-water soly., %	4.11	10.2	5.73	6.60	
Ether soly., %	0.46	0.71	0.65	0.62	
1% NaOH soly., %	21.1	25.8	21.7	22.7	
Acetic acid, %	3.44	2.59	2.47	2.97	2.37
Methoxyl, %	5.95	6.18	6.02	5.64	6.44
Pentosan, %	23.3	21.8	21.7	22.1	18.7
C.& B.cellulose, %	49.5	48.7	53.2	52.1	
Pentosan, %	24.7	24.2	24.8	24.5	
Alpha-cellulose,%	33.7	32.7	28.6	27.6	
Lignin, %	32.3	32.7	31.1	31.3	23.4
Methoxyl in lignin,%					22.4
Holocellulose, %					75.6

(1) Ind. Eng. Chem. 15:1056(1923)
(2) J. Am. Chem. Soc. 59:802(1937).

Pathology

Resistance to decay: white oaks, intermediate +.
red oaks, low +.

Utilization

Total cut is equivalent to 2.4 billion bd. ft.

Use properties. Straight-grained, heavy, hard, strong, stiff, machines well, finishes smooth, holds nails well, tendency to split, average in glueing, high abrasion resistance, difficult to season, pronounced figure, high shrinkage, beautiful ray fleck on quarter surface, white oaks durable but red oaks not durable. Rapid-growing, second-growth oak is generally stronger, harder, and tougher than old-growth timber which is finer-grained, softer, more easily worked and takes a finer finish.

Pulping. Sulfate process: Reduces readily, rather difficult to bleach; yield, 38%.

Lumber. Commercial white oak lumber is chiefly white oak, chestnut oak, and swamp chestnut oak. Commercial red oak lumber is chiefly northern red oak, southern red oak, swamp red oak, and Shumard oak. Oak is the principal hardwood used in the United States; the average annual production from 1931 to 1940 was 1.2 billion bd. ft. Used for flooring, vehicle and car construction, general millwork, furniture, boxes and crates, cabinets, ships and boats, handles, caskets and coffins, and agricultural implements.

Other uses. Ties, fuel, tight cooperage, posts, mine timbers, poles, piling, sliced veneer. With exception of fuel and veneer, red oak needs treatment for these uses.

Bark of some species of oak is an important source of tannin.

Supply

38 billion bd. ft. of white oaks in the United States (1940 estimate).
45.7 billion bd. ft. of red oaks in the United States (1940 estimate).
95 million bd. ft. and 980 thousand cords in Canada (1935).
9.0 billion bd. ft. in Louisiana (1936).
4.6 billion bd. ft. in North Carolina (1938).
3.3 billion bd. ft. in Georgia (1936).
3.0 billion bd. ft. in southeast Texas (1935).
636 million bd. ft. in northeast Florida (1934).
64 million bd. ft. in northern Michigan (1935).

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ERRATA IN PT. 1

Slash pine, page 31.	The data in the column headed Max (3) under proximate analysis should be lowered one row.
Balsam fir, page 68.	In mechanical process pulping the power requirement is 15 to 25% more than spruce.
Lowland white fir, page 71.	In mechanical process pulping the power requitement is 20% more than spruce.
Black gum, page 97.	Vessel pits in transverse rows of 1 to 5+, not 1 to 54.
Beech, page 113.	Acetyl % in holocellulose from heartwood is 4.76, not 5.76.