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Softwoods of North America

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Abstract

This report describes 52 taxa of North American softwoods, which are organized alphabetically by genus. Descriptions include scientific name, trade name, distribution, tree characteristics, wood characteristics (e.g., general, weight, mechanical properties, drying, shrinkage, working properties, durability, preservation, uses, and toxicity), and additional sources of information. Data were compiled from existing literature, mostly from research done at the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin.

Keywords: softwoods, properties, North America, wood

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This book is dedicated to Elbert Luther Little, Jr. (1907–present) for his significant and voluminous contributions to the nomenclature and geographic distributions of both softwood and hardwood trees of North America (45, 76, 100–139, 197, 198).

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Softwoods of North America

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Introduction

Every week, the USDA Forest Service, Forest Products Laboratory (FPL), receives numerous calls from the public and industry inquiring about wood, especially concerning properties and common names. Much information has been accumulated at FPL in loose-leaf files; the information for a particular wood has been derived from various sources over many years. Responding to information requests has required searching these files and copying selected pages to send to customers.

Martin Chudnoff compiled some of these data, referring to tropical species in *Tropical Timbers of the World* (40). In the interest of efficiency, I began collating and condensing information about woods not covered in Chudnoff's book. It also became apparent that other compilations were necessary to satisfy the needs of FPL customers. To that end, *Softwoods of North America* is the second report of these compilations, covering both commercial and noncommercial softwoods. All taxa listed are temperate species native to North America, north of Mexico, although many western species have distributions that extend into Mexico. Softwood taxa that have native distributions exclusively in Mexico are not covered in this text.

The format for this report is almost identical to that used in Chudnoff's *Tropical Timbers of the World* (40). In addition, aspects of toxicity, such as dermatitis and bronchial problems, are included if known. The descriptions also include a short paragraph delineating the number and distribution of species as well as etymological background (derivation) of the scientific names. Terms relating to wood are defined in the Glossary, followed by a listing of abbreviations used in this document for wood properties and measurement terms.

Data are arranged alphabetically by the genus and species binomial name (for example, eastern white pine is *Pinus strobus* L.). Species covered in this text are those recognized in *Checklist of United States Trees* by E.L. Little, Jr. (119). When two or more species in a genus make up a commercial grouping, the composite is designated by spp. (e.g., *Picea* spp., spruces). For each genus, an introductory page describes the number and geographical areas of species in that group. The introductory page also includes the number of species native to North America and indicates which taxa are covered in this text. To further complete botanical affinities, plant authors (those who named the plant) and family names (ending in -aceae) are also given. Brackets are used to indicate the number of species in different geographical locales. Trade names are keyed to genus and species in the Appendix.

Each species is described in terms of its trade and other common names, distribution, tree characteristics, and general wood characteristics. General wood characteristics include weight (plus moisture content (MC) and specific gravity (SG)), Mechanical properties, drying and shrinkage, working properties, durability, preservation, uses, and toxicity. Finally, additional sources of information are cited.

Other Common Names: The scientific name is followed by one or more trade or common names, taken from the *Checklist of United States Trees* by E.L. Little, Jr. (119). The other common names were taken from a database compiled by R. Miller, Center for Wood Anatomy Research at FPL, in conjunction with J. Ilic, Division of Forest Products, Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. Although this database is vast (more than 100,000 names), it will never be complete because new common names appear constantly.

Distribution: Information on native growth ranges was taken from the *Checklist of United States Trees* (119).

The Tree: Tree form and size were taken from the *American Wood Series* (as cited for each taxon), *Silvics of North America* (34), and *The Complete Trees of North America* (53).

General Wood Characteristics: This section describes the appearance of wood of individual species and species groupings: sapwood and heartwood coloration and unusual changes on exposure to light or air. If anatomical elements are large and irregular, the wood is described as having coarse and uneven texture. If these features are small and evenly distributed, the texture is fine and uniform. Grain defines the arrangement or alignment of wood tissue—straight, spiral, or interlocked. Distinctive scents and tastes are noted. Woods with gummy, oily, or resinous exudates are indicated. This section also contains brief descriptions of working and drying characteristics and the ability of wood to be penetrated by preservatives. Most information was taken from the *American Wood Series* (as cited for each taxon under Additional Reading).

Weight: Specific gravity or density may be related to important wood attributes, such as mechanical strength, shrinkage, paper-forming properties, and cutting forces required in machining. In assessing the use potential of a species, specific gravity often receives first attention. Moisture content of green wood (heartwood unless noted) is included from the *Dry Kiln Operator's Manual* (185).

Basic specific gravity (noted as green values in tables) is the ratio of wood density to the density of water at 39ºF (4ºC) and is calculated from the ovendry weight and volume in the green condition. This may range from less than 0.32 for northern white cedar (*Thuja occidentalis)* to about 0.66 for slash pine (*Pinus elliottii)*. Density, calculated from weight and volume when the woods are green or air dry usually at a moisture content of 12%, is also given. Density can range from about 20 to 55 lb/ft^3 (320 to 881 kg/m^3).

Mechanical Properties: It is emphasized that the mechanical properties presented here were taken from various sources. Sampling and testing procedures may have varied considerably. Values are given so that species can be compared and selected for targeted end uses. However, data reported may not be acceptable to regulatory bodies as a basis for assigning design properties. Such interests are beyond the scope and intent of this document. Sources from which strength data were obtained are cited and listed in the References section.

Data are given for strength tests on wood in the green and dry conditions. The properties include bending strength (modulus of rupture (MOR)), stiffness in bending (modulus of elasticity (MOE)), compression parallel to the grain (maximum crushing strength ($C_{||}$)), compression perpendicular to the grain (stress at proportional limit ($C_{\perp}$), work to maximum load (WML), hardness, and shear parallel to the grain ($shear_{||}$). Most test results reported here are based on the ASTM D 143 procedures using 2-in. (50.8-mm) specimens, except where noted. Most data were taken from the *Wood Handbook* (56).

Drying and Shrinkage: The response of individual woods to air and kiln drying is noted as well as the susceptibility to drying degrade, such as checking, warp, or collapse. Shrinkage values in percent (tangential, radial, and volumetric) from the green to ovendry condition (0% moisture content) or green to various air dry conditions (6%, 12%, or 20% moisture content) are given. No kiln schedule is recommended if it was not found in the literature. Data were taken from the *Wood Handbook* (56) and the *Dry Kiln Operator's Manual* (185).

Working Properties: Much of the information given on working properties of individual species is highly subjective. Described are ease of working the wood using hand and machine tools, tendencies toward torn or chipped grain, smoothness of finish, dulling by cutters, and ease of veneering. Nailing, screwing, or gluing characteristics may be included as well as steam-bending properties, if the species is well suited for these purposes. Most information was taken from the *American Wood Series* (as cited for each taxon).

Durability: Resistance of the wood to attack by decay fungi, insects, and marine borers is described. Precise ratings of decay resistance of heartwood from different species are not possible because of variances within species and the diversity of service conditions to which wood is exposed. However, broad groupings of many native species, based on service records, laboratory tests, and general experience, are helpful in choosing heartwood for use under conditions favorable to decay. Group ratings are exceptionally resistant, very resistant, moderately resistant, and slightly resistant to nonresistant to heartwood decay. The extent of variations in decay resistance of individual trees or wood samples of a species is much greater for most more resistant species than for the slightly resistant or nonresistant species. Where decay hazards exist, heartwood of species in the resistant or very resistant category generally gives satisfactory service, but heartwood of species in the other two categories will usually require some form of preservative treatment. For severe decay hazards, pressure treatments are often required. Even very decay-resistant species may require preservative treatment for important structural uses or other uses where failure, caused by decay, would endanger life or require expensive repairs.

Consideration is also given to vulnerability to attack by powder-post beetles (*Lyctus* spp.), subterranean and dry-wood termites, and other insects. If data were available, resistance to such attack is reported here. Most data were taken from the *Wood Handbook* (56).

Preservation: In general, sapwood is more permeable to preservatives than is heartwood. Treatability of sapwood and heartwood using either open-tank or pressure-vacuum processes is described. Ratings may range from permeable, where 15 to 20 lb/ft^3 (240 to 320 kg/m^3) and more of preservative solutions are absorbed with complete or deep chemical penetration, to extremely resistant, where absorption is only 2 to 3 lb/ft^3 (32 to 48 kg/m^3) or less and lateral penetration is superficial. There is no standard treatability test. Ratings may be based on laboratory trials using a wide range of specimen sizes, with or without end coatings, or actual commercial treating plant experience. Most data were taken from the *Wood Handbook* (56).

Uses: Suitability of a wood for particular applications may be based on personal preference, indigenous uses, or experience. Nevertheless, the lists of uses indicate the properties and working characteristics of the wood and may suggest applications still not realized. Trees formerly classified as uneconomic or weed species are now frequently in high demand. Therefore, use categories should not be considered restrictive. If a tree is noted for the yield of products other than wood (e.g., gums, latex, fiber, tannins, nuts, and fruits), this is also indicated. Most information was taken from the *American Wood Series* (as cited for each taxon).

Toxicity: As a material, wood is not considered toxic or carcinogenic by the U.S. Environmental Protection Agency, but sawdust is considered toxic. Almost all woods, including U.S. native white pine and paper birch, have constituents that are allergenic or toxic to someone. However, most people are unaffected by most woods. Dust generated in woodworking may irritate skin and mucous membranes and even cause nosebleeds and respiratory disorders. When information was available, woods that are particularly toxic are noted. This does not mean that the wood or wood byproducts are not toxic. If working with the wood has been reputed to cause skin or mucous membrane irritations, this is noted. Data were taken from *Woods Injurious to Human Health* (71), *Botanical Dermatology* (158), and *Toxic Woods* (214).

Additional Reading: Literature references are cited by number and a complete listing is given in the References section. The references can be used to trace the source of the reported measurements to determine the representation of these data. For instance, for some species, data from only one tree may have been available; for others, wood from many trees may have been tested. References for additional information are cited at the end of each wood description.

Pinus contorta Dougl. Ex. Loud.
Pinaceae
Lodgepole Pine

The word *pinus* is the classical Latin name. The word *contorta* means contorted or twisted, alluding to the irregular crown of the typical, scrubby shore pine of the coast. Poles of this tree were used by Native Americans for litters, drag sleds, teepees, and lodges.

Other Common Names: Beach pine, bird's-eye pine, black pine, Bolander's pine, coast pine, contorta pijn, contorta pijn, contorta pine, contorta tall, contorta-tall, cypress, drehkiefer, Henderson pine, jack pine, knotty pine, lodgepole kiefer, lodgepole pijn, lodgepole pine, Mexican contorta pine, Murray kiefer, Murray pine, north-coast scrub pine, pin de murray, pin lodgepole, pino contorcido, pino contorta, prickly pine, Rocky Mountain lodgepole pine, sand pine, scrub pine, shore pine, Sierra lodgepole pine, spruce pine, tamarack, tamarack pine, twisted pine, twisted-branch pine, western jack-pine, western scrub pine, white pine.

Distribution: Lodgepole pine is native to the Pacific Coast and Rocky Mountain regions, from the northern end of southeastern Alaska, central Yukon and southwestern Mackenzie District, south into Alberta, British Columbia, and from Washington to central Montana, south along the Pacific Coast to northern California, in the Sierra Nevada and the high mountains of southern California, and in the Rocky Mountains (primarily in northeastern Utah and southern Colorado). It is also found locally in the Black Hills of South Dakota, southwestern Saskatchewan, and the mountains of northern Mexico.

The Tree: Lodgepole pine trees vary in growth rate, depending upon location. Trees from the Rocky mountains reach heights of 80 ft (24.38 m), with diameters of 1 ft (0.30 m). Trees from the mountains of Oregon reach heights of 75 ft (22.86 m), with diameters of 1 ft (0.30 m). Trees from the Sierra Nevada reach heights of 100 ft (30.48 m), with diameters of 17 in. (43.18 cm). Trees from the coastal areas reach heights of 40 ft (12.19 m), with diameters of 20 in. (50.80 cm). Dwarf trees reach heights of 20 to 40 ft (6.10 to 12.19 m).

General Wood Characteristics: The sapwood of lodgepole pine is nearly white to a pale yellow, and the heartwood is light yellow to a yellowish brown. The sapwood and heartwood are not easily separated from each other. The wood has a resinous odor, is straight grained, has a medium to fine texture, and has pronounced dimples on the split, tangential surface. It is moderately light in weight, moderately soft, moderately weak in bending and endwise compression, and moderately low in shock resistance. It is comparable to ponderosa pine in weight, strength, shrinkage, and hardness.

Weight

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green(41%)[a]	0.38[b]	39[c]	625
12%	0.41[b]	29[c]	465
Ovendry	0.43[c]	NA	NA

[a]Reference (185).
[b]Reference (192).
[c]Reference (56).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.08×10^6 in/lb^2	7.45 GPa	1.34×10^6 in/lb^2	9.24 GPa
MOR	5.50×10^3 in/lb^2	37.9 MPa	9.40×10^3 in/lb^2	64.8 MPa
$C_{\parallel}$	2.61×10^3 in/lb^2	18.0 MPa	5.37×10^3 in/lb^2	37.0 MPa
$C_{\perp}$	0.25×10^3 in/lb^2	1.72 MPa	0.61×10^3 in/lb^2	4.21 MPa
WML	5.6 in-in/lb^3	38.6 kJ/m^3	6.8 in-in/lb^3	46.9 kJ/m^3
Hardness	330 lbf	1470 N	480 lbf	2130 N
$Shear_{\parallel}$	0.68×10^3 in/lb^2	4.69 MPa	0.88×10^3 in/lb^2	6.07 MPa

[a]Reference (192) (2-in. (5-cm) standard).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC[a]	6% MC[b]	20% MC[b]
Tangential	6.7	5.4	2.2
Radial	4.3	3.6	1.5
Volumetric	11.1	9.2	3.8

[a]It shrinks appreciably, but seasons easily. May contain warp, possibly as a result of compression wood (178).
[b]Reference (56).
[c]Reference (192).

Kiln drying schedules

Conventional temperature/moisture content-controlled schedules

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Lower grades	T5-C5	NA	NA	NA	NA	NA
Upper grades	T10-C4	NA	T9-C3	NA	NA	L

[a]References (28, 185).

Conventional temperature/time-controlled schedules[a]

	Lower grades			Upper grades			
Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	4/4, 5/4 stock	6/4 stock	8/4 stock	12/4, 16/4 stock
Standard	291	291	291	291	294	294	289

[a]References (28, 185).

High temperature[a]

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	Studs 412/407

[a]References (28, 185).

Working Properties: Lodgepole pine is easy to work with tools, easy to glue, average in paint-holding ability, and holds nails or screws moderately well.

Durability: It is not durable under conditions that favor decay and should be treated with a preservative (56).

Preservation: The heartwood is difficult to treat with preservatives, but the sapwood is permeable (56).

Uses: Historic—railroad ties, mine timbers, lumber, house logs, and rough construction. Current—8-ft (2.4-m) studs, knotty pine paneling, shelving, cabinetry, millworks, interior finish, fence posts, framing, siding, finish, flooring, corral rails, transmission or telephone poles, house logs, veneer, plywood, pulpwood, and firewood.

Toxicity: In general, working with lodgepole pine wood can cause dermatitis, allergic bronchial asthma, or rhinitis in some individuals (71, 158, 214).

Additional Reading: 46, 53, 74, 119, 142, 143, 144, 172, 206, 211.

Pseudotsuga menziesii (Mirb.) Franco
Pinaceae
Douglas-Fir

There are two recognized varieties of Douglas-fir: coast Douglas-fir [*P. menziesii* (Mirb.) Franco var. *menziesii*] and Rocky Mountain Douglas-fir [*P. menziesii* var *glauca* (Biessn.) Franco]. Douglas-fir is named for Henry Douglas (1798-1834), a Scottish botanist who traveled in North America. The word *Pseudotsuga* means "false hemlock," and *menziesii* is used in recognition of Archibald Menzies (1754–1842), a Scottish physician and naturalist, who discovered Douglas-fir in 1793 on Vancouver Island, British Columbia.

Other Common Names: abete di Douglas, abete odoroso d'America, abeto, acahuite, achahuite, alpine hemlock, bigcone-spruce, black fir, blaue Douglas-tanne, blauwe Douglas, blauwe Douglas spar, blue Douglas-fir, British Columbia Douglas-fir, British Columbia pine, British Columbian pine, cahuite, Canadian Douglas-fir, coast Douglas-fir, Colorado Douglas-fir, Colorado pino real, Colorado real pino, Columbian pine, common Douglas, common Douglas-fir, cork-barked Douglas spruce, desert fir, Douglaasfenyo, Douglas, Douglas azul, Douglas bleu, Douglas des montagnes, Douglas du Colorado, Douglas glauca, Douglas pine, Douglas-spruce, Douglas vert, Douglasfichte, Douglas-fir, Douglas-gran, Douglasia, Douglasia azzurra, Douglasia glauca, Douglasie, Douglaska, Douglaskuusi, Douglasspar, Douglastanne, Duglas, Duglazija, false hemlock, golden rod fir, gray Douglas, green Douglas, groene Douglas, grune Douglas-tanne, guallame, guayame, guayame Colorado, hallarin, hayarin, hayarin Colorado, hemlock, inland Douglas-fir, interior Douglas-fir, Montana fir, Oregon, Oregon Douglas, Oregon Douglas-fir, Oregon fir, Oregon-pine, Oregon spruce, Pacific Coast Douglas-fir, Patton's hemlock, pin de Douglas, pin de i'Oregon, pin d'Oregon, pinabete, pinho de Douglas, pino de corcho, pino de Douglas, pino de Oregon, pino Oregon, pino real, Puget Sound pine, red fir, red pine, red spruce, Rocky Mountain Douglas-fir, Santiam quality fir, sapin de Douglas, spruce, yellow Douglas-fir, yellow fir, yellow national fir.

Distribution: The range of Douglas-fir extends from the Rocky Mountains to the Pacific Coast and from Mexico to central British Columbia. The Douglas-fir production comes from the Coast States of Oregon, Washington, and California, and the Rocky Mountain States.

The Tree: Douglas-fir reaches heights of 250 ft (76.20 m), with a diameter of 6 ft (1.83 m), in coastal stands that are between 200 and 800 years old. The largest intact specimen was recorded at 330 ft (100.58 m) near Littlerock, Washington.

General Wood Characteristics: The wood of Douglas-fir varies widely in weight and strength. The sapwood of Douglas-fir is narrow in old-growth trees but can be as much as 3 in. (7.62 cm) wide in second-growth trees of commercial size. Young trees of moderate to rapid growth have reddish heartwood and are called red-fir. Very narrow-ringed wood of old trees may be yellowish brown and is known on the market as yellow-fir.

Weight[a]

			Weight	
Location	MC[b]	SpGr[c]	lb/ft^3	kg/m^3
Coast	Green(37%)[d]	0.45	38	610
	12%	0.48	34	540
	Ovendry	0.51	NA	NA
Interior West	Green(34%)[d]	0.46	38	610
	12%	0.50	31	500
	Ovendry	0.52	NA	NA
Interior North	Green(30%)[d]	0.45	35	560
	12%	0.48	30	480
	Ovendry	0.50	NA	NA

Weight—con.

Interior South	Green(30%)[d]	0.43	NA	NA
	12%	0.46	32	NA
	Ovendry	NA	NA	NA

[a]Reference (56). Coast is defined as Oregon and Washington west of the summit of the Cascade Mountains. Interior West includes California and counties in Oregon and Washington east but adjacent to the Cascade summit. Interior North includes the remaining counties of Oregon and Washington as well as the states of Idaho, Montana, and Wyoming. Interior South includes Utah, Colorado, Arizona, and New Mexico.
[b]Moisture content.
[c]Specific gravity.
[d]Reference (185).

Mechanical propertiesa

Property	Green		Dry	
Coast				
MOE	1.56×10^6 in/lb^2	10.8 GPa	1.95×10^6 in/lb^2	13.4 GPa
MOR	7.70×10^3 in/lb^2	53.1 MPa	12.4×10^3 in/lb^2	85.5 MPa
$C_{\parallel}$	3.78×10^3 in/lb^2	26.1 MPa	7.23×10^3 in/lb^2	49.8 MPa
$C_{\perp}$	0.38×10^3 in/lb^2	2.62 MPa	0.80×10^3 in/lb^2	5.52 MPa
WML	7.6 in-in/lb^3	52.4 kJ/m^3	9.9 in-in/lb^3	68.3 kJ/m^3
Hardness	500 lbf	2220 N	710 lbf	3160 N
$Shear_{\parallel}$	0.90×10^3 in/lb^2	6.20 MPa	1.13×10^3 in/lb^2	7.79 MPa
Interior West				
MOE	1.51×10^6 in/lb^2	10.4 GPa	1.83×10^6 in/lb^2	12.6 GPa
MOR	7.70×10^3 in/lb^2	53.1 MPa	12.6×10^3 in/lb^2	86.9 MPa
$C_{\parallel}$	3.87×10^3 in/lb^2	26.7 MPa	7.43×10^3 in/lb^2	51.2 MPa
$C_{\perp}$	0.42×10^3 in/lb^2	2.90 MPa	0.76×10^3 in/lb^2	5.24 MPa
WML	7.2 in-in/lb^3	49.6 kJ/m^3	10.6 in-in/lb^3	73.1 kJ/m^3
Hardness	510 lbf	2270 N	660 lbf	2940 N
$Shear_{\parallel}$	0.94×10^3 in/lb^2	6.48 MPa	1.29×10^3 in/lb^2	8.89 MPa
Interior North				
MOE	1.41×10^6 in/lb^2	9.72 GPa	1.79×10^6 in/lb^2	12.3 GPa
MOR	7.40×10^3 in/lb^2	51.0 MPa	13.1×10^3 in/lb^2	90.3 MPa
$C_{\parallel}$	3.47×10^3 in/lb^2	23.9 MPa	6.90×10^3 in/lb^2	47.6 MPa
$C_{\perp}$	0.36×10^3 in/lb^2	2.48 MPa	0.77×10^3 in/lb^2	5.31 MPa
WML	8.1 in-in/lb^3	55.8 kJ/m^3	10.5 in-in/lb^3	72.4 kJ/m^3
Hardness	420 lbf	1870 N	600 lbf	2670 N
$Shear_{\parallel}$	0.95×10^3 in/lb^2	6.55 MPa	1.40×10^3 in/lb^2	9.65 MPa
Interior South				
MOE	1.16×10^6 in/lb^2	8.00 GPa	1.49×10^6 in/lb^2	10.3 GPa
MOR	6.80×10^3 in/lb^2	46.9 MPa	11.9×10^3 in/lb^2	82.0 MPa
$C_{\parallel}$	3.11×10^3 in/lb^2	21.4 MPa	6.23×10^3 in/lb^2	43.0 MPa
$C_{\perp}$	0.34×10^3 in/lb^2	2.34 MPa	0.74×10^3 in/lb^2	5.10 MPa
WML	8.0 in-in/lb^3	55.2kJ/m^3	9.0 in-in/lb^3	62.0 kJ/m^3
Hardness	360 lbf	1600 N	510 lbf	2270 N
$Shear_{\parallel}$	0.95×10^3 in/lb^2	6.55 MPa	1.51×10^3 in/lb^2	10.4 MPa

[a] Reference (56) (2-in. (5-cm) standard).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC[b]	0% MC[c]	0% MC[d]
Tangential	7.6	6.9	7.5
Radial	4.8	3.8	4.8
Volumetric	12.4	10.7	11.8

[a]Reference (56). Coastal timbers can contain red-brown chemical stains, gray sapwood stains, ring failure or honeycomb, possibly as a result of wood extractives, slow drying or wetwood (wetwood occurs infrequenty)(185).
[b]Coast.
[c]Interior North.
[d]Interior West.

Kiln drying schedule

Conventional temperature/moisture content-controlled schedules[a]

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Lower grades						
Coastal	T7-A4	NA	T7-A4[b]	NA	NA	NA
Inland	T9-A4[c]	NA	T9-A4[c]	NA	NA	NA
Upper grades						
Coastal	T11-A4	NA	T10-A3	T5-A1	T5-A1	NA
Inland	NA	NA	NA	NA	NA	NA

[a]References (28, 185).
[b]Maximum wet-bulb depression 25°F(-4°C). Reference (185).
[c]Maximum wet-bulb depression 20°F(-7°C). Reference (185).

Conventional temperature/time-controlled schedules[a]

Condition	Lower grades			Upper grades			
	4/4, 5/4 stock	6/4 stock	8/4 stock	4/4, 5/4 stock	6/4 stock	8/4 stock	12/4, 16/4 stock
Standard	291[b]	291[c]	291[c]	294[d]	294[d]	294[d]	288

[a]Reference (28).
[b]Omit step 1 and reduce step 3 to 12 h. Reference (28).
[c]Reduce step 3 to 12 h. Rreference (28).
[d]Omit step 1 for vertical grain. Reference (28).

High temperature[a]

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400[b,c,d,e]	400[b,e]	400[b,e]/414[e]	NA

[a]Reference (28).
[b]Schedule for western species is for 6 in. (15 cm) and narrower in width, for use with common and dimension grade, except as noted for upper grades. Reference (28).
[c]Reduce step 1 and 2 to 6 h for 4/4–5/4 for western species. Reference (28).
[d]In upper grades, use only vertical grain stock. Reference (28).
[e]Can be dried with western larch. Reference (28).

Working Properties: Douglas-fir wood is strong, moderately hard, and very stiff. It is rather difficult to work with using hand tools, splits easily, but has good machining properties.

Durability: The heartwood is moderately resistant to decay (56).

Preservation: Douglas fir is difficult to impregnate with preservatives and often must be incised to allow penetration (29)

Uses: Douglas-fir is used mostly for building and construction purposes in the form of lumber, timbers, piles, and plywood. Considerable quantities go into cooperage stock, mine timbers, poles, and fencing. Douglas-fir lumber is used in the manufacture of various products, including sash, doors, laminated beams, general millwork, boxes, pallets, and crates. Small amounts are used for flooring, furniture, ship and boat construction, and tanks. Douglas-fir plywood has found ever-increasing usefulness in construction, furniture, cabinets, and many other products.

Toxicity: Can cause dermatitis, septic splinter wounds, or contact eczema. (71, 158, 214)

Additional Reading: 29.

Sequoia sempervirens (D. Don) Endl.
Taxodiaceae
Redwood

The word sequoia was selected to honor Sequoyah (also spelled Sequoia), or George Guess (1770?–1843), Native American inventor of the Cherokee alphabet. The name was unexplained by its author, an Austrian linguist and botanist. The name *sempervirens* means evergreen. The wood is anatomically distinct from other softwoods.

Other Common Names: Amerikansk sekvoja, California cedar, California redwood, Californische redwood, coast redwood, corla, giant-of-the-forest, Humboldt redwood, ledwood, Mexican cherry, palo colorado, pin rouge d'ambrique, pin rouge d'Amerique, pino rosso d'America, sequoia de California, sequoia roja, sequoia rossa, sequoia toujours vert, sequoie, vavona, vavona burr.

Distribution: Redwood is native to the Pacific Coast region, from extreme southwestern Oregon (Curry County) south to central California (Monterey County).

The Tree: Redwood trees reach heights of 200 to 300 ft (60.96 to 91.44 m), with diameters of 6 to 12 ft (1.83 to 3.66 m). The record tree height is 376 ft (114.60 m), with a diameter of 20 ft (6.10 m) and an age of 2,200 years, which represents the world's tallest tree.

General Wood Characteristics: The sapwood of redwood is narrow and white, and the heartwood varies from a light cherry to a dark mahogany. The heartwood has no characteristic odor or taste. The wood has exceptionally straight grain, coarse texture, high dimensional stability, and is resistant to warping. The wood is moderately strong in bending, strong in endwise compression, stiff, and moderately low in shock resistance. Typical old-growth redwood is moderately light in weight, moderately strong and stiff, and moderately hard.

Weight

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Old Growth			
Green(86%)[a]	0.38[b]	50[c]	801
12%	0.40[b]	28[c]	448
Ovendry	0.42[c]	NA	NA
Second Growth			
Green(127%)[a]	0.34[b]	42[d]	673
12%	0.35[b]	24[d]	384
Ovendry	0.36[d]	NA	NA

[a]Heartwood for old growth; mixed heartwood and sapwood for second growth. Reference (185).
[b]Reference (56).
[c]Reference (192).
[d]Reference (153).

Mechanical properties[a]

Property	Green		Dry	
Old Growth				
MOE	1.18×10^6 in/lb^2	8.14 GPa	1.34×10^6 in/lb^2	9.24 GPa
MOR	7.50×10^3 in/lb^2	51.7 MPa	10.0×10^3 in/lb^2	69.0 MPa
$C_{\parallel}$	4.20×10^3 in/lb^2	29.0 MPa	6.15×10^3 in/lb^2	42.4 MPa
$C_{\perp}$	0.42×10^3 in/lb^2	2.90 MPa	0.70×10^3 in/lb^2	4.83 MPa
WML	7.4 in-in/lb^3	51.0 kJ/m^3	6.9 in-in/lb^3	47.6 kJ/m^3
Hardness	410 lbf	1820 N	480 lbf	2130 N
$Shear_{\parallel}$	0.80×10^3 in/lb^2	5.52 MPa	0.94×10^3 in/lb^2	6.48 MPa
Second Growth				
MOE	0.96×10^6 in/lb^2	6.62 GPa	1.10×10^6 in/lb^2	7.58 GPa
MOR	5.90×10^3 in/lb^2	40.7 MPa	7.90×10^3 in/lb^2	54.5 MPa
$C_{\parallel}$	3.11×10^3 in/lb^2	21.4 MPa	5.22×10^3 in/lb^2	36.0 MPa
$C_{\perp}$	0.27×10^3 in/lb^2	1.86 MPa	0.52×10^3 in/lb^2	3.58 MPa
WML	5.7 in-in/lb^3	39.3 kJ/m^3	5.2 in-in/lb^3	35.8 kJ/m^3
Hardness	350 lbf	1560 N	420 lbf	1870 N
$Shear_{\parallel}$	0.89×10^3 in/lb^2	6.14 MPa	1.11×10^3 in/lb^2	7.65 MPa

[a]Reference (56) (2-in. (5-cm) standard).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC[b]	6% MC[c]	20% MC[c]
Old Growth			
Tangential	4.4	3.5	1.5
Radial	2.6	2.1	0.9
Volumetric	6.8	5.4	2.3
Second Growth			
Tangential	4.9	NA	NA
Radial	2.2	NA	NA
Volumetric	7.0	NA	NA

[a]Heavy stock may contain uneven moisture content, collapse, honeycomb, chemical or iron stains, possibly as a result of wetwood (usually in old growth)(185).
[b]Reference (56).
[c]Reference (192).

Kiln drying schedules

Conventional temperature/moisture content-controlled schedules[a]

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Light	T5-D6	NA	T5-D4	T5-C4	T5-C3	K
Heavy	T4-F5	T3-F5	T3-F4	NA	NA	NA

[a]References (28, 185).

Kiln drying schedules—con.

Conventional temperature/time-controlled schedules[a]

	Lower grades			Upper grades			
Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	4/4, 5/4 stock	6/4 stock	8/4 stock	12/4, 16/4 stock
Light	289	288	b	289	288	b	NA
Medium and Heavy	c	c	c	c	c	c	NA

[a]References (28, 185).
[b]Air dry to 20% MC, then dry using table 286 in (185).
[c]Air dry to 20% MC, then dry using table 289 in (185). Prone to collapse (185).

Working Properties: Redwood works easily with both hand and machine tools, with little dulling effect on tools. It planes well, provided the cutters are sharp, and it splinters easily when working on the end grain. It holds nails well and paints and finishes satisfactorily. It also stains well, but glues best with alkaline adhesives.

Durability: In general, the heartwood of redwood is resistant to very resistant to decay (56). The heartwood from old-growth trees has high decay resistance, but heartwood from second-growth trees generally ranges from resistant to moderately decay resistant.

Preservation: Redwood is moderately resistant to preservative treatments.

Uses: Most redwood lumber is used for building (high value building construction, heavy beams, planks). It is remanufactured extensively into siding, sash, doors, blinds, finish, casket stock, and containers. Because of its durability, it is useful for cooling towers, tanks, silos, shakes, shingles, wood-stave pipe, and outdoor furniture. It is used in agriculture for buildings and equipment. Its use for timbers and large dimension in bridges and trestles is relatively minor. The wood splits readily, and the manufacture of split products, such as posts, garden stakes and fence material, is an important business in the redwood area. Some redwood veneer is manufactured for decorative plywood. It is also used for pulping, particleboard, and novelties (from burl wood).

Toxicity: Working with redwood can cause allergic reactions (71, 158, 214).

Additional Reading: 20, 44, 73, 98, 120, 142, 156, 177.