

United States  
Department of  
Agriculture

**Forest Service**

Forest  
Products  
Laboratory

General  
Technical  
Report  
FPL-GTR-102



# 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

## Acknowledgments

Sincere thanks to the staff of the USDA Forest Service, Forest Products Laboratory, for their aid in the preparation of this work. Special thanks to David Green, David Kretschmann, and Kent McDonald of the Engineering Properties of Wood Group; John "Rusty" Dramm of State and Private Forestry; Scott Leavengood and James Reeb of Oregon State University; and Lisa Johnson of the Southern Pine Inspection Bureau who reviewed this manuscript. Also thanks to Susan LeVan, Assistant Director, Forest Products Laboratory, for her support and the Information Services team, Forest Products Laboratory, for final editing and production of this report.

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).

September 1997

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Alden, Harry A. 1997. Softwoods of North America. Gen. Tech. Rep. FPL–GTR–102. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 151 p.

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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 39°F (4°C) and is calculated from the oven-dry 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<sup>3</sup> (320 to 881 kg/m<sup>3</sup>).

**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<sub>||</sub>)). 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 oven-dry 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<sup>3</sup> (240 to 320 kg/m<sup>3</sup>) 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<sup>3</sup> (32 to 48 kg/m<sup>3</sup>) 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.

***Abies* spp. Mill.**  
**Pinaceae**  
**Firs**

The genus *Abies* (True Firs) is composed of about 40 species native to North America [9], Central America [7], Africa [2], Europe [1], and Eurasia [25]. The wood of some species in this genus can be distinguished microscopically. *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The species native to North America are listed in the following. An asterisk means that technical information is available on this species and is included in this text.

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<b>Scientific name</b>	<b>Trade name</b>
<i>Abies amabilis</i> *	Pacific silver fir
<i>Abies balsamea</i> *	Balsam fir
<i>Abies bracteata</i>	Bristlecone fir
<i>Abies concolor</i> *	White fir
<i>Abies fraseri</i>	Fraser fir
<i>Abies grandis</i> *	Grand fir
<i>Abies lasiocarpa</i> *	Subalpine fir
<i>Abies magnifica</i> *	California red fir
<i>Abies procera</i> *	Noble fir

---



***Abies amabilis***  
**Dougl. ex Forbes**  
**Pinaceae**  
**Pacific Silver Fir**

Pacific silver fir (*Abies amabilis*) is a species in the white fir group, which includes California red fir (*Abies magnifica*), white fir (*Abies concolor*), grand fir (*Abies grandis*), subalpine fir (*Abies lasiocarpa*), and noble fir (*Abies procera*). *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *amabilis* means lovely.

**Other Common Names:** abete amabilis, abeto amabilis, alpine fir, amabilis den, amabilis fir, Amerikansk silver-gran, Cascades fir, lovely silver fir, lovely fir, lovely red fir, purpur-gran, purpurtanne, red fir, red silver fir, sapin amabilis, sapin gracieux, silver fir, tannub el gamil, western fir, western balsam fir, white fir.

**Distribution:** Pacific silver fir is native to the Pacific Coast region from Alaska south to western Oregon and locally in northwestern California (Siskiyou County). It grows from about sea level, in the western limits of its range, to 6,000 ft (1828.8 m) in the Cascades.

**The Tree:** Pacific silver fir commonly grows to heights of 200 ft (60.96 m), with a diameter of 2 ft (0.61 m). The record height is 245 ft (74.68 m), with a diameter of 8 ft (2.44 m). The maximum age reported is 590 years.

**General Wood Characteristics:** The wood of Pacific silver fir ranges from nearly white to reddish brown. The sapwood is indistinguishable from the heartwood. It has a medium to coarse texture and is generally straight grained. It is easy to work and dimensionally stable when dried. It is moderate to moderately low in strength, stiffness, shock resistance, and nail withdrawal resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (55%) <sup>a</sup>	0.40 <sup>b</sup>	36 <sup>b</sup>	577
12%	0.43 <sup>b</sup>	27 <sup>c</sup>	433
Ovendry	0.42 <sup>d</sup>	NA	NA

<sup>a</sup>Reference (184).

<sup>b</sup>Reference (194).

<sup>c</sup>Reference (152).

<sup>d</sup>Reference (191).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.42 \times 10^6$ in/lb <sup>2</sup>	9.79 GPa	$1.76 \times 10^6$ in/lb <sup>2</sup>	12.1 GPa
MOR	$6.40 \times 10^3$ in/lb <sup>2</sup>	44.1 MPa	$11.0 \times 10^3$ in/lb <sup>2</sup>	75.8 MPa
C <sub>  </sub>	$3.14 \times 10^3$ in/lb <sup>2</sup>	21.6 MPa	$6.41 \times 10^3$ in/lb <sup>2</sup>	44.2 MPa
C <sub>⊥</sub>	$0.22 \times 10^3$ in/lb <sup>2</sup>	1.52 MPa	$0.45 \times 10^3$ in/lb <sup>2</sup>	3.10 MPa
WML	6.0 in-in/lb <sup>3</sup>	41.4 kJ/m <sup>3</sup>	9.3 in-in/lb <sup>3</sup>	64.1 kJ/m <sup>3</sup>
Hardness	310 lbf	1380 N	430 lbf	1910 N
Shear <sub>  </sub>	$0.75 \times 10^3$ in/lb <sup>2</sup>	5.17 MPa	$1.22 \times 10^3$ in/lb <sup>2</sup>	8.41 MPa

<sup>a</sup>Reference (194) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	9.2	7.8	3.3
Radial	4.4	3.7	1.5
Volumetric	13.0	11.0	4.6

<sup>a</sup>Reference (194).

<sup>b</sup>Reference (191).

### Kiln drying schedule<sup>a</sup>

Condition	4/4, 5/4 stock <sup>a</sup>	6/4 stock	8/4 stock <sup>a</sup>	10/4 stock	12/4 stock	British schedule 4/4 stock <sup>b</sup>
Standard	T12-B5	NA	T10-B3	NA	NA	L

<sup>a</sup>References (28, 184).

<sup>b</sup>Reference (73).

Pacific silver fir dries easily, but may have problems with wetwood, caused by a bacterial infection. Shrinkage of the wood is rated low to moderately high. It may contain uneven moisture content, shake, or splits, possibly as a result of wetwood (184).

**Working Properties:** Pacific silver fir is easy to work, moderately low in nail withdrawal resistance, good in paint-holding properties, and easily glued.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (194).

**Preservation:** Penetration by preservatives is difficult (56).

**Uses:** Lumber, plywood, pulp for paper, framing, sheathing, subflooring, concrete forms, decking, planking, beams, posts, siding, paneling, millwork, prefabricated buildings and structural members, industrial crating and shook, furniture parts, mobile homes, and fresh fruit and vegetable containers.

**Toxicity:** Working with the wood can cause eczema or dermatitis (71, 158, 214).

**Additional Reading:** 28, 44, 53, 56, 71, 74, 152, 153, 158, 171, 185, 192, 214.

***Abies balsamea*  
(L.) Mill.  
Pinaceae  
Balsam Fir**

*Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *balsamea* is the ancient word for the balsam tree, referring to the resinous pockets or blisters in the bark.

**Other Common Names:** Abete balsamico, abeto balsamico, abeto oloroso, balm-of-gilead, balm-of-gilead fir, balsam, balsam-gran, balsam-tanne, balsem-den, balsemzilver-den, beaumier de Gilead, blister fir, blister pine, blisters cho-koh-tung, bracted balsam fir, Canadian balsam, Canadian fir, eastern fir, fir pine, firs d'America, fir-tree, Gilead fir, sapin, sapin baumier, sapin beaumier, sapin blanc, sapin rouge, silver fir, silver pine, single pine, single spruce, var.

**Distribution:** From Newfoundland and Labrador west to northeast Alberta, south and east to southern Manitoba, Minnesota, northeast Iowa, central Wisconsin, central Michigan, southern Ontario, New York, central Pennsylvania, Connecticut, and Maine.

**The Tree:** Balsam fir normally reaches heights of 60 ft (18.29 m), with diameters of 1.5 ft (0.46 m). Trees growing in optimal conditions can reach heights of 90 ft (27.43 m), with diameters of 2.5 ft (0.76 m). It grows from sea level to about 6,000 ft (1828.8 m).

**General Wood Characteristics:** The wood is white to pale brown. It is without distinctive odor or taste. It is light weight and soft, has good splitting resistance, and is low in shock resistance. Mechanically, it ranks better than white spruce (*Picea glauca*) and is less than or equal to properties of red (*Picea rubens*) and black spruce (*Picea mariana*). It has low nail-holding capacity.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (88%) <sup>a</sup>	0.33 <sup>b</sup>	45 <sup>c</sup>	721
12%	0.35 <sup>b</sup>	25 <sup>c</sup>	401
Ovendry	0.41 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.25 \times 10^6$ in/lb <sup>2</sup>	8.62 GPa	$1.45 \times 10^6$ in/lb <sup>2</sup>	10.0 GPa
MOR	$5.50 \times 10^3$ in/lb <sup>2</sup>	37.9 MPa	$9.20 \times 10^3$ in/lb <sup>2</sup>	63.4 MPa
C <sub>  </sub>	$2.63 \times 10^3$ in/lb <sup>2</sup>	18.1 MPa	$5.28 \times 10^3$ in/lb <sup>2</sup>	36.4 MPa
C <sub>⊥</sub>	$0.19 \times 10^3$ in/lb <sup>2</sup>	1.31 MPa	$0.40 \times 10^3$ in/lb <sup>2</sup>	2.76 MPa
WML	4.7 in-in/lb <sup>3</sup>	32.4 kJ/m <sup>3</sup>	5.1 in-in/lb <sup>3</sup>	35.2 kJ/m <sup>3</sup>
Hardness	290 lbf	1290 N	400 lbf	1780 N
Shear <sub>  </sub>	$0.66 \times 10^3$ in/lb <sup>2</sup>	4.55 MPa	$0.94 \times 10^3$ in/lb <sup>2</sup>	6.48 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	6.9	5.5	2.3
Radial	2.9	2.3	1.0
Volumetric	11.2	9.0	3.7

<sup>a</sup>May contain uneven moisture content, possibly as a result of wetwood (178).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-E5	NA	T10-E4	T8-A4	T8-A4	L

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Balsam fir works easily with both hand tools and machine operations. It finishes well, provided sharp cutting edges are used. It takes nails, paint, varnish, and polish well. It has good splitting resistance.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56). It is susceptible to attack by ambrosia beetles (pinhole borers), longhorn beetles, Buprestid beetles, and *Sirex* wood wasps (74).

**Preservation:** Resistant to preservative treatments (74).

**Uses:** The tree is a favorite Christmas tree, and the wood is used for pulpwood, lumber, light frame construction, paneling, and crates. The oleoresin (balsam) is used in microscopy, medicinal compounds, and spirit varnishes.

**Toxicity:** Working with the wood can cause eczema or dermatitis (71, 158, 214).

**Additional Reading:** 11, 75, 122, 146, 163, 166, 176, 197.

***Abies concolor*  
(Gord. & Glend.)  
Lindl. Ex Hildebr.  
Pinaceae  
White Fir**

White fir (*Abies concolor*) is a species in the white fir group, which includes Pacific silver fir (*Abies amabilis*), California red fir (*Abies magnifica*), grand fir (*Abies grandis*), subalpine fir (*Abies lasiocarpa*), and noble fir (*Abies procera*). *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *concolor* means of uniform color, referring to the needles, which are pale blue green on both surfaces.

**Other Common Names:** Abete concolore, abete di Low, abete glauco, abeto de Low, abeto del Colorado, balsam, balsam fir, balsam-tree, bastard pine, black gum, blue fir, California white fir, Colorado den, Colorado fir, Colorado silver fir, Colorado white balsam, concolor fir, concolor silver fir, eenkleurige Colorado den, gleichfarbige tanne, Kalifornisk silver-gran, Kolorado-gran, lengshan, Low den, low-gran, Lows fir, Low's white fir, oyamel, Pacific white fir, pinabete, pino real blanco, Rocky Mountain white fir, sapin concolore, sapin de Low, sapin du Colorado, silver fir, tannuba abyad, western balsam fir, white balsam.

**Distribution:** White fir is native to the mountains from central Colorado west to south-east Idaho and southwest Oregon, south to southern California and east to southern Arizona and southern New Mexico. It also grows in northwest Mexico.

**The Tree:** White fir trees reach heights of 180 ft (54.86 m), with diameters of 6 ft (1.83 m) on the west coast (California and Oregon); in Arizona and New Mexico, the tree can reach heights of 134 ft (40.84 m), with diameters of 4 ft (1.22 m). A record specimen from the Sierra Nevada measured 192-ft tall (58.52-m), with a diameter of almost 9 ft (2.74 m).

**General Wood Characteristics:** Both sapwood and heartwood are nearly white to a reddish brown. It has a medium to coarse texture and no characteristic odor or taste, although there may be a slight disagreeable odor when green. It normally is straight grained, easy to work, and stays in place when properly dried. It is moderate to moderately low in strength, stiffness, ability to resist shock, and nail withdrawal resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (98%) <sup>a</sup>	0.37 <sup>b</sup>	47 <sup>c</sup>	753
12%	0.39 <sup>b</sup>	26 <sup>c</sup>	417
Ovendry	0.40 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.16 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.00 GPa	1.50 × 10 <sup>6</sup> in/lb <sup>2</sup>	10.3 GPa
MOR	5.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	40.7 MPa	9.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	67.6 MPa
C <sub>  </sub>	2.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	20.0 MPa	5.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	40.0 MPa
C <sub>⊥</sub>	0.28 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.93 MPa	0.53 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.65 MPa
WML	5.6 in-in/lb <sup>3</sup>	38.61 kJ/m <sup>3</sup>	7.2 in-in/lb <sup>3</sup>	49.6 kJ/m <sup>3</sup>
Hardness	340 lbf	1510 N	480 lbf	2130 N
Shear <sub>  </sub>	0.76 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.24 MPa	1.10 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.58 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>b</sup>
Tangential	7.0	5.7	2.4
Radial	3.3	2.6	1.1
Volumetric	9.8	7.8	3.3

<sup>a</sup>May contain uneven moisture content, shake, splits, or chemical brown stain, possibly as a result of wetwood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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	T9-D6	NA	T9-D5	NA	NA	NA
Upper grades	T12-E5	T11-D5	T10-E4	T8-A4	T8-A4	NA

<sup>a</sup>Reference (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	4- by 6-in. decking (405) Studs (406)

<sup>a</sup>References (28, 184).

White fir is easily dried, but is susceptible to wetwood bacterial attack, which requires special handling during drying.

**Working Properties:** White fir is easy to work and stays in place when properly dried. It paints and glues well and is moderate to moderately low in nail-holding ability.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** Considered difficult to penetrate with preservatives (152).

**Uses:** The tree is a favorite Christmas tree. The wood is used for solid construction (framing, sheathing, subflooring, concrete forms, decking, planking, beams, posts, siding, and paneling), plywood, pulp, millwork, prefabricated buildings, structural members, crating, shook, furniture parts, and fruit and vegetable containers.

**Toxicity:** Can cause dermatitis or eczema (71, 158, 214).

**Additional Reading:** 77, 94, 119, 171.

***Abies grandis***  
**(Dougl. Ex D. Don) Lindl.**  
**Pinaceae**  
**Grand Fir**

Grand fir (*Abies grandis*) is a species in the white fir group, which includes white fir (*Abies concolor*), Pacific silver fir (*Abies amabilis*), California red fir (*Abies magnifica*), subalpine fir (*Abies lasiocarpa*), and noble fir (*Abies procera*). *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *grandis* means large.

**Other Common Names:** Abete bianco Americano, abete blanco Americano, abeto blanco Americano, Amerikansk gran, balsam fir, balsam, California great fir, Californische den, giant fir, great silver fir, groise tanne, jedle obrovska, kaempegran, Kalifornische kustentanne, Kalifornische reisentanne, kust-gran, kustgran, lowland fir, lowland white fir, Oregon fir, Oregon white fir, Puget Sound fir, reuzenzilverspar, rough-barked fir, sapin du Vancouver, sapin grandissime, silver fir, tall silver fir, Vancouver den, Vancouver-gran, vancouvergran, western balsam fir, western white fir, white fir, yellow fir.

**Distribution:** Grand fir is native to the Northern Rocky Mountain region from southeast British Columbia south to western Montana and central Idaho, northeast from southwest British Columbia and western Washington to northwest California.

**The Tree:** Grand fir trees commonly reach heights of 140 ft (42.67 m), with diameters of 4 ft (1.22 m). They can reach heights of 250 ft (76.2 m), with a diameter of 5 ft (1.52 m).

**General Wood Characteristics:** The wood of grand fir ranges from nearly white to reddish brown. The sapwood is indistinguishable from the heartwood. It has a medium to coarse texture and is generally straight grained. It is easy to work and is dimensionally stable when dried. It is moderate to moderately low in strength, stiffness, shock resistance, and nail withdrawal resistance. It dries easily, but may have problems with wetwood, caused by a bacterial infection.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (91%) <sup>a</sup>	0.35 <sup>b</sup>	45 <sup>c</sup>	721
12%	0.37 <sup>b</sup>	28 <sup>c</sup>	449
Ovendry	0.42 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.25 \times 10^6$ in/lb <sup>2</sup>	8.62 GPa	$1.57 \times 10^6$ in/lb <sup>2</sup>	10.8 GPa
MOR	$5.80 \times 10^3$ in/lb <sup>2</sup>	40.0 MPa	$8.90 \times 10^3$ in/lb <sup>2</sup>	61.4 MPa
C <sub>  </sub>	$2.94 \times 10^3$ in/lb <sup>2</sup>	20.3 MPa	$5.29 \times 10^3$ in/lb <sup>2</sup>	36.5 MPa
C <sub>⊥</sub>	$0.27 \times 10^3$ in/lb <sup>2</sup>	1.86 MPa	$0.50 \times 10^3$ in/lb <sup>2</sup>	3.45 MPa
WML	5.6 in-in/lb <sup>3</sup>	38.61 kJ/m <sup>3</sup>	7.5 in-in/lb <sup>3</sup>	51.7 kJ/m <sup>3</sup>
Hardness	360 lbf	1600 N	490 lbf	2180 N
Shear <sub>  </sub>	$0.74 \times 10^3$ in/lb <sup>2</sup>	5.10 MPa	$0.90 \times 10^3$ in/lb <sup>2</sup>	6.20 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.5	6.0	2.5
Radial	3.4	2.7	1.1
Volumetric	11.0	8.8	3.7

<sup>a</sup>May contain uneven moisture content, shake or splits possibly as a result of wetwood (178).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules

Condition	4/4, 5/4 stock <sup>a</sup>	6/4 stock <sup>a</sup>	8/4 stock <sup>a</sup>	10/4 stock <sup>a</sup>	12/4 stock <sup>a</sup>	British schedule 4/4 stock <sup>b</sup>
Standard	T12-E5	NA	T10-E4	T8-A4	T8-A3	L

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (74).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Grand fir is easy to work, is moderately low in nail withdrawal resistance, good in paint-holding properties, and easily glued.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** Penetration by preservatives is difficult (56).

**Uses:** Lumber, plywood, pulp for paper, framing, sheathing, subflooring, concrete forms, decking, planking, beams, posts, siding, paneling, millwork, prefabricated buildings and structural members, industrial crating and shook, furniture parts, mobile homes, and fresh fruit and vegetable containers.

**Toxicity:** Can cause dermatitis or eczema (71, 158, 214)

**Additional Reading:** 54, 75, 122, 144, 163.



***Abies lasiocarpa*  
(Hook.) Nutt.  
Pinaceae  
Subalpine Fir**

Subalpine fir (*Abies lasiocarpa*) is a species in the white fir group, which includes grand fir (*Abies grandis*), white fir (*Abies concolor*), Pacific silver fir (*Abies amabilis*), California red fir (*Abies magnifica*), and noble fir (*Abies procera*). There are two recognized varieties of this species: the typical Subalpine Fir [*Abies lasiocarpa* (Hook.) Nutt. var. *lasiocarpa*] and Corkbark Fir [*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm.]. *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *lasiocarpa* means with woolly or hairy fruits.

**Other Common Names:** Abete bianco Americano, abete sughero, abeto blanco Americano, abeto corcho, alamo de la sierra, alpen-den, alpine fir, Amerikansk vit-gran, Arizona cork fir, Arizona corkbark fir, Arizona fir, balsam, balsam fir, berg-gran, black balsam, caribou fir, cork fir, corkbark, corkbark fir, downey-cone fir, downy-cone subalpine fir, kork-gran, kurkschors-den, mountain balsam, mountain fir, Oregon balsam fir, Oregon balsam-tree, pino real blanco, pino real blanco de las sierras, pumpkin-tree, Rocky Mountain fir, Rocky Mountains fir, sapin blanc d’Amerique, sapin concolore, sapin d’Arizona, sapin liege, subalfir, western balsam, western balsam fir, white balsam, white fir.

**Distribution:** Subalpine fir grows naturally in mountains from central Yukon and the eastern parts of southeast Alaska south through Alberta and British Columbia, from Washington, Oregon, Idaho, and western Montana south to central Colorado southern New Mexico and southeast Arizona. It also grows locally in northeast Nevada and northwest California. It grows from near sea level in the northern limits of its range to 12,000 ft (3657.6) in the south.

**The Tree:** Subalpine fir attains heights of 130 ft (39.62 m), with diameters of 3 ft (0.91 m).

**General Wood Characteristics:** The wood ranges from tan to brown with shades of red or pink. The sapwood is not clearly differentiated from the heartwood. It has a medium luster and no distinctive odor or taste. It varies from very light, soft, and weak to moderately heavy, hard, and strong.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (47%) <sup>a</sup>	0.31 <sup>b</sup>	28 <sup>c</sup>	449
12%	0.32 <sup>b</sup>	33 <sup>c</sup>	529
Ovendry	0.32 <sup>c</sup>	NA	NA

<sup>a</sup>Mixed heartwood and sapwood. Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties**

Property	Green		Dry	
MOE <sup>a</sup>	1.05 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.24 GPa	1.29 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.89 GPa
MOR <sup>a</sup>	4.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	33.8 MPa	8.60 × 10 <sup>3</sup> in/lb <sup>2</sup>	59.3 MPa
C <sub>11</sub> <sup>a</sup>	2.30 × 10 <sup>3</sup> in/lb <sup>2</sup>	15.9 MPa	4.86 × 10 <sup>3</sup> in/lb <sup>2</sup>	33.5 MPa
C <sub>⊥</sub> <sup>a</sup>	0.19 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.31 MPa	0.39 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.69 MPa
WML <sup>b</sup>	4.4 in-in/lb <sup>3</sup>	30.34 kJ/m <sup>3</sup>	2.9 in-in/lb <sup>3</sup>	20.0 kJ/m <sup>3</sup>
Hardness <sup>a</sup>	260 lbf	1160 N	350 lbf	1560 N
Shear <sub>11</sub> <sup>a</sup>	0.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.83 MPa	1.07 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.38 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

<sup>b</sup>Reference (192) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.4	NA	NA
Radial	2.6	NA	NA
Volumetric	9.4	NA	NA

<sup>a</sup>Reference (56). May contain uneven moisture content, shake or splits, possibly as a result of wetwood or compression wood (185).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-B5	NA	T12-B4	NA	NA	NA

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400/416	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Subalpine fir is reported to work well.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** No information available at this time.

**Uses:** Building construction, boxes, crates, planing mill products, sashes, doors, frames, food containers, and pulpwood.

**Toxicity:** Can cause dermatitis or eczema (71, 158, 214).

**Additional Reading:** 3, 75, 122, 144, 163.

***Abies magnifica***  
**A. Murr.**  
**Pinaceae**  
**California Red Fir**

California red fir is a species in the white fir group, which includes Pacific silver fir (*Abies amabilis*), white fir (*Abies concolor*), grand fir (*Abies grandis*), subalpine fir (*Abies lasiocarpa*), and noble fir (*Abies procera*). Shasta red fir (*Abies magnifica* var. *shastensis* Lemm.) is a recognized variety of California red fir. *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *magnifica* means magnificent, referring to the large size of the cones.

**Other Common Names:** Abete di California, abete Shasta, abeto de California, abeto Shasta, California red-bark fir, Californische rode den, giant red fir, golden fir, great red fir, Kalifornisk prakt-gran, magnificent fir, Murray fir, red bark fir, red fir, red-bark fir, sapin magnifique, sapin rouge Californien, sapin Shasta, Shasta red fir, Shasta den, Shasta fir, Shasta-gran, silvertip, western balsam fir, white fir.

**Distribution:** California red fir is native to southwest Oregon (Cascade Mountains) south to the northern Coast Ranges of California and through the Sierra Nevada to central California and extreme western Nevada.

**The Tree:** California red fir trees reach heights of 150 ft (45.72 m), with diameters of 5 ft (1.52 m). The record tree height is 180 ft (54.86 m), with a diameter of 8.5 ft (2.59 m). California red fir grows in its range at elevations of 6,000 to 9,000 ft (1,828.8 to 2,743.2 m).

**General Wood Characteristics:** The wood of California red fir ranges from nearly white to reddish brown. The sapwood is indistinguishable from the heartwood. It has a medium to coarse texture and is generally straight grained. It is easy to work and is dimensionally stable when dried. It is moderate to moderately low in strength, stiffness, shock resistance, and nail withdrawal resistance. It dries easily, but may have problems with wetwood, caused by a bacterial infection. It has good paint-holding ability and is easily glued.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (198%) <sup>b</sup>	0.36	48	769
12%	0.38	27	433
Ovendry	0.42	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Mixed heartwood and sapwood. Reference (185).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.17 \times 10^6$ in/lb <sup>2</sup>	8.07 GPa	$1.50 \times 10^6$ in/lb <sup>2</sup>	10.3 GPa
MOR	$5.80 \times 10^3$ in/lb <sup>2</sup>	40.0 MPa	$10.5 \times 10^3$ in/lb <sup>2</sup>	72.4 MPa
C <sub>  </sub>	$2.76 \times 10^3$ in/lb <sup>2</sup>	19.0 MPa	$5.46 \times 10^3$ in/lb <sup>2</sup>	37.6 MPa
C <sub>⊥</sub>	$0.33 \times 10^3$ in/lb <sup>2</sup>	2.27 MPa	$0.61 \times 10^3$ in/lb <sup>2</sup>	4.21 MPa
WML	6.4 in-in/lb <sup>3</sup>	44.1 kJ/m <sup>3</sup>	8.9 in-in/lb <sup>3</sup>	61.4 kJ/m <sup>3</sup>
Hardness	360 lbf	1600 N	500 lbf	2220 N
Shear <sub>  </sub>	$0.77 \times 10^3$ in/lb <sup>2</sup>	5.31 MPa	$1.04 \times 10^3$ in/lb <sup>2</sup>	7.17 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.9	5.8	2.4
Radial	4.5	3.2	1.3
Volumetric	11.4	9.8	4.1

<sup>a</sup>May contain uneven moisture content, shake, splits, or warp, possibly as a result of wetwood and/or compression wood (177).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-E5	NA	T10-E4	T8-A3	T8-A3	NA

<sup>a</sup>References (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** California red fir is easy to work, moderately low in nail withdrawal resistance, good in paint-holding properties, and easily glued.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** Penetration by preservatives is difficult (56).

**Uses:** Lumber, plywood, pulp for paper, framing, sheathing, subflooring, concrete forms, decking, planking, beams, posts, siding, paneling, millwork, prefabricated buildings and structural members, industrial crating and shook, furniture parts, mobile homes, and fresh fruit and vegetable containers.

**Toxicity:** Working with California red fir can cause dermatitis or eczema (71, 158, 214).

**Additional Reading:** 75, 93, 122, 144, 163.

***Abies procera* Rehd.**  
**Pinaceae**  
**Noble Fir**

Noble fir (*Abies procera*) is a species in the white fir group, which includes grand fir (*Abies grandis*), white fir (*Abies concolor*), Pacific silver fir (*Abies amabilis*), California red fir (*Abies magnifica*), and subalpine fir (*Abies lasiocarpa*). *Abies* is the classical Latin name of silver fir (*Abies alba* Mill.) of Europe. The word *procera* means tall.

**Other Common Names:** Abeto blanco Americano, Amerikaanse nobel-den, Amerikansk adel-gran, bracted fir, bracted red fir, California red fir, feather-cone fir, feather-coned red fir, kaskadgran, noble red fir, red fir, sapin noble d’Amerique, tuck-tuck, white fir.

**Distribution:** Noble fir is native to the Cascade Mountains and high peaks of the Coast Range (3,000 to 5,000 ft) from western Washington through western Oregon to northwest California.

**The Tree:** Noble fir trees reach heights of 175 ft (53.34 m), with diameters of 5 ft (1.52 m). A record tree height was 278 ft (84.73 m), with a diameter of 9 ft (2.74 m).

**General Wood Characteristics:** The wood of noble fir ranges from nearly white to reddish brown. The sapwood is indistinguishable from the heartwood. It has a medium to coarse texture and is generally straight grained. It is easy to work and is dimensionally stable when dried. It is moderate to moderately low in strength, stiffness, shock resistance, and nail withdrawal resistance. It dries easily but may have problems with wetwood caused by a bacterial infection.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (34%) <sup>a</sup>	0.37 <sup>b</sup>	30 <sup>c</sup>	481
12%	0.39 <sup>b</sup>	26 <sup>c</sup>	417
Ovendry	0.40 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.38 \times 10^6$ in/lb <sup>2</sup>	9.51 GPa	$1.72 \times 10^6$ in/lb <sup>2</sup>	11.9 GPa
MOR	$6.20 \times 10^3$ in/lb <sup>2</sup>	42.7 MPa	$10.7 \times 10^3$ in/lb <sup>2</sup>	73.8 MPa
C <sub>  </sub>	$3.01 \times 10^3$ in/lb <sup>2</sup>	20.7 MPa	$6.10 \times 10^3$ in/lb <sup>2</sup>	42.1 MPa
C <sub>⊥</sub>	$0.27 \times 10^3$ in/lb <sup>2</sup>	1.86 MPa	$0.52 \times 10^3$ in/lb <sup>2</sup>	3.58 MPa
WML	6.0 in-in/lb <sup>3</sup>	41.4 kJ/m <sup>3</sup>	8.8 in-in/lb <sup>3</sup>	60.7 kJ/m <sup>3</sup>
Hardness	290 lbf	1290 N	410 lbf	1820 N
Shear <sub>  </sub>	$0.80 \times 10^3$ in/lb <sup>2</sup>	5.52 MPa	$1.05 \times 10^3$ in/lb <sup>2</sup>	7.24 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	8.3	6.6	2.7
Radial	4.3	3.6	1.5
Volumetric	12.4	11.0	4.6

<sup>a</sup>May warp or split, possibly as a result of wetwood or compression wood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules

Condition	4/4, 5/4 stock <sup>a</sup>	6/4 stock <sup>a</sup>	8/4 stock <sup>a</sup>	10/4 stock <sup>a</sup>	12/4 stock <sup>a</sup>	British schedule 4/4 stock <sup>b</sup>
Standard	T12-A5	T11-A4	T10-A3	T5-A2	T5-A2	L

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (74).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Noble fir is easy to work, moderately low in nail withdrawal resistance, good in paint-holding properties, and easily glued.

**Durability:** Heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** Noble fir is resistant to preservative treatment (74).

**Uses:** Lumber, plywood, pulp for paper, framing, sheathing, subflooring, concrete forms, decking, planking, beams, posts, siding, paneling, millwork, prefabricated buildings and structural members, industrial crating and shook, furniture parts, mobile homes, and fresh fruit and vegetable containers.

**Toxicity:** As in other species of fir, the fresh wood can cause contact dermatitis (71, 158, 214)

**Additional Reading:** 17, 52, 55, 75, 144, 163.

***Chamaecyparis* spp.**  
**Spach**  
**Cupressaceae Cedars**

The genus *Chamaecyparis* is composed of six species native to Japan, Taiwan, and both coasts of North America. The word *chamaecyparis* is derived from the Greek *chamai* (dwarf) and *kuparissos* (cypress). The three North American species are listed below. The wood of each of the three species in this genus is anatomically distinct. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Chamaecyparis lawsoniana</i> *	Port-Orford-cedar
<i>Chamaecyparis nootkatensis</i> *	Alaska-cedar
<i>Chamaecyparis thyoides</i> *	Atlantic white-cedar

***Chamaecyparis lawsoniana***  
**(A. Murr.) Parl.**  
**Cupressaceae**  
**Port-Orford-Cedar**

The word *chamaecyparis* is derived from the Greek *chamai* (dwarf) and *kuparissos* (cypress). The term *lawsoniana* is used in dedication to nursery owners from Edinburgh, Scotland, Peter Lawson and Sons, who introduced this species into cultivation. The seeds were purchased from William Murray, who collected them in California in 1854 and whose brother (A. Murr.) named the species. The other two North American species are Atlantic white-cedar (*Chamaecyparis thyoides*) and Alaska-cedar (*Chamaecyparis nootkatensis*). The wood of each of the three species in this genus is anatomically distinct.

**Other Common Names:** Adel-cypress, Californische cypres, cedar, cedro de Oregon, cedro de Puerto Orford, cedro Port Orford, cipres de Lawson, cipresso di California, cipresso di Lawson, cypres de Lawson, gewone cypres, ginger pine, Lawson chamaecyparis, Lawson cypress, Lawson’s cypres, matchwood, Oregon cedar, Oregon cypress, Oregon zeder, pencil cedar, Port-Orford, Port Orford white-cedar, scheinzypresse, spruce gum, white cedar, white cypress.

**Distribution:** Port-Orford-cedar is native to a narrow zone near the Pacific Coast from southwest Oregon (Lane County and Coos Bay) south to northwest California (Mad River and locally in the Mount Shasta area).

**The Tree:** Port-Orford-cedar trees reach heights of 200 ft (60.96 m), with diameters of 6 ft (1.83 m).

**General Wood Characteristics:** The sapwood of Port-Orford-cedar varies from nearly white to a pale yellowish brown and is 1 to 3 in. (2.54 to 7.62 cm) wide. The heartwood is yellowish white to pale yellowish brown. The wood has a fine, even texture, and the grain is even and straight. It has a characteristic odor (from volatile oils), described as “ginger-like” and a bitter, spicy taste. It is moderately light in weight and is stiff, strong, hard, and somewhat shock resistant. It has little tendency to warp. It works well with tools, has good electrical resistance, and is moderately resistant to acids. It weathers to a light gray, with a silvery sheen, without checks.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (50) <sup>a</sup>	0.39 <sup>b</sup>	36 <sup>c</sup>	577
12%	0.43 <sup>b</sup>	29 <sup>c</sup>	465
Ovendry	0.44 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.30 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.96 GPa	1.70 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.7 GPa
MOR	6.60 × 10 <sup>3</sup> in/lb <sup>2</sup>	45.5 MPa	12.7 × 10 <sup>3</sup> in/lb <sup>2</sup>	87.6 MPa
C <sub>  </sub>	3.14 × 10 <sup>3</sup> in/lb <sup>2</sup>	21.6 MPa	6.25 × 10 <sup>3</sup> in/lb <sup>2</sup>	43.1 MPa
C <sub>⊥</sub>	0.30 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.07 MPa	0.72 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.96 MPa
WML	7.4 in-in/lb <sup>3</sup>	51.0 kJ/m <sup>3</sup>	9.1 in-in/lb <sup>3</sup>	62.7 kJ/m <sup>3</sup>
Hardness	380 lbf	1690 N	720 lbf	3200 N
Shear <sub>  </sub>	0.84 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.79 MPa	1.37 × 10 <sup>3</sup> in/lb <sup>2</sup>	9.44 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).



### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% Mc <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.9	5.5	2.3
Radial	4.6	3.7	1.5
Volumetric	10.1	8.1	3.4

<sup>a</sup>May contain resin exudate, possibly as a result of extractives (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules

Condition	4/4, 5/4 stock <sup>a</sup>	6/4 stock <sup>a</sup>	8/4 stock <sup>a</sup>	10/4 stock <sup>a</sup>	12/4 stock <sup>a</sup>	British schedule 4/4 stock <sup>b</sup>
Standard	T11-B4	NA	T10-B3	NA	NA	J

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (74).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	290	NA	288	290	296	296	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Port-Orford-cedar works well with tools, holds paint, and polishes well.

**Durability:** Heartwood is resistant to very resistant to decay (56).

**Preservation:** The heartwood is moderately resistant to preservative treatment, and the sapwood is permeable (74).

**Uses:** Arrow shafts, storage battery separators, venetian blind slats, sashes, doors, interior finish millwork, mothproof linings for boxes and closets, boats, matches, general construction, water tanks, bridges, dock planking, railroad ties, and mine timbers.

**Toxicity:** Continual inhalation of the volatile oils in this wood can cause kidney problems (diuresis). Can also cause allergic bronchial asthma and/or rhinitis (71, 158, 162, 214).

**Additional Reading:** 19, 69, 160, 162, 188, 209.

***Chamaecyparis  
nootkatensis*  
(D. Don) Spach  
Cupressaceae  
Alaska-Cedar**

The word *chamaecyparis* is derived from the Greek *chamai* (dwarf) and *kuparissos* (cypress). The name *nootkatensis* relates to Nootka Sound, on Vancouver Island, B.C., where it was discovered. The other two North American species are Atlantic white-cedar (*Chamaecyparis thyoides*) and Port-Orford-cedar (*Chamaecyparis lawsoniana*). The wood of each of the three species in this genus is anatomically distinct.

**Other Common Names:** Alaska cypress, Alaska ground cypress, Alaska yellow-cedar, Alaska zeder, Amerikansk cypress, cedro giallo, cipres Americano, cipres Nootka, cipresso Americano, cipresso Americano, cipresso dell’Alasca, cipresso Nootka, cipresso Nootka, cypres de Nootka faux, cypres du Nutka, cypres jaune, faux cypress de Nootka, faux cypress de Nootka, Nootka chamaecyparis, Nootka cypres, Nootka cypress, Nootka false cypress, Nootka Sound cypress, Nootka-false cypress, Nutka cypres, Nutka-cypress, Nutka-zypresse, Pacific Coast yellow cedar, Sitka cypress, Sitka yellow-cedar cypress, sitka-zypresse, yellow-cedar, yellow cypress.

**Distribution:** The coastal forests from southwestern Alaska through British Columbia to northern California.

**The Tree:** Alaska-cedar trees attain heights of 120 ft (36.58 m), with diameters of 6 ft (1.83 m). Trees from Alaska are frequently older than 300 years, Dominant trees can be from 300 to more than 700 years old, with a record of more than 1,040 years.

**General Wood Characteristics:** The sapwood is narrow and sometimes slightly lighter than the bright, clear yellow heartwood. It has a mild, distinctive odor that is best described as “raw potatoes.” The wood is moderately heavy, soft, fine textured, straight grained, easily worked, and durable. It is moderate in strength, stiffness, hardness, and shock resistance. It shrinks little in drying and is stable in use after seasoning.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (32%) <sup>a</sup>	0.42 <sup>b</sup>	36 <sup>c</sup>	577
12%	0.44 <sup>b</sup>	31 <sup>c</sup>	497
Ovendry	0.46 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.14 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.86 GPa	1.42 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.79 GPa
MOR	6.40 × 10 <sup>3</sup> in/lb <sup>2</sup>	44.1 MPa	11.1 × 10 <sup>3</sup> in/lb <sup>2</sup>	76.5 MPa
C <sub>  </sub>	3.05 × 10 <sup>3</sup> in/lb <sup>2</sup>	21.0 MPa	6.31 × 10 <sup>3</sup> in/lb <sup>2</sup>	43.5 MPa
C <sub>⊥</sub>	0.35 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.41 MPa	0.62 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.27 MPa
WML	9.2 in-in/lb <sup>3</sup>	63.4 kJ/m <sup>3</sup>	10.4 in-in/lb <sup>3</sup>	71.7 kJ/m <sup>3</sup>
Hardness	440 lbf	1960 N	580 lbf	2580 N
Shear <sub>  </sub>	0.84 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.79 MPa	1.13 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.79 MPa

<sup>a</sup>Reference (56) (2-in, (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% Mc <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.0	4.8	2.0
Radial	2.8	2.2	0.9
Volumetric	9.2	7.4	3.1

<sup>a</sup>May contain a resin exudate, possibly as a result of extractives (185).

<sup>b</sup>Reference (56).

<sup>c</sup>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
Standard	T12-A3	NA	T11-A2	NA	NA	J

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	287	290	290	287	290	290	NA

<sup>a</sup>References (28, 185).

**Working Properties:** The wood of Alaska-cedar is readily worked by both hand and machine tools. There is a slight dulling effect on cutting edges, but it usually finishes very well. In lumber with a wavy grain, there is a tendency for the grain to pick up in planing and molding. It nails and glues well and holds paint, stains, and varnishes satisfactorily (74).

**Durability:** Alaska-cedar heartwood is resistant to very resistant to decay (56).

**Preservation:** Alaska-cedar is resistant to preservative treatment (74).

**Uses:** Used locally for interior trim, furniture, small boat hulls, and canoe paddles (171). Used commercially for battery separators, bedding for heavy machinery, boat building, bridge and dock decking, cabinetry, carving, cooling towers, framing, furniture, heavy flooring, marine piling, moulding, musical instruments, novelties, paneling, toys, patterns, sash doors, stadium seats, utility poles, water and chemical tanks, and window boxes.

**Toxicity:** No information available at this time for Alaska-cedar.

**Additional Reading:** 13, 51, 64, 65, 67, 122, 150, 154, 210.

***Chamaecyparis  
thyoides***  
**(L.) B.S.P.**  
**Cupressaceae**  
**Atlantic White-Cedar**

The word *chamaecyparis* is derived from the Greek *chamai* (dwarf) and *kuparissos* (cypress). The term *thyoides* means “like *Thuja*,” a related genus containing northern white-cedar. The other two North American species are Port-Orford-cedar (*Chamaecyparis lawsoniana*) and Alaska-cedar (*Chamaecyparis nootkatensis*). The wood of each of the three species in this genus is anatomically distinct.

**Other Common Names:** Amerikansk vit-ceder, cedar, cedre blanc d’Amerique, cedro bianco, cedro bianco Americano, cedro blanco Americano, cipres blanco, cipresso bianco, coast white cedar, juniper, kogelcypres, post cedar, retinospora, southern white-cedar, swamp-cedar, swano white cedar, vit-cypress, white-cedar, white chamaecyparis, white cypress, witte Amerikaanse ceder, zeder-zyprisse.

**Distribution:** Atlantic white-cedar is native to the Coastal Plain of the eastern United States from central Maine south to northern Florida and west to southern Mississippi.

**The Tree:** Trees of Atlantic white-cedar reach heights of 60 ft (18.29 m), with diameters of 1 ft (0.30 m). Under optimal growth conditions, this tree can reach heights of 120 ft (36.58 m), with diameters of 5 ft (1.52 m).

**General Wood Characteristics:** The sapwood of Atlantic white-cedar is narrow and white, and the heartwood is light brown with a reddish or pinkish tinge. The wood has a characteristic aromatic odor when freshly cut and has a faint bitter taste. It is light weight, has a fine texture, and is straight grained. It is moderately soft, low in shock resistance, and weak in bending and endwise compression.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (35%) <sup>a</sup>	0.31 <sup>b</sup>	26 <sup>c</sup>	417
12%	0.32 <sup>b</sup>	33 <sup>c</sup>	529
Ovendry	0.35 <sup>c</sup>	NA	NA

<sup>a</sup>Mixed heartwood and sapwood. Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	0.75 × 10 <sup>6</sup> in/lb <sup>2</sup>	5.17 GPa	0.93 × 10 <sup>6</sup> in/lb <sup>2</sup>	6.41 GPa
MOR	4.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	32.4 MPa	6.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	46.9 MPa
C <sub>  </sub>	2.39 × 10 <sup>3</sup> in/lb <sup>2</sup>	16.5 MPa	4.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	32.4 MPa
C <sub>⊥</sub>	0.24 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.65 MPa	0.41 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.83 MPa
WML	5.9 in-in/lb <sup>3</sup>	40.7 kJ/m <sup>3</sup>	4.1 in-in/lb <sup>3</sup>	28.3 kJ/m <sup>3</sup>
Hardness	290 lbf	1290 N	350 lbf	1560 N
Shear <sub>  </sub>	0.69 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.76 MPa	0.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.52 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% Mc <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	5.4	4.3	1.8
Radial	2.9	2.3	1.0
Volumetric	8.8	7.0	2.9

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-A4	NA	T11-A3	NA	NA	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It works easily with tools, finishes smoothly, holds paint well, and splits easily.

**Durability:** Atlantic white-cedar heartwood is resistant to very resistant to decay (56).

**Preservation:** No information available at this time.

**Uses:** Cooperage, wooden household furniture, boat building, fencing, and industrial millwork.

**Toxicity:** No information available at this time for Atlantic white-cedar.

**Additional Reading:** 67, 75, 94, 122, 123, 150, 154, 163, 174, 185, 193, 210.

***Juniperus* spp.**  
**L. Cupressaceae**  
**Junipers**

The Junipers are composed of about 50 species, native to North America [13], Mexico and Central America [11], West Indies [5], Bermuda [1], and the Old World [25]. The word *juniperus* is the classical Latin name. The wood of all species in this genus looks alike microscopically. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Juniperus ashei</i>	Ashe juniper
<i>Juniperus californica</i>	California juniper
<i>Juniperus communis</i>	Common juniper
<i>Juniperus deppeana*</i>	Alligator juniper
<i>Juniperus erythrocarpa</i>	Redberry juniper
<i>Juniperus flaccida</i>	Drooping juniper
<i>Juniperus monosperma</i>	Oneseed juniper
<i>Juniperus occidentalis*</i>	Western juniper
<i>Juniperus osteosperma</i>	Utah juniper
<i>Juniperus pinchotii</i>	Pinchot juniper
<i>Juniperus scopularum</i>	Rocky Mountain juniper
<i>Juniperus silicicola*</i>	Southern redcedar
<i>Juniperus virginiana*</i>	Eastern redcedar

***Juniperus deppeana*  
Steud.  
Cupressaceae  
Alligator Juniper**

The word *juniperus* is the classical Latin name. The word *deppeana* is in honor of Ferdinand Deppe (?-1861), a German botanist who gave this species a name previously used for another species. An old Scientific name is *Juniperus pachyphloea* Torr. This species was discovered in 1851 in the Zuni Mountains of northwestern New Mexico by Dr. S.W. Woodhouse, a member of the Captain L. Sitgreaves expedition (Zuni and Colorado Rivers).

**Other Common Names:** Alligator enebro, alligator genevier, alligator jeneverboom, alligator wacholder, alligator-en, aori, cedro, cedro chino, checker-bark juniper, eastern alligator juniper, enebro aligator, genevrier, ginepro alligatore, mountain cedar, oakbark juniper, oak-barked cedar, tascate, thick-barked juniper, tlaxcal, western alligator juniper, western juniper.

**Distribution:** Alligator juniper is native to the mountains of Trans-Pecos, Texas, northwest to northwestern New Mexico and northern and southeastern Arizona. It is also found in the mountains of northern and central Mexico, in the states of Coahuila, Michoacan, Mexico, Hidalgo, Tlaxcala, Puebla, and Vera Cruz on dry mountain slopes at 6,000- to 8,000-ft (1828.8- to 2438.4-m) elevation.

**The Tree:** Alligator juniper trees reach heights of 50 ft (15.24 m), with diameters of 3 ft (0.91 m). Record trees have been reported to be 6 ft (1.83 m) in diameter at breast height. Older trees may reach an age of 400 years.

**General Wood Characteristics:** The heartwood of alligator juniper is a light reddish brown. It is soft, light weight, close grained, and brittle. It is easily worked.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.48	42	673
12%	0.51	36	577
Ovendry	0.54	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$0.45 \times 10^6$ in/lb <sup>2</sup>	3.10 GPa	$0.65 \times 10^6$ in/lb <sup>2</sup>	4.48 GPa
MOR	$6.60 \times 10^3$ in/lb <sup>2</sup>	45.5 MPa	$6.70 \times 10^3$ in/lb <sup>2</sup>	46.2 MPa
C <sub>  </sub>	$3.73 \times 10^3$ in/lb <sup>2</sup>	25.7 MPa	$4.12 \times 10^3$ in/lb <sup>2</sup>	28.4 MPa
C <sub>⊥</sub>	$1.03 \times 10^3$ in/lb <sup>2</sup>	7.10 MPa	$1.70 \times 10^3$ in/lb <sup>2</sup>	11.7 MPa
WML	13.4 in-in/lb <sup>3</sup>	92.4 kJ/m <sup>3</sup>	6.5 in-in/lb <sup>3</sup>	44.8 kJ/m <sup>3</sup>
Hardness	820 lbf	3650 N	1160 lbf	5160 N
Shear <sub>  </sub>	$1.28 \times 10^3$ in/lb <sup>2</sup>	8.82 MPa	NA	NA

<sup>a</sup>Reference (153) (2-in. (5-cm) standard)(3 trees tested).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	3.6	NA	NA
Radial	2.7	NA	NA
Volumetric	7.8	NA	NA

<sup>a</sup>Reference (153).

**Kiln Drying Schedules:** No information at this time.

**Working Properties:** It is easily worked.

**Durability:** The heartwood is reported to be very resistant to decay (56, 100).

**Preservation:** No information at this time.

**Uses:** Fence posts and fuel.

**Toxicity:** Can cause dermatitis and respiratory problems (71, 158, 214).

**Additional Reading:** 44.



***Juniperus occidentalis***  
**Hook.**  
**Cupressaceae**  
**Western Juniper**

The word *juniperus* is the classical Latin name. The word *occidentalis* means western.

**Other Common Names:** California juniper, Canada juniper, cedar, enebro occidental, genevrier occidental, ginepro occidentale, pencilwood, San Bernardino juniper, Sierra juniper, vasterlandsk en, western cedar, western red cedar, westerse juniper, yellow cedar.

**Distribution:** Western juniper is native to the mountains of the Pacific Coast region from central and southeastern Washington south to southwestern Idaho, Oregon, northwestern and western Nevada, and from northern to southern California.

**The Tree:** Western juniper trees reach heights of 35 ft (10.67 m), with exceptional trees reaching heights of 87 ft (26.52 m), with a diameter of more than 13 ft (3.96 m). The older trees may live for 1,000 years. It was introduced into England in 1840.

**General Wood Characteristics:** The heartwood of western juniper is a light red to reddish brown. It is durable, fragrant, close grained, moderately heavy, light weight, relatively soft and brittle, and splits easily.

**Mechanical properties:** No information available at this time.

**Drying and shrinkage:** No information available at this time.

**Working Properties:** It is easily worked and takes a fine finish.

**Durability:** The heartwood is reported to have good natural durability (45, 52, 192).

**Preservation:** No information available at this time.

**Uses:** Fence posts, fuel wood, novelties, and potential as a pencil wood.

**Toxicity:** Can cause dermatitis and respiratory problems (71, 158, 214).

***Juniperus silicicola*  
(Small) Bailey  
Cupressaceae  
Southern Redcedar**

The word *juniperus* is the classical Latin name. The word *silicicola* means growing in sand. Some authors place southern redcedar as a variety of eastern redcedar (*Juniperus virginiana* L.).

**Other Common Names:** Amerikaanse magnolia, cedre rouge Americain, cedro rosso Americano, coast juniper, coast red cedar, eastern redcedar, enebro rojo Americano, ginepri d'America, pencil cedar, red cedar, rod-en, sand-cedar, southern juniper, southern red juniper, Virginian pencil cedar.

**Distribution:** Southern redcedar is native to the Coastal Plain of the eastern United States, mostly near the coast, from northeast North Carolina south to central Florida and west to southeast Texas.

**The Tree:** Southern redcedar trees reach heights of 50 ft (15.24 m), with a record of 70 ft (21.34 m). Heights of virgin growth trees along Apalachee Bay (Florida) are reported to have been more than 100 ft (30.48 m).

**General Wood Characteristics:** The heartwood of southern redcedar is a dull red. The wood is straight grained, light weight, soft, and weak.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.42	33	529
12%	0.44	31	497
Ovendry	0.45	NA	NA

<sup>a</sup>Reference (153)(5 trees tested).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$0.93 \times 10^6$ in/lb <sup>2</sup>	6.41 GPa	$1.17 \times 10^6$ in/lb <sup>2</sup>
MOR	$8.40 \times 10^3$ in/lb <sup>2</sup>	57.9 MPa	$9.40 \times 10^3$ in/lb <sup>2</sup>	64.8 MPa
C <sub>  </sub>	$4.36 \times 10^3$ in/lb <sup>2</sup>	30.1 MPa	$6.57 \times 10^3$ in/lb <sup>2</sup>	45.3 MPa
C <sub>⊥</sub>	$0.91 \times 10^3$ in/lb <sup>2</sup>	6.27 MPa	$1.00 \times 10^3$ in/lb <sup>2</sup>	6.89 MPa
WML	8.8 in-in/lb <sup>3</sup>	60.7 kJ/m <sup>3</sup>	5.4 in-in/lb <sup>3</sup>	37.2 kJ/m <sup>3</sup>
Hardness	580 lbf	2580 N	610 lbf	2710 N
Shear <sub>  </sub>	$1.19 \times 10^3$ in/lb <sup>2</sup>	8.20 MPa	$0.75 \times 10^3$ in/lb <sup>2</sup>	5.17 MPa

<sup>a</sup>Reference (153) (2-in. (5-cm) standard) (5 trees tested).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	4.0	NA	NA
Radial	2.2	NA	NA
Volumetric	7.0	NA	NA

<sup>a</sup>Reference (153)(5 trees tested).

**Kiln Drying Schedules:** No information available at this time.

**Working Properties:** It works and finishes well.

**Durability:** No information available at this time.

**Preservation:** No information available at this time.

**Uses:** No information available at this time.

**Toxicity:** Can cause dermatitis and respiratory problems (71, 158, 214).

**Additional Reading:** 44, 51, 122, 204.

***Juniperus virginiana* L.**  
**Cupressaceae**  
**Eastern Redcedar**

The word *juniperus* is the classical Latin name. The word *virginiana* means “of Virginia.”

**Other Common Names:** Amerikaanse magnolia, Amerikansk rod-ceder, bleistift-zeder, blyerts-en, cedar, cederhoutboom, cedre, cedre de Virginie, cedre rouge, cedre rouge American, cedro per matite, cedro rosso Americano, cedro vermelho, coast juniper, coast red cedar, eastern red juniper, enebro Americano, enebro criollo, enebro rojo Americano, enebro Virginiano, genevrier rouge, genevrier rouge de l’Amerique, ginepri d’America, ginepro della Virginia, Ienuparul virginiana, juniper, pencil cedar, pencil juniper, red cedar, red juniper, rod-en, sabina de costa, sand cedar, savin, savin red cedar, southern juniper, southern red cedar, southern red juniper, Tennessee red cedar, Virginiaanse jeneverbes, Virginian cedar, Virginian pencil, cedar, Virginische zeder, Virginische potlood-ceder, Virginische sevenboom, Virginischer wacholder.

**Distribution:** Eastern redcedar is native to the eastern half of the United States, from Maine west to New York, Quebec, Ontario, Michigan, Minnesota, South Dakota, and North Dakota south to Nebraska and Texas east through Florida and Georgia.

**The Tree:** Eastern redcedar has the widest distribution of any other conifer in the eastern United States. It can reach heights of 120 ft (36.58 m) and a diameter of 4 ft (1.22 m). It is a pioneer species, being one of the first trees to invade disturbed areas. It grows very slowly, such that trees 20 years old are only about 20 ft (6.10 m) tall and 3 in. (7.62 cm) in diameter. Older trees have wide, fluted, buttressed bases.

**General Wood Characteristics:** Eastern redcedar has a thin, white sapwood, and the heartwood is red to deep reddish-brown. The sapwood may be in stripes, alternating with the heartwood. It has a fine, uniform texture and a straight grain, except where deflected by knots. The wood is moderately low in strength and stiffness, but it is high in shock resistance. It shrinks little during drying and has good dimensional stability.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (33%) <sup>a</sup>	0.44 <sup>b</sup>	37 <sup>c</sup>	593
12%	0.47 <sup>b</sup>	33 <sup>c</sup>	529
Ovendry	0.49 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	0.65 × 10 <sup>6</sup> in/lb <sup>2</sup>	4.48 GPa	0.88 × 10 <sup>6</sup> in/lb <sup>2</sup>	6.07 GPa
MOR	7.00 × 10 <sup>3</sup> in/lb <sup>2</sup>	48.3 MPa	8.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	60.7 MPa
C <sub>  </sub>	3.57 × 10 <sup>3</sup> in/lb <sup>2</sup>	24.6 MPa	6.02 × 10 <sup>3</sup> in/lb <sup>2</sup>	41.5 MPa
C <sub>⊥</sub>	0.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.83 MPa	0.92 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.34 MPa
WML	15.0 in-in/lb <sup>3</sup>	103.4 kJ/m <sup>3</sup>	8.3 in-in/lb <sup>3</sup>	57.2 kJ/m <sup>3</sup>
Hardness	650 lbf	2890 N	900 lbf	4000 N
Shear <sub>  </sub>	1.01 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.96 MPa	NA	NA

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% Mc <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	4.7	3.8	1.6
Radial	3.1	2.5	1.0
Volumetric	7.8	6.2	2.6

<sup>a</sup>May contain knot checks and/or excessive loss of aromatic oils, possibly caused by excessive drying temperatures (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedule

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T5-A4	NA	T5-A3	NA	NA	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Eastern redcedar is easy to work with both hand and machine tools and has a straight grain. It has tight knots, which can add to the beauty of the wood. It splits easily, holds nails well, and has excellent gluing properties.

**Durability:** The heartwood is highly resistant to decay and attack by insects, including termites (56). The scent of the wood is said to be a natural insect repellent, although this has not been demonstrated scientifically.

**Preservation:** No information available at this time.

**Uses:** Fence posts, chests, wardrobes, closet linings, pencils, carvings, pet bedding, furniture, flooring, scientific instruments, small boats and household items. The trees are also used for Christmas trees. Oil from the wood (cedrol) is used in the manufacture of perfumes and medicines.

**Toxicity:** Can cause dermatitis and respiratory problems (71, 158, 214).

**Additional Reading:** 9, 14, 71, 72, 95, 122, 183.

***Larix* spp. Mill.**  
**Pinaceae**  
**Larches**

The genus *Larix* contains about 10 species, native to North America [3] and Eurasia [7]. The wood of all species in this genus looks alike microscopically. *Larix* is the classical name of *Larix decidua* Mill., or European larch. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Larix laricina</i> *	Tamarack
<i>Larix lyallii</i>	Subalpine larch
<i>Larix occidentalis</i> *	Western larch

***Larix laricina*  
(Du Roi) K. Koch  
Pinaceae  
Tamarack**

*Larix* is the classical name of *Larix decidua* Mill., or European larch. The word *laricina* denotes its similarity to European larch (known as *Pinus larix* L. at the time of tamaracks naming).

**Other Common Names:** Alaska larch, alerce Americano, American larch, Amerikaanse lariks, Amerikansk lark, Amerikansk svart-gran, black larch, Eastern Canadian larch, eastern larch, epinette rouge, hackmatack, hacmack, juniper, Kanada-lark, ka-neh-tens, meleze d’Amerique, red larch, tamarac meizee occidental, tamarac meleze occidental, tamarack larch, tamarak.

**Distribution:** Tamarack grows across northern North America near the northern limit of tree growth. It grows from Newfoundland, Labrador, and Quebec west to Hudson Bay, Mackinaw, the Yukon, and southern Alaska south to British Columbia, Alberta, Manitoba, Minnesota, Wisconsin, northeastern Illinois east to Indiana, Pennsylvania, New Jersey, and Maine. It occurs locally in the mountains of West Virginia and Maryland.

**The Tree:** In general, tamarack grows to heights of 75 ft (22.86 m), with a diameter of 2 ft (0.61 m), occasionally reaching heights of 115 ft (35.05 m), with a diameter of 3.5 ft (1.07 m). Trees 80 ft (24.38 m) tall and 2 ft (0.61 m) in diameter were once common in the Lake States. In the interior of Alaska, tamaracks are commonly 10 ft (3.05 m) tall and 3 in. (7.62 cm) in diameter. On good sites, in Alaska, tamarack reaches heights of 90 ft (27.43 m), with diameters of 1 ft (0.30 m). Maximum ages of tamarack are about 180 years, but trees 335 years old have been found.

**General Wood Characteristics:** The sapwood of tamarack is white and narrow (less than 1 in. (2.54 cm) wide), and the heartwood is yellow to russet brown. The wood is medium to fine in texture, has a silvery cast and an oily feel, and has no distinctive odor or taste. It is intermediate in strength, stiffness, and hardness. It is moderately high in shock resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (49%) <sup>a</sup>	0.49 <sup>b</sup>	47 <sup>c</sup>	753
12%	0.53 <sup>b</sup>	37 <sup>c</sup>	593
Ovendry	0.57 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.24 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.55 GPa	1.64 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.3 GPa
MOR	7.2 × 10 <sup>3</sup> in/lb <sup>2</sup>	49.6 MPa	11.6 × 10 <sup>3</sup> in/lb <sup>2</sup>	80.0 MPa
C <sub>  </sub>	3.48 × 10 <sup>3</sup> in/lb <sup>2</sup>	24.0 MPa	7.16 × 10 <sup>3</sup> in/lb <sup>2</sup>	49.4 MPa
C <sub>⊥</sub>	0.39 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.69 MPa	0.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.52 MPa
WML	7.2 in-in/lb <sup>3</sup>	49.6 kJ/m <sup>3</sup>	7.1 in-in/lb <sup>3</sup>	48.9 kJ/m <sup>3</sup>
Hardness	380 lbf	1690 N	590 lbf	2620 N
Shear <sub>  </sub>	0.86 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.93 MPa	1.28 × 10 <sup>3</sup> in/lb <sup>2</sup>	8.82 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.4	5.9	2.5
Radial	3.7	3.0	1.2
Volumetric	13.6	10.9	4.5

<sup>a</sup>Tamarack has moderately large shrinkage, but exhibits moderately low warping and checking. Reference (84).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedule

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T11-B3	NA	T10-B3	T7-A3	T7-A3	K

<sup>a</sup>References (28, 74, 185).

**Working Properties:** Tamarack works well in most instances, but may have a dulling effect on tools. It has a tendency to split when nailed and is low in paint retention.

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

**Preservation:** It is difficult to penetrate with preservatives (56).

**Uses:** Pulp products (glassine paper), posts, poles, mine timbers, rough timber, fuel wood, boxes, crates, and pails. In Alaska, young stems are used for dogsled runners, boat ribs, and fish traps. In Alberta, the branches are used for making goose and duck decoys.

**Toxicity:** At this time, no information exists on tamarack, but other species of larch can cause dermatitis and contact urticaria (71, 158, 214).

**Additional Reading:** 80, 122, 163.



**Larix occidentalis Nutt.**  
**Pinaceae**  
**Western Larch**

Larix is the classical name of *Larix decidua* Mill., or European larch. The word *occidentalis* means western.

**Other Common Names:** Alerce Americano occidental, British Columbia tamarack, hackmatack, larice Americano occidentale, larice occidentale, meleze occidental, Montana larch, mountain larch, Oregon larch, red American larch, roughbarked larch, tamarack, vastAmerikansk lark, westAmerikaanse lariks, westAmerikaanse lork, westAmerikanische larche, western tamarack.

**Distribution:** Western larch is native to the high mountains of the upper Columbia River Basin in southeastern British Columbia, northwestern Montana, northern and central Idaho, Washington, and northern and northeastern Oregon.

**The Tree:** Western larch trees reach heights of 180 ft (54.86 m), with diameters of 4 ft (1.22 m) at an age of 400 years. Older trees, 700 years, may reach heights of 200 ft (60.96 m), with diameters of 8 ft (2.44 m). About two-thirds of the lumber of this species is produced in Idaho and Montana and a third in Oregon and Washington.

**General Wood Characteristics:** The heartwood of western larch is yellowish brown, and the sapwood is yellowish white. The sapwood is generally not more than 1 in. (2.54 cm) thick. The wood is stiff, moderately strong and hard, moderately high in shock resistance, and moderately heavy. It has moderately high shrinkage. The wood is usually straight grained, splits easily, and is subject to ring shake. Knots are common but generally small and tight. The properties of western larch are similar to those of Douglas-fir, and sometimes the lumber is sold mixed.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (54%) <sup>a</sup>	0.48 <sup>b</sup>	48 <sup>c</sup>	769
12%	0.52 <sup>b</sup>	36 <sup>c</sup>	577
Ovendry	0.59 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.46 \times 10^6$ in/lb <sup>2</sup>	10.1 GPa	$1.87 \times 10^6$ in/lb <sup>2</sup>	12.9 GPa
MOR	$7.70 \times 10^3$ in/lb <sup>2</sup>	53.1 MPa	$13.0 \times 10^3$ in/lb <sup>2</sup>	89.6 MPa
C <sub>  </sub>	$3.76 \times 10^3$ in/lb <sup>2</sup>	25.9 MPa	$7.62 \times 10^3$ in/lb <sup>2</sup>	52.5 MPa
C <sub>⊥</sub>	$0.40 \times 10^3$ in/lb <sup>2</sup>	2.76 MPa	$0.93 \times 10^3$ in/lb <sup>2</sup>	6.41 MPa
WML	10.3 in-in/lb <sup>3</sup>	71.0 kJ/m <sup>3</sup>	12.6 in-in/lb <sup>3</sup>	86.9 kJ/m <sup>3</sup>
Hardness	510 lbf	2270 N	830 lbf	3690 N
Shear <sub>  </sub>	$0.87 \times 10^3$ in/lb <sup>2</sup>	6.00 MPa	$1.36 \times 10^3$ in/lb <sup>2</sup>	9.38 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	9.1	6.3	2.6
Radial	4.5	3.4	1.4
Volumetric	14.0	9.5	4.0

<sup>a</sup>May contain shake (ring failure, checks or resin exudate), possibly caused by wetwood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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	T7-C5 <sup>b</sup>	NA	T7-C5 <sup>c</sup>	NA	NA	NA
Upper grades	T9-B4	T7-C4	T7-C3	T7-A3	T7-A2	K <sup>d</sup>

<sup>a</sup>References (28, 185).

<sup>b</sup>Maximum wet-bulb depression 20°F. Reference (185).

<sup>c</sup>Maximum wet-bulb depression 25°F. Reference (185).

<sup>d</sup>Reference (74).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400/414	NA

<sup>a</sup>References (28, 186).

**Working Properties:** Western larch is somewhat difficult to work, but takes a smooth, hard finish. It has a minor dulling effect on tools. It has a tendency to split when nailed, unless blunt-pointed nails are used. Material with a high resin content may have problems with accepting stains and paint, unless properly seasoned. The wood can be glued satisfactorily.

**Durability:** The heartwood of western larch is moderately resistant to decay (56).

**Preservation:** It is resistant to preservative treatment (74).

**Uses:** Western larch is used mainly in building construction for rough dimension, small timbers, planks and boards, and mine timbers. It is used also for piles, poles, and posts. Some high-grade material is manufactured into interior finish, flooring, sash, and doors.

**Toxicity:** At this time, there is no information on western larch, but other species of larch can cause dermatitis and contact urticaria (71, 158, 214).

**Additional Reading:** 44, 51, 78, 122, 151, 173.

***Libocedrus* spp. Endl.**  
**Cupressaceae**  
**Incense-Cedar**

The genus *Libocedrus* contains about 10 species native to North America [1], South America [1], and the western Pacific from New Zealand to China [8]. It is sometimes placed in the segregate genus, *Calocedrus* Kurz. The word *libocedrus* is from the Greek, drop or tear, and *cedrus*, cedar, referring to the resin drops. It is anatomically distinct from other similar softwoods. The species native to North America is listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Libocedrus decurrens</i> *	Incense-Cedar

***Libocedrus decurrens***  
**Torr.**  
**Cupressaceae**  
**Incense-Cedar**

The word *libocedrus* is from the Greek, drop or tear, and *cedrus*, cedar, referring to the resin drops. The word *decurrens* means decurrent, referring to the scale leaves running down the twig.

**Other Common Names:** Amerikaanse potlood-ceder, bastard cedar, California calocedar, California incense cedar, California post cedar, Californische witte ceder, cedar, cedre a crayons, cedro bianco, cedro bianco di California, cedro de incienso, geurende ceder, heyderie, juniper, Kalifornisch fluss-zeder, libocedro, libocedro de California, libocedro dell'America, pencil cedar, post cedar, red cedar, rod-ceder, roughbark cedar, weihrauch-zeder, weihrauchzeder, white cedar, Witte cedar.

**Distribution:** Incense-cedar is native to the mountains from western Oregon in higher Coast Ranges and Sierra Nevada to southern California and extreme western Nevada, also in northern Baja Peninsula of Mexico.

**The Tree:** Incense-cedar trees commonly reach heights of 100 ft (30.48 m), with diameters of 5 ft (1.52 m) and an age of 500 years. Record trees reach 150 ft (45.72 m) in height, with 9 ft (2.74 m) diameters.

**General Wood Characteristics:** The sapwood of incense-cedar is a creamy white, and the heartwood is light brown to light reddish brown. The heartwood has an aromatic, spicy odor, and is highly resistant to decay. Much of the incense-cedar lumber is more or less pecky; that is, it contains pockets or areas of disintegrated wood caused by advanced stages of localized decay in the living tree. There is no additional development of peck after the lumber is seasoned. It holds paint extremely well, has an unusually straight grain, and has high dimensional stability. It also has a low coefficient of thermal conductivity; that is, it performs well in structures that are kept dry but are subjected to considerable temperature fluctuations. It is light weight, moderately low to low in strength, shock resistance, stiffness, and hardness.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green (40%) <sup>a</sup>	0.35 <sup>b</sup>	45 <sup>c</sup>	721
12%	0.37 <sup>b</sup>	24 <sup>c</sup>	384
Ovendry	0.37 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56)

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	0.84 × 10 <sup>6</sup> in/lb <sup>2</sup>	5.79 GPa	1.04 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.17 GPa
MOR	6.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	42.7 MPa	8.00 × 10 <sup>3</sup> in/lb <sup>2</sup>	55.2 MPa
C <sub>  </sub>	3.15 × 10 <sup>3</sup> in/lb <sup>2</sup>	21.7 MPa	5.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	35.8 MPa
C <sub>⊥</sub>	0.37 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.55 MPa	0.59 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.07 MPa
WML	6.4 in-in/lb <sup>3</sup>	44.1 kJ/m <sup>3</sup>	5.4 in-in/lb <sup>3</sup>	37.2 kJ/m <sup>3</sup>
Hardness	390 lbf	1730 N	470 lbf	2090 N
Shear <sub>  </sub>	0.83 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.72 MPa	0.88 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.07 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	5.2	4.2	1.7
Radial	3.3	2.6	1.1
Volumetric	7.7	6.1	2.5

<sup>a</sup>Heavy stock may contain water pockets and be prone to collapse, possibly as a result of wetwood and/or excessive drying temperatures (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T11-B5	NA	T10-B4	NA	NA	NA

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	290 <sup>b</sup>	290	289	290 <sup>b</sup>	290	289	296

<sup>a</sup>References (28, 185).

<sup>b</sup>Use 12 h for each setting; decrease dry- and wet-bulb settings by 10° for the first 48 h.

**Working Properties:** Incense-cedar works well with hand tools and machines well, forming smooth surfaces. It glues and nails well, but blunt nails should be used to avoid splintering the wood.

**Durability:** The heartwood of incense cedar is resistant to very resistant to decay (56).

**Preservation:** No information available at this time.

**Uses:** Incense-cedar is used principally for lumber and fence posts. Nearly all high grade lumber is used for pencils (#1 species for pencil stock) and venetian blinds. Some is used for chests and toys. Other products are poles and split shingles. It is also used for sheathing under stucco or brick veneer construction, mudsills, rafters, window sashes, greenhouse benches, nursery flats, boardwalks, grave linings, casket shooks, exterior siding, sheathing, subflooring, interior paneling, closet lining, pencils, “mothproof” chests, novelties, rails, grape stakes, trellises, feed troughs, farm outbuildings, and fuel wood.

**Toxicity:** Can cause contact dermatitis and/or eczema (71, 158, 214).

**Additional Reading:** 4, 72, 75, 122, 147, 161.

***Picea* spp. A. Dietr.**  
**Pinaceae**  
**Spruces**

The genus *Picea* is composed of about 30 species native to North America [7], Mexico [2], and Eurasia [20]. The wood of all species in this genus looks alike microscopically. The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Picea brewerana</i>	Brewer spruce
<i>Picea engelmannii</i> *	Engelmann spruce
<i>Picea glauca</i> *	White spruce
<i>Picea mariana</i> *	Black spruce
<i>Picea pungens</i>	Blue spruce
<i>Picea rubens</i> *	Red spruce
<i>Picea sitchensis</i> *	Sitka spruce

***Picea engelmannii***  
**Parry ex. Engelm.**  
**Pinaceae**  
**Engelmann Spruce**

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The word *engelmannii* is named for George Engelmann (1809–1884), German born physician and botanist of St. Louis, an authority on conifers who first recognized this species as not previously described.

**Other Common Names:** Arizona spruce, balsam, Columbian spruce, Engelmann elm, Engelmann spar, Engelmann-fichte, Engelmanns-gran, epicea d’Engelmann, epinette d’Engelmann, mountain spruce, picea de Englemann, picea di Engelmann, pino real, real pino, Rocky Mountain spruce, silver spruce, spruces d’America, western white spruce, white pine, white spruce.

**Distribution:** Engelmann spruce is native to the Rocky Mountain region from southwestern Alberta and central British Columbia, south in the high mountains from Washington to northern California, east to eastern Nevada, southeastern Arizona and southern New Mexico and north to Wyoming and central Montana. About two-thirds of the lumber is produced in the southern Rocky Mountain States. Most of the remainder comes from the northern Rocky Mountain States and Oregon.

**The Tree:** Engelmann spruce trees commonly reach heights of 130 ft (39.62 m), with diameters of 3 ft (0.91 m). Larger trees may exceed 130 ft (39.62 m) in height and 3.5 ft (1.07 m) in diameter.

**General Wood Characteristics:** The heartwood of Engelmann spruce is nearly white with a slight tinge of red. The sapwood varies from 0.75 to 2 in. (1.90 to 5.08 cm) in width and is often difficult to distinguish from heartwood. The wood has medium to fine texture and is without characteristic taste or odor. It is generally straight grained and light in weight. It is low in strength as a beam or post. It is limber, soft, low in shock resistance, and has moderately small shrinkage. The lumber typically contains numerous small knots.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(51%) <sup>a</sup>	0.33 <sup>b</sup>	39 <sup>c</sup>	625
12%	0.35 <sup>b</sup>	23 <sup>c</sup>	368
Ovendry	0.35 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.03 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.10 GPa	1.30 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.96 GPa
MOR	4.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	32.4 MPa	9.30 × 10 <sup>3</sup> in/lb <sup>2</sup>	64.1 MPa
C <sub>  </sub>	2.18 × 10 <sup>3</sup> in/lb <sup>2</sup>	15.0 MPa	4.48 × 10 <sup>3</sup> in/lb <sup>2</sup>	30.9 MPa
C <sub>⊥</sub>	0.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.38 MPa	0.41 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.83 MPa
WML	5.1 in-in/lb <sup>3</sup>	35.2 kJ/m <sup>3</sup>	6.4 in-in/lb <sup>3</sup>	44.1 kJ/m <sup>3</sup>
Hardness	260 lbf	1160 N	390 lbf	1730 N
Shear <sub>  </sub>	0.64 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.41 MPa	1.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	8.27 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	7.1	5.3	2.2
Radial	3.8	2.7	1.1
Volumetric	11.0	8.3	3.5

<sup>a</sup>Reference (56).

<sup>b</sup>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	T7-B6	T5-B5	T5-B5 <sup>b</sup>	NA	NA	NA
Upper grades	T9-E5	NA	T7-E4	T7-A4	T7-A3	K

<sup>a</sup>References (28, 185).

<sup>b</sup>Maximum wet-bulb depression 2°F (-4°C). Reference (185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	289	289	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 178).

**Working Properties:** Engelmann spruce is easily worked.

**Durability:** The heartwood of spruce is slightly resistant to nonresistant to decay (56).

**Preservation:** Engelmann spruce is resistant to preservative treatment (74).

**Uses:** Engelmann spruce is used principally for lumber and mine timbers, railroad cross ties, and poles. It is also used in building construction as dimension lumber, flooring, sheathing, and studding. It has excellent properties for pulp and paper making.

**Toxicity:** Working with fresh spruce wood can cause dermatitis or other contact sensitivity (71, 158, 214).

**Additional Reading:** 2, 46, 52, 53, 75, 119, 151, 210.



***Picea glauca*  
(Moench) Voss  
Pinaceae  
White Spruce**

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The word *glauca* means glaucous, or covered with a bloom, referring to the blue green foliage.

**Other Common Names:** Adirondack spruce, Alberta spar, Alberta spruce, Alberta white spruce, Alberta-gran, Black Hills spruce, blue spruce, bog spruce, Canadese spar, Canadese witte spar, Canadian spruce, cat spruce, double spruce, eastern blue spruce, eastern Canadian spruce, eastern spruce, epicea Canadien, epinette a biere, epinette blanche, epinette grise, epinette jaune, he-balsam, juniper, Labrador spruce, Maritime spruce, New Brunswick spruce, northern spruce, Nova Scotia spruce, picea Canadese, picea de Alberta, picea de Canada, picea del Canada, picea di Alberta, pine, Porsild spruce, Quebec spruce, sapin blanc, sapin de Normandie, sapinette blanche, sapinette d' Alberta, single spruce, skunk spruce, spruce pine, spruces d' America, St. John's spruce, transcontinental spruce, vit-gran, water spruce, western white spruce, wit-spar, yew pine.

**Distribution:** White spruce is native to widespread areas across northern North America near the northern limit of trees, from Newfoundland, Labrador, and northern Quebec, west to the Hudson Bay, northwest Mackinaw, and northwestern and southwestern Alaska, south to southern British Columbia, southern Alberta and northwestern Montana, east to southern Manitoba, central Minnesota, central Michigan, southern Ontario, northern New York and Maine. It is also found locally in the Black Hills of South Dakota and Wyoming.

**The Tree:** White spruce trees reach heights of 110 ft (33.53 m), with diameters of 2 ft (0.61 m). Exceptionally large trees have been reported with a height of 150 ft (45.72 m) and a diameter of 4 ft (1.22).

**General Wood Characteristics:** The wood dries easily, is stable after drying, is moderately light in weight and easily worked, has moderate shrinkage, and is moderately strong, stiff, tough, and hard. It is straight, even grained, soft, and finishes with a satin-like surface. The wood is creamy white or straw colored, and there is little difference between the color of the heartwood and sapwood.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.33 <sup>a</sup>	35 <sup>b</sup>	561
12%	0.36 <sup>a</sup>	28 <sup>b</sup>	449
Ovendry	0.45 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.14 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.86 GPa	1.43 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.86 GPa
MOR	5.00 × 10 <sup>3</sup> in/lb <sup>2</sup>	34.5 MPa	9.40 × 10 <sup>3</sup> in/lb <sup>2</sup>	64.8 MPa
C <sub>  </sub>	2.35 × 10 <sup>3</sup> in/lb <sup>2</sup>	16.2 MPa	5.18 × 10 <sup>3</sup> in/lb <sup>2</sup>	35.7 MPa
C <sub>⊥</sub>	0.21 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.45 MPa	0.43 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.96 MPa
WML	6.0 in-in/lb <sup>3</sup>	41.4 kJ/m <sup>3</sup>	7.7 in-in/lb <sup>3</sup>	53.1 kJ/m <sup>3</sup>
Hardness	320 lbf	1420 N	480 lbf	2130 N
Shear <sub>  </sub>	0.64 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.41 MPa	0.97 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.69 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.2	NA	NA
Radial	4.7	NA	NA
Volumetric	13.7	NA	NA

<sup>a</sup>Reference (192). May contain pockets, collapse, or ring failure, possibly as a result of wetwood (rare occurrence in northern and southern limits of botanical range)(185).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock <sup>a</sup>	6/4 stock <sup>a</sup>	8/4 stock <sup>a</sup>	10/4 stock <sup>a</sup>	12/4 stock <sup>a</sup>	British schedule 4/4 stock <sup>b</sup>
Standard	T11-B4	NA	T10-B3	T5-A2	T5-A2	K

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (73).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	289	289	288

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	Studs/412
Gas-fired Kilns	410	NA	411	NA

<sup>a</sup>References (28, 185).

**Working Properties:** White spruce is easily worked.

**Durability:** The heartwood of spruce is slightly resistant to nonresistant to decay (56).

**Preservation:** White spruce is resistant to preservative treatment (74).

**Uses:** The largest use of white spruce is pulpwood. It is also used for framing material, general millwork, boxes and crates, and piano sounding boards.

**Toxicity:** Working with fresh spruce wood can cause dermatitis or other contact sensitivity (71, 158, 214).

**Additional Reading:** 7, 46, 53, 119, 160.

***Picea mariana*  
(Mill.) B.S.P.  
Pinaceae  
Black Spruce**

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The word *mariana* means “of Maryland,” in the broad sense for North America, as this species is not native to Maryland.

**Other Common Names:** Amerikaanse zwarte spar, Amerikansk svart-gran, blue spruce, bog spruce, Canadian spruce, double spruce, eastern spruce, Eastern Canadian spruce, epicea noir d’Amerique, epinette batarde, epinette jaune, epinette noire, he balsam, he-balsam, juniper, muckeag spruce, New Brunswick spruce, picea negra Americana, picea nera Americana, Quebec spruce, sapin noir, sapinette noire, sapinette noire’Amerique, schwarz-fichte, schwarzfichte, shortleaf black spruce, spruce pine, spruces d’America, St. John’s spruce, swamp black spruce, swamp spruce, transcontinental spruce, water spruce, western spruce, yew pine.

**Distribution:** Black spruce has a widespread distribution across northern North America near the northern limit of trees, from Newfoundland, Labrador, and northern Quebec, west to the Hudson Bay, northwest Mackinaw, and central, western and southern Alaska, south to central British Columbia, and east to southern Manitoba, central Minnesota, Wisconsin, southeastern Michigan southern Ontario, New York, central and northeastern Pennsylvania, northern New Jersey, Rhode Island, and Massachusetts.

**The Tree:** Black spruce trees reach heights of more than 50 ft (15.24 m), with diameters of 1 ft (0.30 m). Exceptional trees grow to 90 ft (27.43 m), with a diameter of almost 2 ft (0.61 m).

**General Wood Characteristics:** The wood dries easily, is stable after drying, is moderately light in weight and easily worked, has moderate shrinkage, and is moderately strong, stiff, tough, and hard. It is not very resistant to bending or end-wise compression. It is straight, even grained, medium to fine textured, soft, and produces a lustrous finish. It is without characteristic odor or taste. The wood is a pale yellowish white, and there is little difference in color between the heartwood and sapwood. It has exceptional resonance qualities, in the form of thin boards. It has moderately high shrinkage, but is easily air or kiln dried.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(52%) <sup>a</sup>	0.38 <sup>b</sup>	32 <sup>c</sup>	513
12%	0.42 <sup>b</sup>	28 <sup>c</sup>	449
Ovendry	0.43 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.38 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.51 GPa	1.61 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.0 GPa
MOR	6.10 × 10 <sup>3</sup> in/lb <sup>2</sup>	42.1 MPa	10.8 × 10 <sup>3</sup> in/lb <sup>2</sup>	74.5 MPa
C <sub>  </sub>	2.84 × 10 <sup>3</sup> in/lb <sup>2</sup>	19.6 MPa	5.96 × 10 <sup>3</sup> in/lb <sup>2</sup>	41.1 MPa
C <sub>⊥</sub>	0.24 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.65 MPa	0.55 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.79 MPa
WML	7.4 in-in/lb <sup>3</sup>	51.0 kJ/m <sup>3</sup>	10.5 in-in/lb <sup>3</sup>	72.4 kJ/m <sup>3</sup>
Hardness	370 lbf	1640 N	520 lbf	2310 N
Shear <sub>  </sub>	0.74 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.10 MPa	1.23 × 10 <sup>3</sup> in/lb <sup>2</sup>	8.48 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.8	5.4	2.3
Radial	4.1	3.3	1.4
Volumetric	11.3	9.0	3.8

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T11-B4	NA	T10-B3	T5-A2	T5-A2	K

<sup>a</sup>References (28, 74, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	289	289	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It is easily worked, glues well, is average in paint-holding ability, but rates low in nail-holding capacity.

**Durability:** The heartwood of spruce is slightly resistant to nonresistant to decay (56).

**Preservation:** It is difficult to penetrate with preservatives (56).

**Uses:** The largest use of black spruce is pulpwood. It is also used for framing material, general millwork, boxes and crates, and piano sounding boards.

**Toxicity:** Working with fresh spruce wood can cause dermatitis or other contact sensitivity (71, 158, 214).

**Additional Reading:** 46, 53, 59, 72, 119, 164, 196.

***Picea rubens* Sarg.**  
**Pinaceae**  
**Red Spruce**

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The word *rubens* means reddish, referring to the reddish-brown cones.

**Other Common Names:** Abetina rossa, Adirondack spruce, black spruce, blue spruce, Canadese rode spar, Canadian red spruce, Canadian spruce, double spruce, eastern spruce, epicea rouge du Canada, he balsam, he-balsam, Hudson-fichte, Kanadensisk rod-gran, North American red spruce, picea roja de Canada, picea rossa del Canada, rot-fichte, sapinette rouge du Canada, spruce pine, spruces d’America, West Virginia spruce, yellow spruce.

**Distribution:** Red spruce is native to Cape Breton Islands, Nova Scotia, and New Brunswick, west to Maine, southern Quebec, and southeastern Ontario and south to central New York, northeastern Pennsylvania, northern New Jersey, and Massachusetts. It also grows in the Appalachian Mountains of extreme western Maryland, eastern West Virginia, northern and western Virginia, western North Carolina, and eastern Tennessee.

**The Tree:** Red spruce can reach heights of 110 ft (33.53 m), with diameters of 4.5 ft (1.37 m). At the northern limit of its range, red spruce reaches heights of only 80 ft (24.38 m), with diameters of 2 ft (0.61 m).

**General Wood Characteristics:** The wood dries easily and is stable after drying, is moderately light in weight and easily worked, has moderate shrinkage, and is moderately strong, stiff, tough, and hard. It is not very resistant to bending or end-wise compression. It is straight, even grained, medium to fine textured, soft, and produces a lustrous finish. It is without characteristic odor or taste. The wood is a pale yellowish white, and there is little difference in color between the heartwood and sapwood. It has exceptional resonance qualities, in the form of thin boards. It has moderately high shrinkage, but is easily air or kiln dried.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.37 <sup>a</sup>	34 <sup>b</sup>	545
12%	0.40 <sup>a</sup>	28 <sup>b</sup>	449
Ovendry	0.41 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.33 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.17 GPa	1.61 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.1 GPa
MOR	6.00 × 10 <sup>3</sup> in/lb <sup>2</sup>	41.4 MPa	10.8 × 10 <sup>3</sup> in/lb <sup>2</sup>	74.5 MPa
C <sub>  </sub>	2.72 × 10 <sup>3</sup> in/lb <sup>2</sup>	18.7 MPa	5.54 × 10 <sup>3</sup> in/lb <sup>2</sup>	38.2 MPa
C <sub>⊥</sub>	0.26 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.79 MPa	0.55 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.79 MPa
WML	6.9 in-in/lb <sup>3</sup>	47.6 kJ/m <sup>3</sup>	8.4 in-in/lb <sup>3</sup>	57.9 kJ/m <sup>3</sup>
Hardness	350 lbf	1560 N	490 lbf	2180 N
Shear <sub>  </sub>	0.75 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.17 MPa	1.29 × 10 <sup>3</sup> in/lb <sup>2</sup>	8.89 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	7.8	6.2	2.6
Radial	3.8	3.0	1.3
Volumetric	11.8	9.4	3.9

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T11-B4	NA	T10-B3	T5-A2	T5-A2	K

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	291	291	NA

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	410	NA	411	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It is easily worked, glues well, has average paint-holding ability, and low nail-holding capacity.

**Durability:** The heartwood of spruce is slightly resistant to nonresistant to decay (56).

**Preservation:** It is difficult to penetrate with preservatives (56).

**Uses:** The largest use of red spruce is pulpwood. It is also used for framing material, general millwork, boxes and crates, and piano sounding boards.

**Toxicity:** Working with fresh spruce wood can cause dermatitis or other contact sensitivity (711, 158, 214).

**Additional Reading:** 16, 25, 46, 53, 74, 119, 164, 188.

***Picea sitchensis*  
(Bong.) Carr.  
Pinaceae  
Sitka Spruce**

The word *picea* comes from the ancient Latin name (*pix, picis* = pitch) of a pitchy pine, probably Scotch pine (*Pinus sylvestris* L.). The word *sitchensis* is for Sitka Island (now Baranof Island) in southeastern Alaska.

**Other Common Names:** Abete di Sitka, British Columbia sitka-spruce, coast west spruce, coast spruce, eipcea de Menzies, epicea de Menzies, epicea de Sitka, epinette de sitka, great tideland spruce, Menzies spar, Menzies spruce, Menziesie, picea de Sitka, picea di Sitka, sequoia silver spruce, silver spruce, Sitka spar, Sitka-fichte, Sitkafichte, Sitka-gran, sitka-gran, Sitkankuusi, Sitka-spar, spruces d’America, tideland spruce, West Coast spruce, western spruce, yellow spruce.

**Distribution:** Sitka spruce is native to the Pacific Coast region from southern Alaska (Kodiak Island and Cook Inlet), southeast through southeastern Alaska, western British Columbia, western Washington, western Oregon, and northwestern California.

**The Tree:** Sitka spruce trees normally reach heights of 160 ft (48.77 m), with diameters of 5 ft (1.52 m). A record tree was recorded to be 216 ft (65.84 m) tall, with a diameter of 16.7 ft (5.09 m).

**General Wood Characteristics:** The sapwood of Sitka spruce is a creamy white to light yellow, and the heartwood is pinkish yellow to brown. The sapwood may be 3 to 6 in. (7.62 to 15.24 cm) wide or even wider in young trees. The wood has a fine, uniform texture and generally has a straight grain. It is moderately light in weight, moderately low in bending and compressive strength, moderately stiff, moderately soft, and moderately low in resistance to shock. On the basis of weight, it rates high in strength properties and can be obtained in clear, straight-grained pieces. It has moderately small shrinkage. It is not difficult to kiln dry and can be worked easily (when free of knots).

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(41%) <sup>a</sup>	0.37 <sup>b</sup>	33 <sup>c</sup>	529
12%	0.40 <sup>b</sup>	28 <sup>c</sup>	449
Ovendry	0.42 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.23 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.48 GPa	1.57 × 10 <sup>6</sup> in/lb <sup>2</sup>	10.8 GPa
MOR	5.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	39.3 MPa	10.2 × 10 <sup>3</sup> in/lb <sup>2</sup>	70.3 MPa
C <sub>  </sub>	2.67 × 10 <sup>3</sup> in/lb <sup>2</sup>	18.4 MPa	5.61 × 10 <sup>3</sup> in/lb <sup>2</sup>	38.7 MPa
C <sub>⊥</sub>	0.28 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.93 MPa	0.58 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.00 MPa
WML	6.3 in-in/lb <sup>3</sup>	43.4 kJ/m <sup>3</sup>	9.4 in-in/lb <sup>3</sup>	64.8 kJ/m <sup>3</sup>
Hardness	350 lbf	1560 N	510 lbf	2270 N
Shear <sub>  </sub>	0.76 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.24 MPa	1.15 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.93 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	7.5	6.0	3.8
Radial	4.3	3.4	1.4
Volumetric	11.5	9.2	2.5

<sup>a</sup>Young growth may contain checks, splits or raised grain, possibly caused by fast-growth juvenile wood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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	T7-A5	NA	NA	NA	NA	NA
Upper grades	T12-B5	T12-B4	T11-B3	T5-B2	T5-B2	J

<sup>a</sup>Reference (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	294	294	287	287	287	290	288

<sup>a</sup>References (28, 185).

**Working Properties:** Sitka spruce is easily worked if free of knots.

**Durability:** The heartwood of spruce is slightly resistant to nonresistant to decay (56).

**Preservation:** It is resistant to preservation treatments under pressure, but can be treated by a water diffusion process.

**Uses:** Sitka spruce is used principally for lumber, pulpwood, and cooperage. Boxes and crates account for a considerable amount of the remanufactured lumber. Other important uses are furniture, planing-mill products, sash, doors, blinds, millwork, sounding boards for high quality pianos, guitar faces, ladders (rails), components for experimental light aircraft, oars, planking, masts and spars for boats, and turbine blades and boats. Sitka spruce has been by far the most important wood for aircraft construction, because it has the highest strength to weight ratio. Thin panels of Sitka spruce are highly resonant, making them desirable for piano sounding boards.

**Toxicity:** Working with fresh wood can cause dermatitis or other contact sensitivities (71, 158, 214).

**Additional Reading:** 15, 37, 46, 53, 66, 69, 72, 119, 201.



***Pinus* L. Pinaceae**  
**Pines**

The genus *Pinus* is composed of about 95 species native to the New World (North America and South America) [60] and the Old World (Eurasia and northern Africa) [35]. In the New World, it is native to the West Indies [4], Central America [5], Mexico [38], the United States, and Canada [37]. The wood of pine can be separated microscopically into the white, red, yellow, and the foxtail/pinyon pine groups. Pines native to the southeastern United States are generally referred to as “The Southern Pines,” all of which are in the yellow pine group. The word *pinus* is the classical Latin name. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name	Anatomical Group
<i>Pinus albicaulis</i>	Whitebark pine	White
<i>Pinus aristata</i>	Bristlecone pine	Foxtail/Pinyon
<i>Pinus attenuata</i>	Knobcone pine	Yellow
<i>Pinus balfouriana</i>	Foxtail pine	Foxtail/Pinyon
<i>Pinus banksiana*</i>	Jack pine	Yellow
<i>Pinus cembroides</i>	Mexican pinyon	Foxtail/Pinyon
<i>Pinus clausa*</i>	Sand pine	Yellow
<i>Pinus contorta*</i>	Lodgepole pine	Yellow
<i>Pinus coulteri</i>	Coulter pine	Yellow
<i>Pinus echinata*</i>	Shortleaf pine	Yellow
<i>Pinus edulis*</i>	Pinyon	Foxtail/Pinyon
<i>Pinus elliotii*</i>	Slash pine	Yellow
<i>Pinus engelmannii</i>	Apache pine	Yellow
<i>Pinus flexilis*</i>	Limber pine	White
<i>Pinus glabra*</i>	Spruce pine	Yellow
<i>Pinus jeffreyi*</i>	Jeffrey pine	Yellow
<i>Pinus lambertiana*</i>	Sugar pine	White
<i>Pinus leiophylla</i>	Chihuahua pine	Yellow
<i>Pinus monophylla</i>	Singleleaf Pinyon	Foxtail/Pinyon
<i>Pinus monticola*</i>	Western White pine	White
<i>Pinus muricata</i>	Bishop pine	Yellow
<i>Pinus palustris*</i>	Longleaf pine	Yellow
<i>Pinus ponderosa*</i>	Ponderosa pine	Yellow
<i>Pinus pungens*</i>	Table Mountain pine	Yellow
<i>Pinus quadrifolia</i>	Parry Pinyon	Foxtail/Pinyon
<i>Pinus radiata*</i>	Monterey pine	Yellow
<i>Pinus resinosa*</i>	Red pine	Red
<i>Pinus rigida*</i>	Pitch pine	Yellow
<i>Pinus sabiniana</i>	Digger pine	Yellow
<i>Pinus serotina*</i>	Pond pine	Yellow
<i>Pinus strobiformis</i>	Southwestern White pine	White
<i>Pinus strobus*</i>	Eastern White pine	White
<i>Pinus taeda*</i>	Loblolly pine	Yellow
<i>Pinus torreyana</i>	Torrey pine	Yellow
<i>Pinus virginiana*</i>	Virginia pine	Yellow
<i>Pinus washoensis</i>	Washoe pine	Yellow

***Pinus banksiana***  
**Lamb.**  
**Pinaceae**  
**Jack Pine**

The word *pinus* is the classical Latin name. The word *banksiana* is used in dedication to Joseph Banks (1743–1820), director of Kew Gardens, England, botanical collector, and patron of sciences, to whom its author was obliged for first knowledge of it.

**Other Common Names:** Banks-den, Banksian pine, banksiana-tall, Banks-pijn, banks-tall, black jack pine, black pine, blackjack pine, British Honduras pitch pine, bull pine, Canada horn pine, Canada horn-cone pine, Canadian horn pine, check pine, chek pine, cypres, cypress, eastern jack-pine, gray pine, Hudson Bay pine, juniper, labrador pine, northern scrub pine, pin chetif, pin de Banks, pin des rochers, pin gris, pin gris d’Amerique, pino banksiano, princess pine, scrub pine, Sir Joseph banks pine, Sir Joseph Banks pine, spruce pine, zwerg-kiefer.

**Distribution:** Jack pine is native to Cape Breton Islands, Nova Scotia, Prince Edward Island, New Brunswick, Maine, and central Quebec, west to northern Ontario, northern Manitoba, southwestern Keewatin, and western Mackinaw, south to extreme northwestern Indiana, Michigan, southern Ontario, northern New York, and New Hampshire.

**The Tree:** Jack pine trees normally reach heights of 65 ft (19.81 m), with diameters of 10 in. (25.40 cm). Exceptional trees can be found that are 100 ft (30.48 m) tall, with diameters of 2 ft (0.61 m).

**General Wood Characteristics:** The sapwood of jack pine is nearly white, and the heartwood is light brown to orange. The sapwood may make up half or more of the volume of a tree. The wood has a rather coarse texture and is somewhat resinous. It is moderately light in weight, moderately low in bending and compressive strength, moderately low in shock resistance, and low in stiffness. It also has moderately small shrinkage. Lumber from jack pine is generally knotty. In lumber, jack pine is sometimes included along with other pines with which it grows, including red pine and eastern white pine.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.40 <sup>a</sup>	50 <sup>b</sup>	801
12%	0.43 <sup>a</sup>	39 <sup>b</sup>	625
Ovendry	0.46 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.07 \times 10^6$ in/lb <sup>2</sup>	7.38 GPa	$1.35 \times 10^6$ in/lb <sup>2</sup>	9.31 GPa
MOR	$6.00 \times 10^3$ in/lb <sup>2</sup>	41.4 MPa	$9.90 \times 10^3$ in/lb <sup>2</sup>	68.3 MPa
C <sub>  </sub>	$2.95 \times 10^3$ in/lb <sup>2</sup>	20.3 MPa	$5.66 \times 10^3$ in/lb <sup>2</sup>	39.0 MPa
C <sub>⊥</sub>	$0.30 \times 10^3$ in/lb <sup>2</sup>	2.07 MPa	$0.58 \times 10^3$ in/lb <sup>2</sup>	4.00 MPa
WML	7.2 in-in/lb <sup>3</sup>	49.6 kJ/m <sup>3</sup>	8.3 in-in/lb <sup>3</sup>	57.2 kJ/m <sup>3</sup>
Hardness	400 lbf	1780 N	570 lbf	2530 N
Shear <sub>  </sub>	$0.75 \times 10^3$ in/lb <sup>2</sup>	5.17 MPa	$1.17 \times 10^3$ in/lb <sup>2</sup>	8.07 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	6.6	NA	NA
Radial	3.7	NA	NA
Volumetric	10.3	NA	NA

<sup>a</sup>Reference (56).

### 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 <sup>a</sup>	T9-C4	NA	T9-C3	NA	NA	NA
Upper grades <sup>b</sup>	T12-B4	NA	T11-B3	T7-A3	T7-A3	L

<sup>a</sup>References (28, 185).

<sup>b</sup>References (74, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	NA	NA	NA

<sup>a</sup>References (28, 185)(Omit first 12 h of schedule).

#### High temperature<sup>a</sup>

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

<sup>a</sup>References (28, 185).

**Working Properties:** Jack pine ranks average in workability with tools. Compared with red pine, it has lower nail-holding capacity and is more liable to split when nailed.

**Durability:** Jack pine's durability is very limited when exposed to conditions favorable to decay (56, 177).

**Preservation:** Penetration with preservatives is difficult (177).

**Uses:** Jack pine is used for pulpwood, box lumber, pallets, and fuel. Less important uses include mine timber, slack cooperage, poles, and posts.

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

**Additional Reading:** 46, 53, 119, 171, 178, 179.

***Pinus clausa***  
**(Chapm. Ex Engelm.)**  
**Vasey ex Sarg.**  
**Pinaceae**  
**Sand Pine**

The word *pinus* is the classical Latin name. The word *clausa* means “closed,” referring to the serotinous cones being closed for several years before releasing seeds (in some populations of this species).

**Other Common Names:** Alabama pijn, Alabama pine, Alabama tall, Florida spruce pine, northern sand pine, oldfield pine, pin d’Alabama, pino de Alabama, pino di Alabama, scrub pine, southern sand pine, spruce pine, upland spruce pine.

**Distribution:** Sand pine is native to northeastern to southern and northwestern Florida and extreme southern Alabama.

**The Tree:** Sand pine trees can reach heights of 80 ft (24.38 m), with diameters of 2 ft (0.61 m). The record tree in Florida has a height of 103 ft (31.39 m), with a diameter of 2 ft (0.61 m). Most trees are small and shrubby, growing to only 15 to 20 ft (4.57 to 6.10 m).

**General Wood Characteristics:** Sand pine is normally a small shrubby tree; therefore, no general information about the wood is available at this time.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.46 <sup>a</sup>	38 <sup>b</sup>	609
12%	0.48 <sup>a</sup>	34 <sup>b</sup>	545
Ovendry	0.51 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (153).

**Mechanical properties**

Property	Green		Dry	
	MOE <sup>a</sup>	1.02 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.03 GPa	1.41 × 10 <sup>6</sup> in/lb <sup>2</sup>
MOR <sup>a</sup>	7.50 × 10 <sup>3</sup> in/lb <sup>2</sup>	51.7 MPa	11.6 × 10 <sup>3</sup> in/lb <sup>2</sup>	80.0 MPa
C <sub>  </sub> <sup>a</sup>	3.44 × 10 <sup>3</sup> in/lb <sup>2</sup>	23.7 MPa	6.92 × 10 <sup>3</sup> in/lb <sup>2</sup>	47.7 MPa
C <sub>⊥</sub> <sup>a</sup>	0.45 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.10 MPa	0.84 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.79 MPa
WML <sup>a</sup>	9.6 in-in/lb <sup>3</sup>	66.2 kJ/m <sup>3</sup>	9.6 in-in/lb <sup>3</sup>	66.2 kJ/m <sup>3</sup>
Hardness <sup>b</sup>	480 lbf	2130 N	730 lbf	3250 N
Shear <sub>  </sub>	1.14 × 10 <sup>3</sup> in/lb <sup>2a</sup>	7.86 MPa	1.10 × 10 <sup>3</sup> in/lb <sup>2b</sup>	7.58 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

<sup>b</sup>Reference (153) (2-in. (5-cm) standard).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.3	NA	NA
Radial	3.9	NA	NA
Volumetric	10.0	NA	NA

<sup>a</sup>Reference (153).

**Kiln Drying Schedules:** No information available at this time.

**Working Properties:** No information available at this time.

**Durability:** No information available at this time.

**Preservation:** No information available at this time.

**Uses:** Used locally for sand retention and fuel wood.

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

**Additional Reading:** 32, 43, 46, 53, 119.

***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**

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

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (192).

<sup>c</sup>Reference (56).

### Mechanical properties<sup>a</sup>

Property	Green		Dry	
MOE	$1.08 \times 10^6$ in/lb <sup>2</sup>	7.45 GPa	$1.34 \times 10^6$ in/lb <sup>2</sup>	9.24 GPa
MOR	$5.50 \times 10^3$ in/lb <sup>2</sup>	37.9 MPa	$9.40 \times 10^3$ in/lb <sup>2</sup>	64.8 MPa
C <sub>  </sub>	$2.61 \times 10^3$ in/lb <sup>2</sup>	18.0 MPa	$5.37 \times 10^3$ in/lb <sup>2</sup>	37.0 MPa
C <sub>⊥</sub>	$0.25 \times 10^3$ in/lb <sup>2</sup>	1.72 MPa	$0.61 \times 10^3$ in/lb <sup>2</sup>	4.21 MPa
WML	5.6 in-in/lb <sup>3</sup>	38.6 kJ/m <sup>3</sup>	6.8 in-in/lb <sup>3</sup>	46.9 kJ/m <sup>3</sup>
Hardness	330 lbf	1470 N	480 lbf	2130 N
Shear <sub>  </sub>	$0.68 \times 10^3$ in/lb <sup>2</sup>	4.69 MPa	$0.88 \times 10^3$ in/lb <sup>2</sup>	6.07 MPa

<sup>a</sup>Reference (192) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

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

<sup>a</sup>It shrinks appreciably, but seasons easily. May contain warp, possibly as a result of compression wood (178).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules

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

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	291	294	294	289

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

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

<sup>a</sup>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.



***Pinus echinata* Mill.**  
**Pinaceae**  
**Shortleaf Pine**

The word *pinus* is the classical Latin name. The word *echinata* means spiny or prickly, referring to the cones. Shortleaf pine is one of the southern pines.

**Other Common Names:** Amerikaanse shortleaf, Arkansas pine, Arkansas shortleaf pine, Arkansas soft pine, bull pine, Carolina pine, forest pine, igel kiefer, North Carolina pine, North Carolina yellow pine, oldfield pine, pin a feuilles courtes, pin dortleaf, pin doux, pin shortleaf, pino pece Americano, pino tea Americano, pitch pine, poor pine, rosemary, Rosemary pine, rosemary shortleaf, shortleaf yellow pine, shortleaved pine, shortschat pine, shortstraw pine, slash pine, soderns gul-tall, southern yellow pine, spruce pine, sydstaternas gul-tall, Virginia yellow pine, yellow pine, yellow shortleaf pine, yellow yellow pine.

**Distribution:** Shortleaf pine is native to extreme southeastern New York and New Jersey, west to Pennsylvania, southern Ohio, eastern Kentucky, southern Illinois and southern Missouri, south to eastern Oklahoma and eastern Texas, east to northern Florida and Georgia.

**The Tree:** Shortleaf pine trees normally reach heights of 100 ft (30.48 m), with diameters of 3 ft (0.91 m). Exceptional trees may grow to 130 ft tall (39.62 m), with a diameter of 4 ft (1.22 m).

**General Wood Characteristics:** The sapwood of shortleaf pine is a yellowish white, and the heartwood is a reddish brown. The sapwood is usually wide in second growth stands. Heartwood begins to form when the tree is about 20 years old. In old, slow-growth trees, sapwood may be only 1 to 2 in. (2.54 to 5.08 cm) in width. The wood of shortleaf pine is very heavy and strong, very stiff, hard, and moderately high in shock resistance. It also has a straight grain and a medium texture.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(32%) <sup>a</sup>	0.47 <sup>b</sup>	52 <sup>c</sup>	833
12%	0.51 <sup>b</sup>	36 <sup>c</sup>	577
Ovendry	0.54 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.39 \times 10^6$ in/lb <sup>2</sup>	9.58 GPa	$1.75 \times 10^6$ in/lb <sup>2</sup>	12.0 GPa
MOR	$7.40 \times 10^3$ in/lb <sup>2</sup>	51.0 MPa	$13.1 \times 10^3$ in/lb <sup>2</sup>	90.3 MPa
C <sub>  </sub>	$3.53 \times 10^3$ in/lb <sup>2</sup>	24.3 MPa	$7.27 \times 10^3$ in/lb <sup>2</sup>	50.1 MPa
C <sub>⊥</sub>	$0.35 \times 10^3$ in/lb <sup>2</sup>	2.41 MPa	$0.82 \times 10^3$ in/lb <sup>2</sup>	5.65 MPa
WML	8.2 in-in/lb <sup>3</sup>	56.5 kJ/m <sup>3</sup>	11.0 in-in/lb <sup>3</sup>	75.8 kJ/m <sup>3</sup>
Hardness	440 lbf	1960 N	690 lbf	3070 N
Shear <sub>  </sub>	$0.91 \times 10^3$ in/lb <sup>2</sup>	6.27 MPa	$1.39 \times 10^3$ in/lb <sup>2</sup>	9.58 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.7	6.2	2.6
Radial	4.6	3.5	1.5
Volumetric	12.3	9.8	4.1

<sup>a</sup>May contain brown sapwood stain, checks and splits, possibly as a result of excessive drying temperatures (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest Quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	403 <sup>b</sup>

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (185).

**Working Properties:** Shortleaf pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but can be difficult to glue.

**Durability:** The heartwood is moderate to low in resistance to decay (56).

**Preservation:** The sapwood is more easily impregnated with preservatives.

**Uses:** The dense, high strength lumber of southern pines are used extensively for stringers in construction of factories, warehouses, bridges, trestles, docks, roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses as building material, such as interior finish, sheathing, subflooring, joists, boxes, pallets, and crates. Southern pines are also used for tight and slack cooperage. When used for piles, poles, and mine timbers, southern pines are usually treated with preservatives. Structural grade plywood from southern pine is a major use.

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

**Additional Reading:** 44, 51, 59, 73, 97, 120, 183.

***Pinus edulis* Engelm.**  
**Pinaceae**  
**Pinyon**

The word *pinus* is the classical Latin name. The word *edulis* means edible, referring to the large seeds, known as pinyon nuts, pine nuts, and pinones.

**Other Common Names:** Arizona pijn, Arizona pine, Arizona-tall, Colorado pijn, Colorado pine, Colorado pinyon, foxtail pine, nut pine, pin d'Arizona, pinien-nussbaum, pino di Colorado, pinon, pinyon Colorado, two-leaf pinyon, two-needle pinyon.

**Distribution:** Pinyon is native to the southern Rocky Mountain region, predominantly in the foothills, from Colorado and Utah south to central Arizona and southern New Mexico. It is also found locally in southwestern Wyoming, extreme northwestern Oklahoma, the Trans-Pecos area of Texas, southeastern California, and northwestern Mexico (Chihuahua).

**The Tree:** Pinyon trees reach heights of 10 to 51 ft (3.05 to 15.54 m), with diameters of 6 to 30 in. (15.24 to 76.20 cm), depending on site conditions. An exceptionally large specimen was recorded at 69 ft (21.03 m) tall, with a diameter of more than 5 ft (1.52 m). Pinyons generally are small trees, growing less than 35 ft (10.67 m) tall, with diameters less than 18 in. (45.72 cm). Pinyons are long lived, growing for 75 to 200 years, with dominant trees being 400 years old. Pinyons 800 to 1,000 years old have been recorded.

**General Wood Characteristics:** The wood of pinyon is moderately heavy compared with other pines. It is slow grown and often knotty, but strong. The heartwood is yellow.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.50	51	817
12%	0.53	37	593
Ovendry	0.57	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$0.65 \times 10^6$ in/lb <sup>2</sup>	4.48 GPa	$1.14 \times 10^6$ in/lb <sup>2</sup>	7.86 GPa
MOR	$4.80 \times 10^3$ in/lb <sup>2</sup>	33.1 MPa	$7.80 \times 10^3$ in/lb <sup>2</sup>	53.8 MPa
C <sub>  </sub>	$2.59 \times 10^3$ in/lb <sup>2</sup>	17.9 MPa	$6.40 \times 10^3$ in/lb <sup>2</sup>	44.1 MPa
C <sub>⊥</sub>	$0.48 \times 10^3$ in/lb <sup>2</sup>	3.31 MPa	$1.52 \times 10^3$ in/lb <sup>2</sup>	10.5 MPa
WML	7.6 in-in/lb <sup>3</sup>	52.4 kJ/m <sup>3</sup>	4.7 in-in/lb <sup>3</sup>	32.4 kJ/m <sup>3</sup>
Hardness	600 lbf	2670 N	860 lbf	3820 N
Shear <sub>  </sub>	$0.92 \times 10^3$ in/lb <sup>2</sup>	6.34 MPa	NA	NA

<sup>a</sup>Reference (153) (2-in. (5-cm) standard).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	5.2	NA	NA
Radial	4.6	NA	NA
Volumetric	9.9	NA	NA

<sup>a</sup>Reference (153).

**Kiln Drying Schedules:** No information available at this time.

**Working Properties:** No information available at this time.

**Durability:** No information available at this time.

**Preservation:** No information available at this time.

**Uses:** Firewood, novelties, mine timbers, pulping, charcoal. The nuts are a culinary delicacy, and the trees have been used as commercial Christmas trees.

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

**Additional Reading:** 44, 51, 120, 168.

***Pinus elliottii* Engelm.**  
**Pinaceae**  
**Slash Pine**

The word *pinus* is the classical Latin name. The name *elliottii* is used in honor of Stephen Elliott (1771–1830), botanist and banker of South Carolina and author of “Sketch of the Botany of South Carolina and Georgia.” Slash pine has two recognized varieties: the typical slash pine (*Pinus elliottii* Engelm. var. *elliotti*) and South Florida slash pine (*Pinus elliottii* var. *densa* Little & Dorman).

**Other Common Names:** American pitch pine, bastard pine, British Honduras pitch pine, Cuba pine, Cuban pine, Dade County pine, Dade County slash pine, Elliott-tall, Florida pine, Florida southern pine, Florida-tall, Gulf Coast pitch pine, longleaf, longleaf pine, longleaf pitch pine, longleaf yellow pine, meadow pine, Nicaraguan pine, pin de la Floride du sud, pinavete, pino de Florida del sur, pino di Florida del sud, pino grasso, pino pece, pino tea, pitch pine, pitchpin Americain, saltwater pine, she pine, South Florida slash pine, Southern Florida pine, southern Florida slash pine, southern pine, southern yellow pine, spruce pine, swamp pine, thong, yellow pine, yellow slash pine, Zuid-Florida pijn.

**Distribution:** Slash pine is native to the coastal plains from southern South Carolina to southern Florida (also the lower Florida Keys), west to southeast Louisiana.

**The Tree:** Slash pine trees reach heights of 70 ft (21.34 m), with a diameter of 2 ft (0.61 m).

**General Wood Characteristics:** The sapwood of slash pine is a yellowish white, and the heartwood is a reddish brown. It is very strong and heavy, very stiff, hard, and moderately high in shock resistance. It has straight grain and has a medium texture.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.54 <sup>a</sup>	56 <sup>b</sup>	897
12%	0.59 <sup>a</sup>	41 <sup>b</sup>	657
Ovendry	0.66 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.53 \times 10^6$ in/lb <sup>2</sup>	10.5 GPa	$1.98 \times 10^6$ in/lb <sup>2</sup>	13.6 GPa
MOR	$8.70 \times 10^3$ in/lb <sup>2</sup>	60.0 MPa	$16.3 \times 10^3$ in/lb <sup>2</sup>	112 MPa
C <sub>  </sub>	$3.82 \times 10^3$ in/lb <sup>2</sup>	26.3 MPa	$8.14 \times 10^3$ in/lb <sup>2</sup>	56.1 MPa
C <sub>⊥</sub>	$0.53 \times 10^3$ in/lb <sup>2</sup>	3.65 MPa	$1.02 \times 10^3$ in/lb <sup>2</sup>	7.03 MPa
WML	9.6 in-in/lb <sup>3</sup>	66.2 kJ/m <sup>3</sup>	13.2 in-in/lb <sup>3</sup>	91.0 kJ/m <sup>3</sup>
Hardness	NA	NA	NA	NA
Shear <sub>  </sub>	$0.96 \times 10^3$ in/lb <sup>2</sup>	6.62 MPa	$1.68 \times 10^3$ in/lb <sup>2</sup>	11.58 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.6	6.2	2.6
Radial	5.4	4.4	1.8
Volumetric	12.1	9.8	4.1

<sup>a</sup>May contain brown sapwood stain, checks and splits, possibly caused by excessive drying temperatures (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest Quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	403 (2 by4's)

<sup>a</sup>References (28, 185).

**Working Properties:** Slash pine is difficult to work with using hand tools, but ranks high in nail-holding capacity.

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

**Preservation:** The sapwood is easy to impregnate with preservatives; the heartwood is difficult to impregnate. Pressure treatments may considerably extend durability and usefulness of the sapwood.

**Uses:** The wood is used for heavy construction (bridges, trestles, and dock works), pulp, plywood, utility poles, piling, railroad ties, and mine timbers. The resin is used for rosin and turpentine.

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

**Additional Reading:** 59, 73, 76, 120, 134, 164.

***Pinus flexilis* James**  
**Pinaceae**  
**Limber Pine**

The word *pinus* is the classical Latin name. The word *flexilis* means flexible or limber.

**Other Common Names:** Bull pine, Californische buigzame pijn, hallarin, hange kiefer, jack pine, limber-twig pine, mjuk-tall, pin blanc de l'ouest, pin pliable de l'ouest, pino enano, pino flessibile, pino flexible, pino huiyoco, pino nayar, Rocky Mountain pine, Rocky Mountain white pine, western white pine, white pine.

**Distribution:** Limber pine is native to the Rocky Mountain region, from southwestern Alberta and southeastern British Columbia, south and in the mountains of Montana, Idaho, Nevada, and central and southern California, east to northern New Mexico and north to Colorado and Wyoming. It is also locally found in northeastern Oregon, northern Arizona, western Nebraska, the Black Hills of South Dakota, and southwestern North Dakota.

**The Tree:** Limber pine trees reach heights of 50 ft (15.24 m), with diameters of 2 ft (0.61 m). Exceptional trees have been reported to have heights of 80 ft (24.38 m) and diameters of 4 ft (1.22 m).

**General Wood Characteristics:** The wood of limber pine is light, soft, close grained, and is easily worked with tools. The sapwood is narrow and a creamy white, and the heartwood is brownish to orange-yellow and may turn reddish brown upon exposure to the air.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.37	39	625
12%	0.40	28	449
Ovendry	0.42	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$0.80 \times 10^6$ in/lb <sup>2</sup>	5.52 GPa	$1.17 \times 10^6$ in/lb <sup>2</sup>
MOR	$5.20 \times 10^3$ in/lb <sup>2</sup>	35.8 MPa	$9.10 \times 10^3$ in/lb <sup>2</sup>	62.7 MPa
C <sub>  </sub>	$2.41 \times 10^3$ in/lb <sup>2</sup>	16.6 MPa	$5.29 \times 10^3$ in/lb <sup>2</sup>	36.5 MPa
C <sub>⊥</sub>	$0.32 \times 10^3$ in/lb <sup>2</sup>	2.21 MPa	$0.72 \times 10^3$ in/lb <sup>2</sup>	4.96 MPa
WML	5.2 in-in/lb <sup>3</sup>	35.8 kJ/m <sup>3</sup>	6.8 in-in/lb <sup>3</sup>	46.9 kJ/m <sup>3</sup>
Hardness	310 lbf	1380 N	430 lbf	1910 N
Shear <sub>  </sub>	$0.74 \times 10^3$ in/lb <sup>2</sup>	5.10 MPa	$0.80 \times 10^3$ in/lb <sup>2</sup>	5.52 MPa

<sup>a</sup>Reference (153) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	5.1	NA	NA
Radial	2.4	NA	NA
Volumetric	8.2	NA	NA

<sup>a</sup>Reference (153).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	NA	NA	NA	NA	NA	NA

<sup>a</sup>References (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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 <sup>b</sup>	291 <sup>b</sup>	291 <sup>b</sup>	291 <sup>b</sup>	294	294	NA

<sup>a</sup>References (28, 185).

<sup>b</sup>Omit first 12 h of schedule. Reference (28).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400 <sup>b,c</sup>	400 <sup>b</sup>	400 <sup>b</sup>	412 <sup>d</sup>

<sup>a</sup>References (28, 185).

<sup>b</sup>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).

<sup>c</sup>Reduce step 1 and 2 to 6 h for 4/4-5/4 for western species. Reference (28).

<sup>d</sup>Studs. Reference (28).

**Working Properties:** Limber pine works well with tools.

**Durability:** No information available at this time.

**Preservation:** No information available at this time.

**Uses:** Boxes, railroad ties, poles, mine timbers, locally for fuel.

**Toxicity:** In general, working with pine wood can cause dermatitis, allergic bronchial asthma, or rhinitis in some individuals (70, 151, 206).

**Additional Reading:** 44, 51, 120, 180.



***Pinus glabra* Walt.**  
**Pinaceae**  
**Spruce Pine**

The word *pinus* is the classical Latin name. The word *glabra* means glabrous or smooth, referring to the bark.

**Other Common Names:** Amerikaanse witte pijn, black pine, bottom white pine, cedar pine, kings-tree, lowland spruce pine, pin blanc Americain, pino blanco Americano, poor pine, southern white pine, spruce lowland pine, Walter pine, white pine.

**Distribution:** Spruce pine is native to the coastal plain from eastern South Carolina to northern Florida and west to southeastern Louisiana.

**The Tree:** Spruce pine trees reach heights of 100 ft (30.48 m), with diameters of 3 ft (0.91 m). A record tree has been recorded at a height of 123 ft (37.49 m), with a diameter of more than 4 ft (1.22 m). In stands, spruce pine self prunes to a height of 60 ft (18.29 m).

**General Wood Characteristics:** The sapwood of spruce pine is a yellowish white; the heartwood is a reddish brown. The sapwood is usually wide in second-growth stands. Heartwood begins to form when the tree is about 20 years old. In old, slow-growth trees, sapwood may be only 1 to 2 in. (2.54 to 5.08 cm) in width. The wood of spruce pine is very heavy and strong, very stiff, hard, and moderately high in shock resistance. It has a straight grain and a medium texture. Spruce pine wood is lower in most strength values than the major southern pines. It compares favorably with white fir in important bending properties, in crushing strength, perpendicular and parallel to the grain, and in hardness. It is similar to the denser species, such as coast Douglas-fir and loblolly pine, in shear parallel to the grain.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.41	NA	NA
12%	0.44	NA	NA
Ovendry	NA	NA	NA

<sup>a</sup>Reference (56).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.00 \times 10^6$ in/lb <sup>2</sup>	6.89 GPa	$1.23 \times 10^6$ in/lb <sup>2</sup>	8.48 GPa
MOR	$6.00 \times 10^3$ in/lb <sup>2</sup>	41.4 MPa	$10.4 \times 10^3$ in/lb <sup>2</sup>	71.7 MPa
C <sub>  </sub>	$2.84 \times 10^3$ in/lb <sup>2</sup>	19.6 MPa	$5.65 \times 10^3$ in/lb <sup>2</sup>	39.0 MPa
C <sub>⊥</sub>	$0.28 \times 10^3$ in/lb <sup>2</sup>	1.93 MPa	$0.73 \times 10^3$ in/lb <sup>2</sup>	5.03 MPa
WML	NA	NA	NA	NA
Hardness	450 lbf	2000 N	660 lbf	2940 N
Shear <sub>  </sub>	$0.90 \times 10^3$ in/lb <sup>2</sup>	6.20 MPa	$1.49 \times 10^3$ in/lb <sup>2</sup>	10.27 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

**Drying and shrinkage:** No shrinkage information available at this time.

**Kiln drying schedules**

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest Quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 91, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 91, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4 403 2 by 10 403 4 by 4 404

<sup>a</sup>References (28, 91, 185). All the southern pines have moderately high shrinkage but are stable when properly seasoned.

**Working Properties:** Spruce pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but it is difficult to glue.

**Durability:** The heartwood is moderate to low in resistance to decay (56).

**Preservation:** The sapwood is more easily impregnated with preservatives than is the heartwood.

**Uses:** The dense and high strength lumber of southern pines are used extensively for stringers in construction of factories, warehouses, bridges, trestles, docks, roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses for building material, such as interior finish, sheathing, subflooring, joists, boxes, pallets, and crates. Southern pines are also used for tight and slack cooperage. When used for railroad cross ties, piles, poles and mine timbers, it is usually treated with preservatives. Structural grade plywood from southern pine has become a major use. Until recent years, the principal uses of spruce pine were locally for lumber, pulpwood, and fuel wood. The lumber reportedly was used for sash, doors, and interior finish because of its lower specific gravity and less marked distinction between earlywood and latewood. Recently, it is used for plywood.

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

**Additional Reading:** 44, 51, 59, 91, 120, 183, 185.

***Pinus jeffreyi***  
**Grev. & Balf.**  
**Pinaceae**  
**Jeffrey Pine**

The word *pinus* is the classical Latin name. The word *jeffreyi* is used in honor of the discoverer, John Jeffrey (1826–1853), Scottish botanical explorer who collected seeds and plants in Oregon and California (1850–1853) for introduction in Scotland. Jeffrey pine was first classified as a variety of ponderosa pine and has the identical wood properties of ponderosa pine.

**Other Common Names:** Blackbark pine, blackwood pine, bull pine, Jeffrey pijn, Jeffrey’s pine, Jeffrey-tall, peninsula black pine, peninsula pine, pin de Jeffrey, pino de Jeffrey, pino di Jeffrey, pino negro, pinos, ponderosa pine, redbark pine, redbark sierra pine, sapwood pine, truckee pine, western black pine, western yellow pine.

**Distribution:** Jeffrey pine is native to the mountains of southwestern Oregon, south in California through the Sierra Nevada to western Nevada and southern California. It is also found in northern Mexico.

**The Tree:** Jeffrey pine trees reach heights of 200 ft (60.96 m), with diameters of 6 ft (1.83 m). A survivor of early timber harvests was measured at a height of 175 ft (53.34 m) and a diameter of 7.5 ft (2.29 m). Jeffrey pine trees may live to be 500 years of age.

**General Wood Characteristics:** Jeffrey pine is identical to ponderosa pine, with respect to its mechanical and physical properties. Both are in the Yellow Pine Grouping. The following general information is for ponderosa pine. The heartwood is yellowish to light reddish brown or orange, and the wide sapwood is nearly white to pale yellow. In young trees, the sapwood can make up over half the volume; in older trees, the sapwood may be 2 in. (5.08 cm) or more wide. The wood of the outer portions of saw timber size is moderately light in weight, moderately low in strength, moderately soft, moderately stiff, and moderately low in shock resistance. It is moderately weak in bending and endwise compression. It is straight grained (but can be dimpled on the tangential surface) and has moderately low shrinkage. It is quite uniform in texture and has little tendency to warp and twist.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.37	47	753
12%	0.40	28	449
Ovendry	0.42	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$0.98 \times 10^6$ in/lb <sup>2</sup>	6.76 GPa	$1.24 \times 10^6$ in/lb <sup>2</sup>
MOR	$5.00 \times 10^3$ in/lb <sup>2</sup>	34.5 MPa	$9.30 \times 10^3$ in/lb <sup>2</sup>	64.1 MPa
C <sub>  </sub>	$2.37 \times 10^3$ in/lb <sup>2</sup>	16.3 MPa	$5.53 \times 10^3$ in/lb <sup>2</sup>	38.1 MPa
C <sub>⊥</sub>	$0.35 \times 10^3$ in/lb <sup>2</sup>	2.41 MPa	$0.79 \times 10^3$ in/lb <sup>2</sup>	5.45 MPa
WML	4.7 in-in/lb <sup>3</sup>	32.4 kJ/m <sup>3</sup>	6.6 in-in/lb <sup>3</sup>	45.5 kJ/m <sup>3</sup>
Hardness	340 lbf	1510 N	500 lbf	2220 N
Shear <sub>  </sub>	$0.69 \times 10^3$ in/lb <sup>2</sup>	4.76 MPa	$1.21 \times 10^3$ in/lb <sup>2</sup>	8.34 MPa

<sup>a</sup>Reference (153) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.7	5.0	2.1
Radial	4.4	3.1	1.3
Volumetric	9.9	7.7	3.2

<sup>a</sup>Reference (153), Jeffrey pine.

<sup>b</sup>Reference (192), ponderosa pine.

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T9-C6	T7-C5	T7-C5	T7-A4	T7-A4	L
Anti-brown Stain	T7-E6	NA	T7-E5	NA	NA	NA

<sup>a</sup>References (28, 185), ponderosa pine.

Conventional temperature/time-controlled schedules

Condition	Lower grades <sup>a</sup>			Upper grades <sup>b</sup>			
	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	299	300	301	302

<sup>a</sup>References (28, 185), Jeffrey pine.

<sup>b</sup>References (28, 185), ponderosa pine.

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185), ponderosa pine.

**Working Properties:** Like ponderosa pine, Jeffrey pine works easily with both hand and machine tools. It finishes and glues well, but the presence of numerous knots can make painting difficult. It is resistant to splitting when nailed but is rated average in nail-holding ability.

**Durability:** As with ponderosa pine, Jeffrey pine is not durable under conditions favorable to decay unless treated with a preservative. The heartwood is slightly resistant to nonresistant to decay (56). Can be susceptible to attack by dry wood termites, ambrosia (pinhole borer) beetles, longhorn beetles, and Buprestid beetles.

**Preservation:** Like ponderosa pine, the sapwood of Jeffrey pine is permeable to preservatives, and the heartwood is moderately resistant to preservative treatments.

**Uses:** Like ponderosa pine, Jeffrey pine is used mainly for lumber and to a lesser extent for piles, poles, posts, mine timbers, veneer, and railroad cross ties. The clear wood is especially well suited for millwork, such as window frames, doors, shelving, mouldings, sash doors, blinds, paneling, mantels, trim, and built-in cases and cabinets. Lower grade lumber is used for boxes and crates. Much of the lumber of intermediate or Lower grades goes into sheathing, subflooring, and roof boards. Knotty Jeffrey pine is used for interior finish. Current uses include particleboard and paper.

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

**Additional Reading:** 44, 51, 78, 120, 138.

***Pinus lambertiana***  
**Dougl.**  
**Pinaceae**  
**Sugar Pine**

The word *pinus* is the classical Latin name. The name *lambertiana* is used in honor of Aylmer Bourke Lambert (1761–1842), from England, author of a classical illustrated work on the genus *Pinus* (including related conifers) and a patron of botany.

**Other Common Names:** Big pine, California sugar pine, Californische, gigantic pine, great sugar pine, Kalifornisch zucker-kiefer, pin de Lambert, pin geant, pin gigantesque, pino de azucar, pino gigantesco, purple-coned sugar, pine, shade pine, socker-tall, sockertall, suiker-pijn, true white pine, zuckerkiefer.

**Distribution:** Sugar pine is native to the mountains from western Oregon, south through California in the Sierra Nevada to western Nevada and southern California.

**The Tree:** Sugar pine trees attain heights of more than 200 ft (60.96 m), with diameters of 3 to 5 ft (0.91 to 1.52 m). They can reach ages of 500 years.

**General Wood Characteristics:** The sapwood of sugar pine is a creamy white to pale yellow, and the heartwood is buff to light brown, sometimes with a red tinge. With respect to mechanical and physical properties, sugar pine resembles eastern and white pine white pine. It is light weight, moderately soft, and has a straight, even grain with an even texture. It is easy to work with using tools, has low shrinkage, high dimensional stability, and seasons without warping or checking. It is low in strength, shock resistance, and stiffness. It has no characteristic taste or odor.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(98%) <sup>a</sup>	0.34 <sup>b</sup>	52 <sup>c</sup>	833
12%	0.36 <sup>b</sup>	25 <sup>c</sup>	401
Ovendry	0.38 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.03 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.10 GPa	1.19 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.20 GPa
MOR	4.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	33.8 MPa	8.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	56.5 MPa
C <sub>  </sub>	2.46 × 10 <sup>3</sup> in/lb <sup>2</sup>	17.0 MPa	4.46 × 10 <sup>3</sup> in/lb <sup>2</sup>	30.7 MPa
C <sub>⊥</sub>	0.21 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.45 MPa	0.50 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.45 MPa
WML	5.4 in-in/lb <sup>3</sup>	37.2 kJ/m <sup>3</sup>	5.5 in-in/lb <sup>3</sup>	37.9 kJ/m <sup>3</sup>
Hardness	270 lbf	1200 N	380 lbf	1690 N
Shear <sub>  </sub>	0.72 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.96 MPa	1.13 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.79 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	5.6	4.5	1.9
Radial	2.9	2.3	1.0
Volumetric	7.9	6.3	2.6

<sup>a</sup>May contain brown stain, possibly as a result of wetwood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>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						
Light	T9-E7	T7-E6	NA	NA	NA	NA
Heavy	NA	NA	NA	NA	NA	NA
Upper grades						
Light	T5-E6	T5-E6	T5-E5	NA	NA	L
Heavy	T5-F6	T5-F6	T5-F5	NA	NA	NA

<sup>a</sup>References (28,185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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
Heavy	304	305	305	304	305	NA	NA
Light	303	303	306	303	303	305	307

<sup>a</sup>References (28, 185).

**Working Properties:** Sugar pine is easy to work with using tools and holds nails well.

**Durability:** The heartwood of sugar pine is slightly resistant to nonresistant to decay (56).

**Preservation:** No information at this time.

**Uses:** Boxes, crates, food containers, millwork (doors, sashes, trim, siding, panels), sheathing, subflooring, roofing, foundry patterns, piano keys, and organ pipes. Like eastern white pine, sugar pine is suitable for use in nearly every part of a house because of the ease with which it can be cut, its ability to stay in place, and its good nailing properties.

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

**Additional Reading:** 23, 76, 87, 88, 120, 202, 203, 210.

***Pinus monticola***  
**Dougl. Ex D. Don**  
**Pinaceae**  
**Western White Pine**

The word *pinus* is the classical Latin name. The word *monticola* means inhabiting mountains.

**Other Common Names:** Berg-tall, Columbia pijn, finger-cone pine, Idaho white pine, little sugar pine, mountain pine, mountain white pine, Norway white pine, pin argente, pin argente Americain, pino bianco Americano, pino blanco Americano, silver pine, soft pine, vasterns Weymouth-tall, Weymouth berg-pijn, Weymouth mountain pine, white pine, yellow pine.

**Distribution:** Western white pine is native to the mountains from northwestern Montana, extreme southwestern Alberta and southern British Columbia, south to Washington, Oregon, and California through the Sierra Nevada to western Nevada and central California.

**The Tree:** Western white pine trees reach heights of 180 ft (54.86 m), with a clear bole for 70 to 100 ft (21.34 to 30.48 m) and diameters of 3.5 ft (1.07 m). Over-mature trees may reach heights of 197 ft (60.05 m), with diameters of almost 6 ft (1.83 m). They may grow for 300 to 400 years.

**General Wood Characteristics:** The sapwood of western white pine is nearly white to pale yellow, and the heartwood is cream to light reddish brown and may turn darker upon exposure. The wood has a slight resinous odor, but no characteristic taste. It is straight grained and has a rather coarse texture. It is soft, light, moderately weak in bending, moderately strong in end compression and moderately low in shock resistance. It works well with tools, glues well, and holds paint very well. It does not split when nailed, but has medium nail-holding ability. It is easy to dry, has moderate shrinkage, and stays in place well after proper drying. It is low in decay resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(62%) <sup>a</sup>	0.35 <sup>b</sup>	35 <sup>c</sup>	561
12%	0.38 <sup>b</sup>	27 <sup>c</sup>	433
Ovendry	0.42 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.19 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.20 GPa	1.46 × 10 <sup>6</sup> in/lb <sup>2</sup>	10.1 GPa
MOR	4.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	32.4 MPa	9.70 × 10 <sup>3</sup> in/lb <sup>2</sup>	66.9 MPa
C <sub>  </sub>	2.43 × 10 <sup>3</sup> in/lb <sup>2</sup>	16.7 MPa	5.04 × 10 <sup>3</sup> in/lb <sup>2</sup>	34.7 MPa
C <sub>⊥</sub>	0.19 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.31 MPa	0.47 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.24 MPa
WML	5.0 in-in/lb <sup>3</sup>	34.5 kJ/m <sup>3</sup>	8.8 in-in/lb <sup>3</sup>	60.7 kJ/m <sup>3</sup>
Hardness	260 lbf	1160 N	420 lbf	1870 N
Shear <sub>  </sub>	0.68 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.69 MPa	1.04 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.17 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).



### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.4	5.9	2.5
Radial	4.1	3.3	1.4
Volumetric	11.8	9.4	3.9

<sup>a</sup>May contain brown stain, possibly as a result of wetwood (178).

<sup>b</sup>Reference (56).

<sup>c</sup>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						
Standard	T9-C6	NA	T7-C6 <sup>b</sup>	NA	NA	NA
Water Core	T9-E6	NA	NA	NA	NA	NA
Upper grades						
Standard	T9-C5	T7-C5	T7-C4	T7-C4	T5-C3	L

<sup>a</sup>References (28, 185).

<sup>b</sup>Maximum wet-bulb depression 20°F, Reference (178).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	295	301	301	295	301	301	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It works well with tools, glues well, and holds paint very well. It does not split when nailed, but has medium nail-holding ability.

**Durability:** The heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** No information available at this time.

**Uses:** Practically all western white pine is sawed into lumber and used mainly for building construction, matches, boxes, patterns, and millwork products, such as sash, frames, doors, and blinds. In building construction, boards of the Lower grades are used for sheathing, knotty paneling, subflooring, and roof strips. High grade material is made into siding of various kinds, exterior and interior trim, and finish. It has practically the same uses as eastern white pine and sugar pine. It is also used for crates, cut stock, furniture, laminated roof decking, plywood, veneer, pulp, paper, and particle board.

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

**Additional Reading:** 44, 51, 64, 73, 120, 141.

***Pinus palustris* Mill.**  
**Pinaceae**  
**Longleaf Pine**

The word *pinus* is the classical Latin name. The name *palustris* means “of marshes.” Longleaf pine is also in a group called the southern pines, which includes Shortleaf pine (*P. echinata* Mill.), loblolly pine (*P. taeda* L.), and slash pine (*P. elliottii* Engelm.).

**Other Common Names:** American pitch pine, Amerikaanse pitchpine, broom pine, brown pine, fat pine, figured-tree, Florida longleaf pine, Florida pine, Florida yellow pine, Georgia heart pine, Georgia longleaf pine, Georgia pine, Georgia pitch pine, Georgia yellow pine, Gulf Coast pitch pine, hard pine, heart pine, hill pine, langbarrig tall, longleaf, longleaf pitch pine, longleaf yellow pine, longleaved pitch pine, longstraw pine, madera pino, moeras-pijn, North Carolina pitch pine, palustris pine, pin de Boston, pin des marais, pino del sur, pino giallo, pino grasso, pino palustre, pino pantano, pino pece, pino tea, pino tea roja, pitch pine, pitchpin, pitchpin Americanin, red pine, Rosemary pine, soderns gul-all, southern hard pine, southern heart pine, southern pine, southern pitch pine, southern yellow pine, sump-all, sumpf kiefer, swamp pine, sydstaternas gul-tall, tea pine, Texas longleaf pine, Texas yellow pine, turpentine pine, yellow pine.

**Distribution:** Longleaf pine is native to the southeastern United States, in the Coastal Plain from southeastern Virginia to central Florida and west to eastern Texas.

**The Tree:** Longleaf pine trees reach heights of 100 ft (30.48 m), with a diameter of 3 ft (0.91 m).

**General Wood Characteristics:** The sapwood of longleaf pine is a yellowish white; the heartwood is a reddish brown. The sapwood is usually wide in second-growth stands. Heartwood begins to form when the tree is about 20 years old. In old, slow-growth trees, sapwood may be only 1 to 2 in. (2.54 to 5.08 cm) in width. The wood of longleaf pine is very heavy and strong, very stiff, hard, and moderately high in shock resistance. It also has a straight grain and a medium texture.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(31%) <sup>a</sup>	0.54 <sup>b</sup>	55 <sup>c</sup>	881
12%	0.59 <sup>b</sup>	41 <sup>c</sup>	657
Ovendry	0.62 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.59 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.0 GPa	1.98 × 10 <sup>6</sup> in/lb <sup>2</sup>	13.6 GPa
MOR	8.50 × 10 <sup>3</sup> in/lb <sup>2</sup>	58.6 MPa	14.5 × 10 <sup>3</sup> in/lb <sup>2</sup>	100 MPa
C <sub>  </sub>	4.32 × 10 <sup>3</sup> in/lb <sup>2</sup>	29.8 MPa	8.47 × 10 <sup>3</sup> in/lb <sup>2</sup>	58.4 MPa
C <sub>⊥</sub>	0.48 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.31 MPa	0.96 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.62 MPa
WML	8.9 in-in/lb <sup>3</sup>	61.4 kJ/m <sup>3</sup>	11.8 in-in/lb <sup>3</sup>	81.4 kJ/m <sup>3</sup>
Hardness	590 lbf	2620 N	870 lbf	3870 N
Shear <sub>  </sub>	1.04 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.17 MPa	1.51 × 10 <sup>3</sup> in/lb <sup>2</sup>	10.4 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.5	6.0	2.5
Radial	5.1	4.1	1.7
Volumetric	12.2	9.8	4.1

<sup>a</sup>All the southern pines have moderately large shrinkage but are stable when properly seasoned.

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 185), 3 by 5 timbers use table 285, 10/4 and 12/4 flitches use table 283.

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 185). May contain brown sapwood stain, checks and splits, possibly as a result of excessive drying temperatures (185).

**Working Properties:** Longleaf pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but there may be difficulty in gluing.

**Durability:** The heartwood is moderately resistant to decay (192).

**Preservation:** The sapwood is permeable to preservative treatments.

**Uses:** The dense and high strength lumber of southern pine is used extensively in construction of stringers for factories, warehouses, bridges, trestles, docks, roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses for building material, such as interior finish, sheathing, subflooring, and joists, and boxes, pallets, and crates. Southern pine is also used for tight and slack cooperage. When used for railroad cross ties, piles, poles, and mine timbers, it is usually treated with preservatives. Structural grade plywood from southern pine has become a major use.

**Toxicity:** Working with longleaf pine can cause dermatitis, allergic bronchial asthma, or rhinitis (71, 158, 214)

**Additional Reading:** 6, 30, 44, 51, 59, 73, 120.

***Pinus ponderosa***  
**Dougl. Ex Laws.**  
**Pinaceae**  
**Ponderosa Pine**

The word *pinus* is the classical Latin name. The name *ponderosa* refers to ponderous, or heavy, referring to the wood.

**Other Common Names:** Arizona pijn, Arizona pine, Arizona ponderosa pine, Arizona white pine, Arizona yellow pine, Arizona-tall, big pine, bird's-eye pine, blackjack pine, British soft pine, British Columbia soft pine, British Columbia pine, bull pine, California white pine, California yellow pine, foothills yellow pine, gelb kiefer, gul-tall, heavy pine, heavy-wooded pine, knotty pine, longleaf pine, Pacific ponderosa pine, pin a bois lourd, pin d'Arizona, pin de Bentham, pinabete, pino, pino blanco, pino cenizo, pino chino, pino de Arizona, pino di Arizona, pino giallo, pino ponderosa, pino ponderoso, pino real, pitch pine, ponderosa pijn, pondosa, pondosa pine, red pine, rock pine, vastamerikansk langbarri tall, western pitch pine, western yellow pine, westerse gele pijn, yellow pine.

**Distribution:** Widely distributed throughout the Rocky Mountains and mountains of the Pacific coast. It grows from North Dakota and Montana west to British Columbia and south through Washington, Oregon, and southern California east through Arizona and the Trans-Pecos area of Texas, north through New Mexico, Oklahoma, Colorado, Nebraska, and South Dakota. It also grows in northern Mexico. Major producing areas are in Oregon, Washington, and California. Other important producing areas are in Idaho and Montana; lesser amounts come from the southern Rocky Mountain region and the Black Hills of South Dakota and Wyoming. It has been planted in New Zealand, Australia, and South Africa.

**The Tree:** Ponderosa pine reaches heights of 180 ft (54.86), with diameters of 4 ft (1.22 m). It has a pyramidal crown when young, maturing to a flat crown. The trees may live for 300 to 600 years.

**General Wood Characteristics:** Botanically, ponderosa pine belongs to the yellow pine group rather than the white pine group. However, much of the wood is somewhat similar to the white pines in appearance and properties. The heartwood is yellowish to light reddish brown or orange, and the wide sapwood is nearly white to pale yellow. In young trees, the sapwood can make up more than half the volume; in older trees, the sapwood may be 2 in. (5.08 cm) or more wide. The wood of the outer portions of ponderosa pine of saw timber size is moderately light in weight, moderately low in strength, moderately soft, moderately stiff, and moderately low in shock resistance. Ponderosa pine is moderately weak in bending and endwise compression. It is straight grained (but can be dimpled on the tangential surface) and has moderately low shrinkage. It is quite uniform in texture and has little tendency to warp and twist. Jeffrey pine (*P. jeffreyi*), which grows in close association with ponderosa pine in California and Oregon, is usually marketed and sold as ponderosa pine.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(40%) <sup>a</sup>	0.38 <sup>b</sup>	45 <sup>c</sup>	721
12%	0.40 <sup>b</sup>	28 <sup>c</sup>	449
Ovendry	0.42 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Mechanical properties<sup>a</sup>

Property	Green		Dry	
	MOE	$1.00 \times 10^6$ in/lb <sup>2</sup>	6.89 GPa	$1.29 \times 10^6$ in/lb <sup>2</sup>
MOR	$5.10 \times 10^3$ in/lb <sup>2</sup>	35.2 MPa	$9.40 \times 10^3$ in/lb <sup>2</sup>	64.8 MPa
C <sub>  </sub>	$2.45 \times 10^3$ in/lb <sup>2</sup>	16.9 MPa	$5.32 \times 10^3$ in/lb <sup>2</sup>	36.7 MPa
C <sub>⊥</sub>	$0.28 \times 10^3$ in/lb <sup>2</sup>	1.93 MPa	$0.58 \times 10^3$ in/lb <sup>2</sup>	4.00 MPa
WML	5.2 in-in/lb <sup>3</sup>	35.8 kJ/m <sup>3</sup>	7.1 in-in/lb <sup>3</sup>	49.0 kJ/m <sup>3</sup>
Hardness	320 lbf	1420 N	460 lbf	205 N
Shear <sub>  </sub>	$0.70 \times 10^3$ in/lb <sup>2</sup>	4.83 MPa	$1.13 \times 10^3$ in/lb <sup>2</sup>	7.79 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.2	5.0	2.1
Radial	3.9	3.1	1.3
Volumetric	9.7	7.7	3.2

<sup>a</sup>Ponderosa pine dries easily, either by air seasoning or in a dry kiln. It is moderately low in shrinkage. Reference (56). Mature growth timbers may contain brown stain, possibly as a result of wetwood, and young growth may contain warp, possibly as a result of juvenile wood or compression wood (185).

<sup>b</sup>Care should be taken, if air seasoning, to avoid blue staining of the sapwood. 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						
Heartwood	T9-A6	T7-A6	T5-A5	NA	NA	NA
Sapwood	T11-C7	NA	NA	NA	NA	NA
Antibrown-stain	NA	NA	NA	NA	NA	NA
Upper grades						
Heartwood	NA	NA	NA	NA	NA	NA
Sapwood	T9-C6	T7-C6	T7-C5	T7-A4	T7-A4	L
Antibrown-stain	T7-E6	NA	T7-E5	NA	NA	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Ponderosa pine works easily using both hand and machine tools. It finishes and glues well, but the presence of knots makes painting difficult. It is resistant to splitting when nailed, but is rated average in nail-holding ability.

**Durability:** Ponderosa pine is not durable under conditions favorable to decay unless treated with a preservative. The heartwood is slightly resistant to nonresistant to decay (56). The wood can be susceptible to attack by dry wood termites, ambrosia (pinhole borer) beetles, longhorn beetles, and Buprestid beetles.

**Preservation:** The sapwood is permeable to preservatives, and the heartwood is moderately resistant to preservative treatments.

**Uses:** Ponderosa pine is used mainly for lumber and, to a lesser extent, for piles, poles, posts, mine timbers, veneer, and railroad cross ties. The clear wood is especially well suited for millwork, such as window frames, doors, shelving, mouldings, sash doors, blinds, paneling, mantels, trim, and built-in cases and cabinets. Lower grade lumber is used for boxes and crates. Much of the lumber of intermediate or lower grades goes into sheathing, subflooring, and roof boards. Knotty ponderosa pine is used for interior finish. A considerable amount of sawmill and secondary mill residues now go into particleboard and paper.

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

**Additional Reading:** 40, 73, 120, 138.

***Pinus pungens* Lamb.**  
**Pinaceae**  
**Table Mountain Pine**

The word *pinus* is the classical Latin name. The word *pungens* means sharp point, from the peculiar, stout, hooked spines on the cones. Table mountain pine is one of the southern pines.

**Other Common Names:** Black pine, hickory pine, mountain pine, pin pungens, pino pungens, poverty pine, prickly pine, pungens tall, pungens-pijn, ridge pine, southern mountain pine, table mountain pine, yellow pine.

**Distribution:** Table mountain pine is native to the Appalachian Mountain region from Pennsylvania southwest to eastern West Virginia, Virginia, northwestern South Carolina, northeastern Georgia, and eastern Tennessee. It is also found locally in New Jersey and Delaware.

**The Tree:** In the Great Smoky Mountains, table mountain pine trees reach heights of 95 ft (28.96 m), with diameters of 3 ft (0.91 m). In other areas, trees may grow to heights of 66 ft (20.12 m), with a diameter of more than 1 ft (0.30 m).

**General Wood Characteristics:** The sapwood of table mountain pine is a yellowish white, and the heartwood is a reddish brown. The wood is soft, weak, and brittle, very coarse grained, and knotty with conspicuous resin ducts. It is moderately heavy (but lighter than other southern pines). It can be straight grained and has a medium texture.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.49	54	865
12%	0.52	36	577
Ovendry	0.55	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$1.27 \times 10^6$ in/lb <sup>2</sup>	8.76 GPa	$1.55 \times 10^6$ in/lb <sup>2</sup>
MOR	$7.50 \times 10^3$ in/lb <sup>2</sup>	51.7 MPa	$11.6 \times 10^3$ in/lb <sup>2</sup>	80.0 MPa
C <sub>  </sub>	$3.54 \times 10^3$ in/lb <sup>2</sup>	24.4 MPa	$6.83 \times 10^3$ in/lb <sup>2</sup>	47.1 MPa
C <sub>⊥</sub>	$0.56 \times 10^3$ in/lb <sup>2</sup>	3.86 MPa	$1.21 \times 10^3$ in/lb <sup>2</sup>	8.34 MPa
WML	8.1 in-in/lb <sup>3</sup>	55.8 kJ/m <sup>3</sup>	8.7 in-in/lb <sup>3</sup>	60.0 kJ/m <sup>3</sup>
Hardness	490 lbf	2180 N	660 lbf	2940 N
Shear <sub>  </sub>	$0.96 \times 10^3$ in/lb <sup>2</sup>	6.62 MPa	$1.20 \times 10^3$ in/lb <sup>2</sup>	8.27 MPa

<sup>a</sup>Reference (153) (2-in. (5-cm) standard).



### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	6.8	NA	NA
Radial	3.4	NA	NA
Volumetric	10.9	NA	NA

<sup>a</sup>Reference (153).

### Kiln drying schedules: The following are schedules for the southern pines

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 92, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 92, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 92, 185).

**Working Properties:** It can be straight grained, has a medium texture, and is difficult to work with using hand tools. It holds nails well, but is not easy to glue.

**Durability:** The heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** The sapwood is easily impregnated with preservatives

**Uses:** Regarding the southern pines, lumber of lower density and strength finds many uses for building material, such as interior finish, sheathing, subflooring, and joists, and boxes, pallets, and crates. Table mountain pine is used for pulpwood, low grade saw timber, and firewood.

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

**Additional Reading:** 44, 46, 51, 59, 1120, 183.

***Pinus radiata* D. Don  
(*Pinus insignis*  
Douglas ex Loudon)  
Pinaceae  
Radiata Pine**

The word *pinus* is the classical Latin name. The name *radiata* means radiate or rayed, referring to the markings on the cone scales.

**Other Common Names:** insignis, insignis pine, insignis-pijn, insignispijn, insular pine, insular two-leaved pine, Monterey fohre, Monterey kiefer, Monterey kieffer, Monterey nmanty, Monterey pine, Monterey small-coned pine, nearly smooth-cone pine, nearly-smooth cone pine, pin de Monterey, pin radiata, pin radiata, pino de Monterey, pino di Monterey, pino insegne, pino insigne, radiata pijn, Radiatakiefer, radiatamanty, radiata-tall, remarkable cone pine, remarkable pine, small-coned Monterey pine, smooth-cone pine, spreading-cone pine.

**Distribution:** Native to the central coast of California from sea level to a maximum elevation of 1,000 ft (304.8 m). Planted extensively in the southern hemisphere, mainly in Chile, New Zealand, Australia, and South Africa.

**The Tree:** In native stands, it can reach heights of 70 to 110 ft (21.34 to 33.53 m), with diameters of 2 to 3 ft (0.61 to 0.91 m). Plantation-grown trees may reach a height of 80 to 90 ft (24.38 to 27.43 m) in 20 years.

The following data are mostly for plantation-grown radiata pine.

**General Wood Characteristics:** Heartwood is light brown to pinkish brown; distinct from the paler creamy white sapwood. Growth rings mostly wide and distinct, false rings may be common; grain usually straight; texture moderately even and fine; moderate to high luster in sapwood; odor slightly resinous.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green <sup>a</sup>	NA	25	401
12% <sup>b</sup>	NA	33	529
12% <sup>c</sup>	NA	34	545
12% <sup>d</sup>	NA	32	513
12% <sup>e</sup>	NA	28	449
Ovendry <sup>a</sup>	0.33	NA	NA
Ovendry <sup>b</sup>	0.43	NA	NA
Ovendry <sup>c</sup>	0.44	NA	NA
Ovendry <sup>d</sup>	0.42	NA	NA
Ovendry <sup>e</sup>	0.38	NA	NA

<sup>a</sup>Reference (1),  
<sup>b</sup>Reference (49),  
<sup>c</sup>Reference (50),  
<sup>d</sup>Reference (180),  
<sup>e</sup>Reference (183).

### Mechanical properties

Property	Green		Dry	
	MOE <sup>a</sup>	0.93 × 10 <sup>6</sup> in/lb <sup>2</sup>	6.41 GPa	1.18 × 10 <sup>6</sup> in/lb <sup>2</sup>
MOE <sup>b</sup>	NA	NA	1.66 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.4 GPa
MOE <sup>c</sup>	1.29 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.89 GPa	1.62 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.2 GPa
MOE <sup>e</sup>	1.06 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.31 GPa	1.37 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.45 GPa
MOR <sup>a</sup>	4.85 × 10 <sup>3</sup> in/lb <sup>2</sup>	33.4 MPa	9.10 × 10 <sup>3</sup> in/lb <sup>2</sup>	62.7 MPa
MOR <sup>b</sup>	NA	NA	12.7 × 10 <sup>3</sup> in/lb <sup>2</sup>	87.6 MPa
MOR <sup>c</sup>	6.41 × 10 <sup>3</sup> in/lb <sup>2</sup>	44.2 MPa	12.0 × 10 <sup>3</sup> in/lb <sup>2</sup>	82.6 MPa
MOR <sup>d</sup>	NA	NA	12.6 × 10 <sup>3</sup> in/lb <sup>2</sup>	86.9 MPa
MOR <sup>e</sup>	5.88 × 10 <sup>3</sup> in/lb <sup>2</sup>	40.5 MPa	11.0 × 10 <sup>3</sup> in/lb <sup>2</sup>	75.9 MPa
C <sub>  </sub> <sup>a</sup>	1.97 × 10 <sup>3</sup> in/lb <sup>2</sup>	13.6 MPa	4.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	33.8 MPa
C <sub>  </sub> <sup>b</sup>	NA	NA	7.00 × 10 <sup>3</sup> in/lb <sup>2</sup>	48.3 MPa
C <sub>  </sub> <sup>c</sup>	3.03 × 10 <sup>3</sup> in/lb <sup>2</sup>	20.9 MPa	6.33 × 10 <sup>3</sup> in/lb <sup>2</sup>	43.6 MPa
C <sub>  </sub> <sup>e</sup>	2.59 × 10 <sup>3</sup> in/lb <sup>2</sup>	17.9 MPa	5.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	40.7 MPa
C <sub>⊥</sub> <sup>b</sup>	NA	NA	0.52 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.58 MPa
WML <sup>e</sup>	NA	NA	NA	NA
Hardness <sup>c</sup>	498 lbf	2210 N	792 lbf	3520 N
Hardness <sup>e</sup>	500 lbf	2220 N	625 lbf	2780 N
Shear <sub>  </sub> <sup>b</sup>	NA	NA	1.64 × 10 <sup>3</sup> in/lb <sup>2</sup>	11.3 MPa

<sup>a</sup>Reference (1).

<sup>b</sup>Reference (49).

<sup>c</sup>Reference (50).

<sup>d</sup>Reference (180).

<sup>e</sup>Reference (183); (all are from 2-in. (5-cm) standard).

Forest Products Laboratory toughness 154 in-lbf (17.4 N-m) for green material (5/8-n. (1.6-cm) specimen). Reference (50).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC	20% MC
Tangential	6.7	NA	NA
Radial	3.4	NA	NA
Volumetric	10.7	NA	NA

<sup>a</sup>Air or kiln dries rapidly with little degrade. Movement in service is rated as medium. Reference (50).

### Kiln drying schedule<sup>a</sup>

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock	British schedule 4/4, 5/4, 6/4 stock
Standard	T13-C4S	T11-C3S	NA	NA	NA	K

<sup>a</sup>References (28, 185).

**Working Properties:** The wood machines easily, although the grain tends to tear around large knots. Easy to nail and glue; takes paint and varnish well.

**Durability:** Sapwood is prone to attack by stain fungi and vulnerable to boring insects. Heartwood is durable above ground.

**Preservation:** Sapwood readily treated with open tank and pressure methods. Plantation-grown stock is mostly sapwood. Heartwood moderately resistant.

**Uses:** Veneers and plywood, pulp and paper, fiber and particleboard, light construction, boxes and crates, millwork.

**Toxicity:** Can cause allergic contact dermatitis (71, 158).

**Additional Reading:** 12, 24, 26, 37, 39 49, 73, 77, 89, 120, 159, 166.

***Pinus resinosa* Ait.**  
**Pinaceae**  
**Red Pine**

The word *pinus* is the classical Latin name. The word *resinosa* means resinous.

**Other Common Names:** Amerikansk rod-tall, Canadese rode pijn, Canadian pine, Canadian red pine, eastern red pine, hard pine, northern pine, Norway pine, Ottawa Red pine, pig iron pine, pig-iron-Norway, pin de norvege, pin resineux, pin rouge, pin rouge d’Amerique, pin rouge du Canada, pino rojo Americano, pino rosso Americano, pitch pine, Quebec pine, red deal, shellbark Norway pine, tannub ahmar, yellow deal.

**Distribution:** Red pine is native to Cape Breton Island, Nova Scotia, Prince Edward Island, New Brunswick, southern Quebec and Maine, west to central Ontario and southeastern Manitoba, south to southeastern Minnesota and east to Wisconsin, Michigan, southern Ontario, northern Pennsylvania, northern New Jersey, Connecticut, and Massachusetts. It is also found locally in northern Illinois, eastern West Virginia, and Newfoundland.

**The Tree:** Red pine trees reach heights of 80 ft (24.38 m), with diameters of 3 ft (0.91 m). A record tree was reported at a height of 150 (45.72 m), with a diameter of 5 ft (1.52 m). Long-lived stands may contain trees as old as 200 years.

**General Wood Characteristics:** The sapwood of red pine is nearly white to yellow, and the heartwood varies from red to reddish brown. The wood has an oily feel and a resinous odor. It is straight, even grained, medium textured, and moderately heavy. It is intermediate in density between longleaf and eastern white pine. It is relatively strong and stiff and moderately high in shock resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(32%) <sup>a</sup>	0.41 <sup>b</sup>	42 <sup>c</sup>	673
12%	0.46 <sup>b</sup>	34 <sup>c</sup>	545
Ovendry	0.51 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (564).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.28 \times 10^6$ in/lb <sup>2</sup>	8.82 GPa	$1.63 \times 10^6$ in/lb <sup>2</sup>	11.2 GPa
MOR	$5.80 \times 10^3$ in/lb <sup>2</sup>	40.0 MPa	$11.0 \times 10^3$ in/lb <sup>2</sup>	75.8 MPa
C <sub>  </sub>	$2.73 \times 10^3$ in/lb <sup>2</sup>	18.8 MPa	$6.07 \times 10^3$ in/lb <sup>2</sup>	41.8 MPa
C <sub>⊥</sub>	$0.26 \times 10^3$ in/lb <sup>2</sup>	1.79 MPa	$0.60 \times 10^3$ in/lb <sup>2</sup>	4.14 MPa
WML	6.1 in-in/lb <sup>3</sup>	42.1 kJ/m <sup>3</sup>	9.9 in-in/lb <sup>3</sup>	68.3 kJ/m <sup>3</sup>
Hardness	340 lbf	1510 N	560 lbf	2490 N
Shear <sub>  </sub>	$0.69 \times 10^3$ in/lb <sup>2</sup>	4.76 MPa	$1.21 \times 10^3$ in/lb <sup>2</sup>	8.34 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.2	5.8	2.4
Radial	3.8	3.7	1.5
Volumetric	11.3	9.2	3.8

<sup>a</sup>Red pine has moderately high shrinkage, but is not difficult to dry.

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-B4	NA	T11-B3	T7-A3	T7-A3	L

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	410	NA	411	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Red pine is easy to work with hand tools, holds nails, screws well, finishes well, but has difficulty holding paint.

**Durability:** It is moderately durable for uses not in contact with the ground.

**Preservation:** It is easy to treat with preservatives

**Uses:** Poles, pilings, cabin logs, posts, lumber for construction (girders, beams, joists, studs, stair parts and trusses), house siding, framing, shelving, trim millwork, lawn and garden furniture, woodenware, novelties, toys, and pulp and paper. The trees are planted for wind breaks and Christmas trees. The bark is used for tanning, and the old stumps are used for turpentine and rosin production.

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

**Additional Reading:** 44, 51, 73, 85, 92, 120, 169.

***Pinus rigida* Mill.**  
**Pinaceae**  
**Pitch Pine**

The word *pinus* is the classical Latin name. The word *rigida* means rigid or stiff, referring to the cone scales. Pitch pine is considered a minor species of the southern pines.

**Other Common Names:** Black Norway pine, black pine, hard pine, jack-pine, longleaf pine, longschat pine, mountain pine, northern pitch pine, Norway black pine, pech kiefer, pek-pijn, Pennsylvania yellow pine, pin a feuilles rigides, pin a l'aubier, pin raide, pin rigida, pino bronco, pino rigido, pino rogado, pitchpin, pond pine, red pine, regida pijn, ridge pine, rigid pine, sap pine, shortleaf pine, soderns gul-tall, southern yellow pine, torch pine, wiesen kiefer, yellow pine.

**Distribution:** Pitch pine is native to southern Maine west to New York, New Jersey, and Pennsylvania and southwest, mostly in the mountains, to southern Ohio, Kentucky, eastern Tennessee, northern Georgia, and northwestern South Carolina. It is also found locally in extreme southern Quebec and southeastern Ontario.

**The Tree:** Pitch pine trees reach heights of 80 ft (24.38 m), with diameters of 2 ft (0.61 m).

**General Wood Characteristics:** The sapwood of pitch pine is a yellowish white, and the heartwood is reddish brown and resinous. The sapwood is usually wide in second growth stands. Heartwood begins to form when the tree is about 20 years old. In old, slow-growth trees, sapwood may be only 1 to 2 in. (2.54 to 5.08 cm) in width. The wood of pitch pine is very heavy, strong, very stiff, hard, and moderately high in shock resistance. It also has a straight grain and a medium texture.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.47 <sup>a</sup>	50 <sup>b</sup>	801
12%	0.52 <sup>a</sup>	34 <sup>b</sup>	545
Ovendry	0.52 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE <sup>a</sup>	1.20 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.27 GPa	1.43 × 10 <sup>6</sup> in/lb <sup>2</sup>
MOR <sup>a</sup>	6.80 × 10 <sup>3</sup> in/lb <sup>2</sup>	46.9 MPa	10.8 × 10 <sup>3</sup> in/lb <sup>2</sup>	74.5 MPa
C <sub>  </sub> <sup>a</sup>	2.95 × 10 <sup>3</sup> in/lb <sup>2</sup>	20.3 MPa	5.94 × 10 <sup>3</sup> in/lb <sup>2</sup>	40.9 MPa
C <sub>⊥</sub> <sup>a</sup>	0.36 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.48 MPa	0.82 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.65 MPa
WML <sup>a</sup>	9.2 in-in/lb <sup>3</sup>	63.4 kJ/m <sup>3</sup>	9.2 in-in/lb <sup>3</sup>	63.4 kJ/m <sup>3</sup>
Hardness <sup>b</sup>	470 lbf	2090 N	620 lbf	2760 N
Shear <sub>  </sub>	0.86 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.93 MPa	1.36 × 10 <sup>3</sup> in/lb <sup>2</sup>	9.38 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

<sup>b</sup>Reference (192) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	7.1	5.7	2.4
Radial	4.0	3.2	1.3
Volumetric	10.9	8.7	3.6

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

### Kiln drying schedules

The following schedules are for the southern pines.

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 92, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 92, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 92, 185). All the southern pines have moderately large shrinkage but are stable when properly seasoned.

**Working Properties:** Pitch pine has straight grain, medium texture, and is difficult to work with using hand tools. It ranks high in nail-holding capacity, but can be difficult to glue.

**Durability:** The heartwood is moderate to low in resistance to decay (56).

**Preservation:** The sapwood is more easily impregnated with preservatives than is the heartwood.



**Uses:** The dense, high strength lumber of southern pines are used extensively for stringers in construction of factories, warehouses, bridges, trestles, and docks, and roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses as building material, such as interior finish, sheathing, subflooring, and joists, boxes, pallets, and crates. Southern pines are also used also for tight and slack cooperage. When used for piles, poles, and mine timbers, the wood is usually treated with preservatives. Structural grade plywood from southern pines has become a major use. Pitch pine is used for lumber, fuel, and pulpwood.

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

**Additional Reading:** 44, 51, 59, 73, 120, 132, 183.

***Pinus serotina* Michx.**  
**Pinaceae**  
**Pond Pine**

The word *pinus* is the classical Latin name. The word *serotina* means late, referring to the cones that remain closed on the trees a few years before opening to release the seeds. The lumber of this species is also graded as a "minor species" in southern pine grading rules.

**Other Common Names:** Amerikansk gul-tall, bastard pine, bay pine, black pine, bull pine, loblolly pine, marsh pine, meadow pine, pin serotina, pino serotina, pocosin pine, spruce pine, wiesen kiefer.

**Distribution:** Pond pine is native to the Coastal Plain from southern New Jersey and Delaware south to central and northwestern Florida and central Alabama.

**The Tree:** Pond pine trees reach heights of 90 ft (27.43 m), with diameters of 3 ft (0.91 m).

**General Wood Characteristics:** The wood of pond pine is heavy, coarse-grained, and resinous, with dark, orange-colored heartwood and thick, pale yellow sapwood. Shrinkage is moderately high. The wood is moderately strong, stiff, moderately hard, and moderately high in shock resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.51 <sup>a</sup>	49 <sup>b</sup>	785
12%	0.56 <sup>a</sup>	38 <sup>b</sup>	609
Ovendry	0.58 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE <sup>a</sup>	1.28 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.82 GPa	1.75 × 10 <sup>6</sup> in/lb <sup>2</sup>
MOR <sup>a</sup>	7.40 × 10 <sup>3</sup> in/lb <sup>2</sup>	51.0 MPa	11.6 × 10 <sup>3</sup> in/lb <sup>2</sup>	80.0 MPa
C <sub>  </sub> <sup>a</sup>	3.66 × 10 <sup>3</sup> in/lb <sup>2</sup>	25.2 MPa	7.54 × 10 <sup>3</sup> in/lb <sup>2</sup>	52.0 MPa
C <sub>⊥</sub> <sup>a</sup>	0.44 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.03 MPa	0.91 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.27 MPa
WML <sup>a</sup>	7.5 in-in/lb <sup>3</sup>	51.7 kJ/m <sup>3</sup>	8.6 in-in/lb <sup>3</sup>	59.3 kJ/m <sup>3</sup>
Hardness <sup>b</sup>	510 lbf	2270 N	740 lbf	3290 N
Shear <sub>  </sub> <sup>a</sup>	0.94 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.48 MPa	1.38 × 10 <sup>3</sup> in/lb <sup>2</sup>	9.51 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

<sup>b</sup>Reference (153) (2-in. (5-cm) standard).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.1	NA	NA
Radial	5.1	NA	NA
Volumetric	11.2	NA	NA

<sup>a</sup>Reference (56). May contain water pockets, dark chemical stains, or honeycomb, possibly as a result of wetwood (infrequent occurrence)(185).

### Kiln drying schedules

The following schedules are for the southern pines.

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 92, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 92, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 92, 185).

**Working Properties:** Pond pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but can be difficult to glue.

**Durability:** The heartwood is moderate to low in resistance to decay (56).

**Preservation:** The sapwood is more easily impregnated with preservatives than is the heartwood.

**Uses:** The dense, high strength lumber of southern pines are used extensively for stringers in construction of factories, warehouses, bridges, trestles, and docks, and roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses as building material, such as interior finish, sheathing, subflooring, and joists, and boxes, pallets, and crates. Southern pines are also used for tight and slack cooperage. When used for piles, poles, and mine timbers, the wood is usually treated with preservatives. Structural grade plywood from southern pine has become a major use.

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

**Additional Reading:** 31, 44, 51, 59, 120, 183.

***Pinus strobus***  
**L. Pinaceae**  
**Eastern White Pine**

The word *pinus* is the classical Latin name. The name *strobus* is the Latin name for pine cone, from the Greek *strobos* (whirling around) and *strobilos* (pine cone). The species *Pinus strobus* is composed of two varieties; the typical Eastern White Pine (*Pinus strobus* var. *strobus* L.) and Chiapas White Pine (*Pinus strobus* var. *chiapensis* Martinez [*P. chiapensis* (Martinez) Andresen]), native to the mountains of southern Mexico and Guatemala.

**Other Common Names:** American white pine, American yellow pine, apple pine, ayacahuite vidriosa, balsam pine, bor vajmutov, borovice tuha, Canadian white pine, Canadian yellow pine, Chiapas pine, Chiapas white pine, Chiapas-pijn, Chiapas-tall, cork pine, eastern pine, kahikatea, Minnesota soft white pine, Minnesota white pine, New England pine, northern pine, northern white pine, Ottawa pine, Ottawa white pine, pattern pine, pin baliveau, pin blanc, pin blanc Canadian, pin de Chiapas, pin du lord, pin jaune, pin potiron, pin Weymouth, pino ayacahuite, pino Canadiense, pino di Chiapas, pino stobo, pino Weymouth, pumpkin pine, Quebec pine, Quebec yellow pine, sapling pine, seidenkiefer, silver pine, simafeny, soft pine, soft cork white pine, soft pine, soft white pine, sosny wejmutka, spruce pine, strobe, strobo, strobus, Tonawanda pine, Weymouth pine, Weymouth-pijn, Weymouthpijn, Weymouths kiefer, Weymouthsden, Weymouthsfohre, Weymouthskiefer, Weymouth-tall, Weymut-tall, white pine, white soft pine, Wisconsin white pine, yellow pine.

**Distribution:** Eastern white pine is native to North America from Newfoundland, the Anticosti Islands, and the Gaspé Peninsula of Quebec, west to central and western Ontario and extreme southeast Manitoba, south to southeastern Minnesota and northeastern Iowa, east to northern Illinois, Ohio, Pennsylvania, and New Jersey and south to northern Georgia and northwest South Carolina. It is also locally distributed in western Kentucky, western Tennessee, and Delaware.

**The Tree:** Eastern white pine grows to heights of 100 ft (30.48 m), with a diameter of 3 to 6 ft (0.91 to 1.83 m). Historically, it has grown to heights of 200 ft (60.96 m), with diameters of 6 ft (1.83 m). Current national champion trees are taller than 140 ft (42.67 m). Prior to the late 1800s, most of the large trees were logged for ship masts.

**General Wood Characteristics:** The heartwood of Eastern white pine is light brown, sometimes with a reddish tinge, turning darker on exposure. The sapwood is white, tinged with yellow. It has a uniform texture, is easily worked with tools, shrinks little, is easily kiln dried, is straight grained, and is dimensionally stable. It is light weight, moderately soft, moderately weak, not stiff, and low in shock resistance. It has medium strength values.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(50%) <sup>a</sup>	0.34 <sup>b</sup>	36 <sup>c</sup>	577
12%	0.35 <sup>b</sup>	25 <sup>c</sup>	401
Ovendry	0.37 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Mechanical properties<sup>a</sup>

Property	Green		Dry	
	MOE	$0.99 \times 10^6$ in/lb <sup>2</sup>	6.83 GPa	$1.24 \times 10^6$ in/lb <sup>2</sup>
MOR	$4.90 \times 10^3$ in/lb <sup>2</sup>	33.8 MPa	$8.60 \times 10^3$ in/lb <sup>2</sup>	59.3 MPa
C <sub>  </sub>	$2.44 \times 10^3$ in/lb <sup>2</sup>	16.8 MPa	$4.80 \times 10^3$ in/lb <sup>2</sup>	33.1 MPa
C <sub>⊥</sub>	$0.22 \times 10^3$ in/lb <sup>2</sup>	1.52 MPa	$0.44 \times 10^3$ in/lb <sup>2</sup>	3.03 MPa
WML	5.2 in-in/lb <sup>3</sup>	35.8 kJ/m <sup>3</sup>	6.8 in-in/lb <sup>3</sup>	46.9 kJ/m <sup>3</sup>
Hardness	290 lbf	1290 N	380 lbf	1690 N
Shear <sub>  </sub>	$0.68 \times 10^3$ in/lb <sup>2</sup>	4.69 MPa	$0.90 \times 10^3$ in/lb <sup>2</sup>	6.20 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% Mc <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	6.1	4.8	2.0
Radial	2.1	1.8	0.8
Volumetric	8.2	6.6	2.7

<sup>a</sup>May contain brown stain or ring failure, possibly as a result of wetwood (178). Reference (56).

<sup>b</sup>reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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						
Standard	T9-C5	NA	T9-C4	NA	NA	NA
Upper grades						
Standard	T11-C5	NA	T10-C4	T10-C4	T8-C3	L
Antibrown-stain	276	NA	277	NA	278	NA

<sup>a</sup>References (28, 185).

### Conventional temperature/time-controlled schedules<sup>a</sup>

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	308	NA	309	NA	NA	NA	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It is easily worked with tools, is straight grained, and is dimensionally stable. It takes stains, glue, and finishes well. It has good nail-holding ability.

**Durability:** The heartwood of eastern white pine is moderately resistant to decay (56).

**Preservation:** The heartwood is moderately resistant to preservative treatment, and the sapwood is permeable (74).

**Uses:** Most eastern white pine is converted into lumber, which is put to a great variety of uses. A large proportion, which is mostly second-growth knotty lumber or the lower grades, goes into container and packaging applications. High grade lumber goes into patterns for castings. Other important uses are sash, doors, furniture, trim, knotty paneling, finish, caskets and burial boxes, shade and map rollers, and toy, dairy, and poultry supplies. The bark is used to produce white pine tar, an antiseptic and expectorant. The tree is a popular Christmas tree.

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

**Additional Reading:** 21, 73, 76, 120, 154, 164, 196.

***Pinus taeda***  
**L. Pinaceae**  
**Loblolly Pine**

The word *pinus* is the classical Latin name. The word *taeda* is the ancient name of resinous pines. Loblolly pine is one of the southern pines.

**Other Common Names:** Arkansas pine, bastard pine, black pine, black slash pine, bog pine, buckskin pine, bull pine, Carolina pine, cornstalk pine, foxtail pine, frankincense pine, heart pine, Indian pine, kienbaum, lobby pine, longleaf pine, longschap pine, long-schat pine, longshucks, longshucks pine, longstraw pine, maiden pine, meadow pine, North Carolina pine, old pine, oldfield pine, pin a l'encens, pin taeda, pinho-teda, pino de incienso, pino dell'incenso, prop pine, Rosemary pine, sap pine, shortleaf pine, shortstraw pine, slash black pine, slash pine, soderns gul-tall, southern pine, southern yellow pine, spruce pine, swamp pine, sydstaternas gul-tall, taeda pine, taeda-pijn, torch pine, Virginia pine, Virginia sap pine, yellow pine.

**Distribution:** Loblolly pine is native to the Coastal Plain and Piedmont, from southern New Jersey and Delaware south to central Florida and west to eastern Texas, and in the Mississippi Valley to extreme southeastern Oklahoma, central Arkansas, and southern Tennessee.

**The Tree:** Loblolly pine trees reach heights of 150 ft (45.72 m), with diameters of 5 ft (1.52 m). A record tree was reported to have a height of 163 ft (49.68 m), with a diameter of 56 in. (1.42 m).

**General Wood Characteristics:** The sapwood of loblolly pine is a yellowish white, and the heartwood is a reddish brown. The sapwood is usually wide in second-growth stands. Heartwood begins to form when the tree is about 20 years old. In old, slow-growth trees, sapwood may be only 1 to 2 in. (2.54 to 5.08 m) in width. The wood of loblolly pine is very heavy and strong, very stiff, hard and moderately high in shock resistance. It has a straight grain and a medium texture.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(33%) <sup>a</sup>	0.47 <sup>b</sup>	53 <sup>c</sup>	849
12%	0.51 <sup>b</sup>	36 <sup>c</sup>	577
Ovendry	0.54 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$1.40 \times 10^6$ in/lb <sup>2</sup>	9.65 GPa	$1.79 \times 10^6$ in/lb <sup>2</sup>
MOR	$7.30 \times 10^3$ in/lb <sup>2</sup>	50.3 MPa	$12.8 \times 10^3$ in/lb <sup>2</sup>	88.2 MPa
C <sub>  </sub>	$3.51 \times 10^3$ in/lb <sup>2</sup>	24.2 MPa	$7.13 \times 10^3$ in/lb <sup>2</sup>	49.2 MPa
C <sub>⊥</sub>	$0.39 \times 10^3$ in/lb <sup>2</sup>	2.69 MPa	$0.79 \times 10^3$ in/lb <sup>2</sup>	5.45 MPa
WML	8.2 in-in/lb <sup>3</sup>	56.5 kJ/m <sup>3</sup>	10.4 in-in/lb <sup>3</sup>	71.7 kJ/m <sup>3</sup>
Hardness	450 lbf	2000 N	690 lbf	3070 N
Shear <sub>  </sub>	$0.86 \times 10^3$ in/lb <sup>2</sup>	5.93 MPa	$1.39 \times 10^3$ in/lb <sup>2</sup>	9.58 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.4	5.9	2.5
Radial	4.8	3.8	1.6
Volumetric	12.3	9.8	4.1

<sup>a</sup>May contain brown sapwood stain, checks and splits, possibly as a result of excessive drying temperatures (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

The following schedules are for the southern pines.

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 92, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 92, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 92, 185).

All the southern pines have moderately high shrinkage but are stable when properly seasoned.

**Working Properties:** Loblolly pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but there can be difficulty in gluing.

**Durability:** The heartwood is moderate to low in resistance to decay (56).

**Preservation:** The sapwood is more easily impregnated with preservatives.



**Uses:** The dense, high strength lumber of southern pines are used extensively for stringers in construction of factories, warehouses, bridges, trestles, and docks, and roof trusses, beams, posts, joists, and piles. Lumber of lower density and strength finds many uses as building material, such as interior finish, sheathing, subflooring, and joists, and boxes, pallets, and crates. Southern pines are also used also for tight and slack cooperage. When used for piles, poles, and mine timbers, the wood is usually treated with preservatives. Structural grade plywood from southern pine has become a major use.

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

**Additional Reading:** 10, 44, 51, 59, 73, 120, 183.

***Pinus virginiana* Mill.**  
**Pinaceae**  
**Virginia Pine**

The word *pinus* is the classical Latin name. The word *virginiana* means “of Virginia.” Virginia pine is another southern pine classified as a "minor species" in the grading rules.

**Other Common Names:** Alligator pine, bastard pine, black pine, cedar pine, hickory pine, jack pine, Jersey pine, New Jersey pine, North Carolina pine, old field pine, pin chetif, pin de Virginie, pin de Virginie, pin pauvre, pino Virginiano, poor pine, poverty pine, river pine, scrub pine, short shucks, shortleaf pine, shortleaved, shortschat pine, shortshucks, spruce, spruce pine, Virginia tall, Virginia-tall, Virginische pijn, Virginische pijn.

**Distribution:** Virginia pine is native to southeastern New York (Long Island) and New Jersey, west to Pennsylvania, central Ohio, and southern Indiana, south to western Kentucky, western Tennessee, and Northeastern Mississippi, and east to central Alabama, northern Georgia, northern South Carolina, and Virginia.

**The Tree:** Virginia pine trees reach heights of 80 ft (24.38 m), with diameters of 2 ft (0.61 m). A record tree was measured at a height of 114 ft (34.75 m), with a diameter of 32 in. (0.81 m).

**General Wood Characteristics:** The heartwood of Virginia pine is orange, and the sapwood nearly white and relatively wide. The wood is moderately heavy, moderately strong, moderately hard, moderately stiff and has moderately high shrinkage and shock resistance.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.45 <sup>a</sup>	54 <sup>b</sup>	865
12%	0.48 <sup>a</sup>	32 <sup>b</sup>	513
Ovendry	0.52 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	1.22 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.41 GPa	1.52 × 10 <sup>6</sup> in/lb <sup>2</sup>
MOR	7.30 × 10 <sup>3</sup> in/lb <sup>2</sup>	50.3 MPa	13.0 × 10 <sup>3</sup> in/lb <sup>2</sup>	89.6 MPa
C <sub>  </sub>	3.42 × 10 <sup>3</sup> in/lb <sup>2</sup>	23.6 MPa	6.71 × 10 <sup>3</sup> in/lb <sup>2</sup>	46.3 MPa
C <sub>⊥</sub>	0.39 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.69 MPa	0.91 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.27 MPa
WML	10.9 in-in/lb <sup>3</sup>	75.1 kJ/m <sup>3</sup>	13.7 in-in/lb <sup>3</sup>	94.6 kJ/m <sup>3</sup>
Hardness	540 lbf	2400 N	740 lbf	3290 N
Shear <sub>  </sub>	0.89 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.14 MPa	1.35 × 10 <sup>3</sup> in/lb <sup>2</sup>	9.31 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.2	NA	NA
Radial	4.2	NA	NA
Volumetric	11.9	NA	NA

<sup>a</sup>Reference (56). May contain brown sapwood stain, checks and splits, possibly as a result of excessive drying temperatures (185).

### Kiln drying schedules

The following schedules are for the southern pines.

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T13-C6	T12-C5	T12-C5	T10-C4	T10-C4	L
Highest quality	279	279	279	T10-C4	T10-C4	NA

<sup>a</sup>References (28, 92, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	281	NA	282	281	NA	282	284

<sup>a</sup>References (28, 92, 185).

#### High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	401/402	NA	NA	2 by 4's 403 2 by 10's 403 4 by 4's 404

<sup>a</sup>References (28, 92, 185).

**Working Properties:** No information available at this time for Virginia pine. In general, southern pine is difficult to work with using hand tools. It ranks high in nail-holding capacity, but it can be difficult to glue.

**Durability:** The heartwood is slightly resistant to nonresistant to decay (56).

**Preservation:** The sapwood is permeable, and the heartwood is moderately resistant to preservative treatment.

**Uses:** It is used for lumber, railroad cross ties, mine timbers, pulpwood, rough construction, and fuel. The trees are sometimes used for Christmas trees.

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

**Additional Reading:** 35, 44, 51, 59, 73, 120, 183.

***Pseudotsuga* spp Carr.**  
**Pinaceae**  
**Douglas-Fir**

The genus *Pseudotsuga* contains about seven species native to North America [2], and eastern Asia (China to Japan) [5]. The wood is anatomically distinct from other softwoods. Douglas-fir is named for Henry Douglas (1798-1834), a Scottish botanist who traveled in North America. The word *Pseudotsuga* means “false hemlock.” The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Pseudotsuga macrocarpa</i>	Bigcone Douglas-fir
<i>Pseudotsuga menziesii*</i>	Douglas-fir

***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, Douglasfenyo, 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, Douglas, 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<sup>a</sup>**

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

**Weight—con.**

Interior South	Green(30%) <sup>d</sup>	0.43	NA	NA
	12%	0.46	32	NA
	Ovendry	NA	NA	NA

<sup>a</sup>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.

<sup>b</sup>Moisture content.

<sup>c</sup>Specific gravity.

<sup>d</sup>Reference (185).

**Mechanical properties<sup>a</sup>**

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

<sup>a</sup> Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

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

<sup>a</sup>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 infrequently)(185).

<sup>b</sup>Coast.

<sup>c</sup>Interior North.

<sup>d</sup>Interior West.

### Kiln drying schedule

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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 <sup>b</sup>	NA	NA	NA
Inland	T9-A4 <sup>c</sup>	NA	T9-A4 <sup>c</sup>	NA	NA	NA
Upper grades						
Coastal	T11-A4	NA	T10-A3	T5-A1	T5-A1	NA
Inland	NA	NA	NA	NA	NA	NA

<sup>a</sup>References (28, 185).

<sup>b</sup>Maximum wet-bulb depression 25°F(-4°C). Reference (185).

<sup>c</sup>Maximum wet-bulb depression 20°F(-7°C). Reference (185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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 <sup>b</sup>	291 <sup>c</sup>	291 <sup>c</sup>	294 <sup>d</sup>	294 <sup>d</sup>	294 <sup>d</sup>	288

<sup>a</sup>Reference (28).

<sup>b</sup>Omit step 1 and reduce step 3 to 12 h. Reference (28).

<sup>c</sup>Reduce step 3 to 12 h. Reference (28).

<sup>d</sup>Omit step 1 for vertical grain. Reference (28).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400 <sup>b,c,d,e</sup>	400 <sup>b,e</sup>	400 <sup>b,e</sup> /414 <sup>e</sup>	NA

<sup>a</sup>Reference (28).

<sup>b</sup>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).

<sup>c</sup>Reduce step 1 and 2 to 6 h for 4/4–5/4 for western species. Reference (28).

<sup>d</sup>In upper grades, use only vertical grain stock. Reference (28).

<sup>e</sup>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 spp. Endl.**  
**Taxodiaceae**  
**Sequoia**

The genus *Sequoia* is represented by one species (*S. sempervirens*). A related tree, the giant sequoia (*Sequoiadendron giganteum*), is also called redwood, big tree, or giant 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 wood of *Sequoia* is anatomically distinct from other softwoods. The species native to North America is listed below. An asterisk means that technical information is available on this species and included in this text.

Scientific name	Trade name
<i>Sequoia sempervirens</i> *	Redwood

***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 ever-green. 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, led-wood, 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**

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

<sup>a</sup>Heartwood for old growth; mixed heartwood and sapwood for second growth. Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

<sup>d</sup>Reference (153).

### Mechanical properties<sup>a</sup>

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

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

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

<sup>a</sup>Heavy stock may contain uneven moisture content, collapse, honeycomb, chemical or iron stains, possibly as a result of wetwood (usually in old growth)(185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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

<sup>a</sup>References (28, 185).

### Kiln drying schedules—con.

Conventional temperature/time-controlled schedules<sup>a</sup>

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
Light	289	288	b	289	288	b	NA
Medium and Heavy	c	c	c	c	c	c	NA

<sup>a</sup>References (28, 185).

<sup>b</sup>Air dry to 20% MC, then dry using table 286 in (185).

<sup>c</sup>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, casement 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.

***Taxodium* spp. Rich.**  
**Taxodiaceae**  
**Baldcypress**

Baldcypress (*Taxodium distichum*) is one of two species in this genus. The other, *Taxodium mucronatum*, is native to Mexico, Guatemala, and the southern most part of Texas. The wood of all species in this genus looks alike microscopically. The word *taxodium* is derived from *Taxus* (yew) and a suffix meaning like, referring to the yew-like leaves. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

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<b>Scientific name</b>	<b>Trade name</b>
<i>Taxodium distichum</i> *	Baldcypress
<i>Taxodium mucronatum</i>	Montezuma Baldcypress

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***Taxodium distichum***  
**(L.) Rich.**  
**Taxodiaceae**  
**Baldcypress**

The word *taxodium* is derived from *Taxus* (yew) and a suffix meaning like, referring to the yew-like leaves. The word *distichum* means two-ranked, referring to the leaves being in two rows.

**Other Common Names:** Amerikanische zypresse, Amerikansk cypress, bald cypress, black-cypress, buck cypress, canoe water pine, Chinese swamp cypress, cipres Americano, cipres calvo, cipres de pantano, cipres pond, cipresso calvo, cipresso del sud, cipresso delle paludi, cipresso pond, common bald cypress, common-baldcypress, cow cypress, cupresso delle paludi, cypres chauve, cypres de la Louisiane, cypres de Louisiane, cypres pond, cypress, deciduous cypress, gulf-cypress, gulf red cypress, knee cypress, Louisiana black cypress, Louisiana cypress, Louisiana red cypress, moeras-cypres, moerascypres, pecky cypress, pond bald cypress, pond baldcypress, pond cypres, pond cypress, red-cypress (coast type), river cypress, satine faux, shui ts'uung, shui tsung kan, southern-cypress, sump-cypress, sumpcypress, Sumpftaxodie, sumpf-zypresse, Sumpfzypresse, sumpfzypresse, swamp-cypress, taxodier chauve, tidewater red-cypress, upland cypress, Virginische sumpfedar, white-cypress, yellow-cypress (inland type), zweizeilige Sumpfzypresse.

**Distribution:** Baldcypress grows in swampy areas along the Atlantic Coast from Delaware to southern Florida, west along the Gulf Coast to southeastern Texas, and along the Mississippi river valley to southeastern Illinois. About half the cypress lumber comes from the Southern States and a fourth from the South Atlantic States. It is not as readily available as it was several decades ago.

**The Tree:** Baldcypress trees can reach heights of 150 ft (45.72 m), with diameters of 12 ft (3.66 m) and an age of 2,000 years. However, it grows most commonly to about 100 ft (30.48 m), 5 ft (1.52 m) in diameter, and an age of 500 years. When grown in wet conditions, the tree produces “knees,” extensions of the roots that grow above the ground and the surface of the water to allow oxygen to reach the roots.

**General Wood Characteristics:** The sapwood of baldcypress is narrow and nearly white. The color of the heartwood varies widely, ranging from light yellowish brown to dark brownish red, brown, or chocolate. The wood is moderately heavy, moderately strong, and moderately hard. Shrinkage is moderately low, but somewhat greater than that of the cedars and less than that of southern pine. Frequently the wood of certain baldcypress trees contains pockets or localized areas that have been attacked by a fungus. Such wood is known as “pecky” cypress. The decay caused by this fungus is arrested when the wood is cut into lumber and dried. Therefore, pecky cypress is durable and useful where water tightness is unnecessary and appearance is not important or a novel effect is desired.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(121%) <sup>a</sup>	0.42 <sup>b</sup>	51 <sup>c</sup>	817
12%	0.46 <sup>b</sup>	32 <sup>c</sup>	993
Ovendry	0.48 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$1.18 \times 10^6$ in/lb <sup>2</sup>	8.14 GPa	$1.44 \times 10^6$ in/lb <sup>2</sup>	9.93 GPa
MOR	$6.60 \times 10^3$ in/lb <sup>2</sup>	45.5 MPa	$10.6 \times 10^3$ in/lb <sup>2</sup>	73.1 MPa
C <sub>  </sub>	$3.58 \times 10^3$ in/lb <sup>2</sup>	24.7 MPa	$6.36 \times 10^3$ in/lb <sup>2</sup>	43.8 MPa
C <sub>⊥</sub>	$0.40 \times 10^3$ in/lb <sup>2</sup>	2.76 MPa	$0.73 \times 10^3$ in/lb <sup>2</sup>	5.03 MPa
WML	6.6 in-in/lb <sup>3</sup>	45.5 kJ/m <sup>3</sup>	8.2 in-in/lb <sup>3</sup>	56.5 kJ/m <sup>3</sup>
Hardness	390 lbf	1730 N	510 lbf	2270 N
Shear <sub>  </sub>	$0.81 \times 10^3$ in/lb <sup>2</sup>	5.58 MPa	$1.00 \times 10^3$ in/lb <sup>2</sup>	6.89 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

**Drying and shrinkage<sup>a</sup>**

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	6.2	5.0	2.1
Radial	3.8	3.0	1.3
Volumetric	10.5	8.4	3.5

<sup>a</sup>Old growth may be susceptible to end checks and water pockets, possibly as a result of refractory wood and/or extractives. Young growth may contain chemical brown stain, possibly as a result of extractives and/or poor air circulation. (184)

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Kiln drying schedule<sup>a</sup>**

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-E3	NA	T11-D2	T8-A4	T8-A4	K

<sup>a</sup>References (28, 185).

**Working Properties:** Baldcypress has moderate strength, hardness, and pliability. To prevent raised grain, it is necessary to use sharp tools when working with baldcypress. It nails and glues well and has high paint-holding ability.

**Durability:** In general, the heartwood is resistant to very resistant to decay (56). The heartwood of old-growth trees is one of the most decay-resistant woods; second-growth trees produce only moderately decay-resistant wood.

**Preservation:** Moderately resistant to preservative treatment (74).

**Uses:** Baldcypress has been used principally for building construction, especially where resistance to decay is required. It was used for beams, posts, and other members in docks, warehouses, factories, bridges, and heavy construction. It is well suited for siding and porch construction. It is also used for caskets, burial boxes, sash, doors, blinds, and general millwork, including interior trim and paneling. Other uses are in tanks, vats, ship and boat building, greenhouse construction, cooling towers, and stadium seats. It is also used for railroad cross ties, poles, piles, shingles, cooperage, and fence posts.

**Toxicity:** No direct information available at this time. However, the wood does not impart taste, odor, or color to food products, implying very low toxicity (87).

**Additional Reading:** 22, 34, 38, 51, 61, 164, 182, 193, 198.

***Taxus* spp. L.**  
**Taxaceae**  
**Yew**

The genus *Taxus* is composed of about 10 species native to North America [3], Mexico and Central America [1], and Eurasia [6]. The wood of all species in this genus looks alike microscopically. The word *taxus* is the classical Latin name, from the Greek *taxos*. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Taxus brevifolia</i> *	Pacific Yew
<i>Taxus floridana</i>	Florida Yew



***Taxus brevifolia* Nutt.**  
**Taxaceae**  
**Pacific Yew**

The word *taxus* is the classical Latin name, from the Greek *taxos*. The word *brevifolia* means short leaf, referring to the size of its needles, relative to the English yew (*Taxus baccata* L.). Recently, taxol, an anti-cancer agent, was isolated from the bark of *Taxus brevifolia*.

**Other Common Names:** Canadese taxus, Canadian yew, if a feuilles courtes, if du Canada, if occidental, Kanadensisk idegran, mountain mahogany, Oregon yew, Pazifische eibe, tassi d’America, tasso Americano, taxo Americano, tejo Americano, western yew, westerse taxus, yew.

**Distribution:** Pacific yew is native to the Pacific Coast region from southeast Alaska, south in western British Columbia, western Washington, western Oregon, and northern and central California (including the Sierra Nevada). It also grows in the Rocky Mountain region from southeast British Columbia south to northwest Montana, northern Idaho, eastern Washington, and northeast Oregon.

**The Tree:** Pacific yew trees reach heights of 50 ft (15.24 m), with diameters of 2 ft (0.61 m). The largest tree on record is 60 ft (18.29 m) tall, with a diameter of 6 ft (1.83 m).

**General Wood Characteristics:** The wood from Pacific yew has a thin, light tan sapwood, and the heartwood is brown to bright orange. It is dense, very hard and strong, heavy, and has a very fine, straight and close grain with a fine texture. It has a high luster and no characteristic odor or taste.

**Weight<sup>a</sup>**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.60	54	865
12%	0.62	44	705
Ovendry	0.67	NA	NA

<sup>a</sup>Reference (153).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
	MOE	$0.99 \times 10^6$ in/lb <sup>2</sup>	6.83 GPa	$1.35 \times 10^6$ in/lb <sup>2</sup>
MOR	$10.1 \times 10^3$ in/lb <sup>2</sup>	69.6 MPa	$15.2 \times 10^3$ in/lb <sup>2</sup>	105 MPa
C <sub>  </sub>	$4.65 \times 10^3$ in/lb <sup>2</sup>	32.1 MPa	$8.10 \times 10^3$ in/lb <sup>2</sup>	55.8 MPa
C <sub>⊥</sub>	$1.04 \times 10^3$ in/lb <sup>2</sup>	7.17 MPa	$2.11 \times 10^3$ in/lb <sup>2</sup>	14.5 MPa
WML	20.2 in-in/lb <sup>3</sup>	139 kJ/m <sup>3</sup>	18.7 in-in/lb <sup>3</sup>	129 kJ/m <sup>3</sup>
Hardness	1150 lbf	5110 N	1600 lbf	7120 N
Shear <sub>  </sub>	$1.62 \times 10^3$ in/lb <sup>2</sup>	11.2 MPa	$2.23 \times 10^3$ in/lb <sup>2</sup>	15.4 MPa

<sup>a</sup>Reference (153) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	5.4	4.3	1.8
Radial	4.0	3.2	1.3
Volumetric	9.7	7.8	3.2

<sup>a</sup>Reference (153).

<sup>b</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T8-B3 <sup>b</sup>	NA	T5-B2 <sup>b</sup>	NA	NA	G

<sup>a</sup>Reference (74).

<sup>b</sup>Corresponds to British schedule G. Reference (185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	290	290	288	290	290	290	NA

<sup>a</sup>References (28, 185).

**Working Properties:** Pacific yew wood works well with tools. It splits during nailing but hold screws well. It bends easily, is excellent for turnery, and finishes smoothly.

**Durability:** The heartwood of Pacific yew is exceptionally high in resistance to decay (10, 192). It may be used for outdoor purposes without preservative treatment.

**Preservation:** No information available at this time.

**Uses:** Archery bows, turnery, cabinetry, canoe paddles, veneer, marquetry, paneling, carvings, furniture, joinery, fences, doors, tables, rustic furniture.

**Toxicity:** Can cause irritation or dermatitis (71, 158, 214).

**Additional Reading:** 27, 73, 76.

***Thuja* spp. L.**  
**Cupressaceae**  
**Thuja**

The genus *Thuja* contains about six species world-wide native to North America [2] and Asia [4]. The wood of all species in this genus looks alike microscopically. The word *thuja* comes from the Greek *thuia*, an aromatic wood (probably a juniper). The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

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<b>Scientific name</b>	<b>Trade name</b>
<i>Thuja occidentalis</i> *	Northern White-Cedar
<i>Thuja plicata</i> *	Western Redcedar

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***Thuja occidentalis***  
**L. Cupressaceae**  
**Northern White-Cedar**

The word *thuja* comes from the Greek *thuia*, an aromatic wood (probably a juniper). The word *occidentalis* means western, referring to the Western Hemisphere (New World).

**Other Common Names:** Abendlandische lebensbaum, albero della vita Americana, American arborvitae, arborvitae, arbre de vie de l'ouest, Atlantic red cedar, cedar, cedre blanc, cedro rosso dell'Atlantico, eastern arborvitae, eastern cedar, eastern white-cedar, gemeiner lebensbaum, gewone thuja, livstrad, Michigan white cedar, New Brunswick cedar, Noordamerikaanse levensboom, swamp cedar, swamp-cedar, thuja, thuya de l'occident, tuia occidentale, tuya, tuya occidental, vanlig tuja, vitae, vit-ceder, western thuja, white cedar.

**Distribution:** Northern white-cedar is native to Quebec (the Anticosti Islands and Gaspé Peninsula), New Brunswick, Prince Edward Island, southwestern Nova Scotia, and Maine, west to northern Ontario and southeastern Manitoba, south to southeastern Minnesota and northeastern Illinois, east to extreme northwestern Indiana, Michigan, southern Ontario, southern New York, Rhode Island, and Massachusetts. It is also found locally in central Manitoba and the Appalachian Mountains in western Pennsylvania, Ohio, West Virginia, western North Carolina, and eastern Tennessee.

**The Tree:** Northern white-cedar trees normally reach heights of 50 ft (15.24 m), with diameters of 2 ft (0.61 m). Exceptional trees may grow 80 ft (24.38 m) tall, with a diameter of 5 ft (1.52 m). The record is 113 ft (34.44 m), with a diameter of 6 ft (1.83 m).

**General Wood Characteristics:** The sapwood of northern white-cedar is thin and white, and the heartwood is a light brown. The wood has an aromatic spicy “cedary or pencil-like” odor. It has an even grain, fine texture, and the lowest density of any commercial domestic wood. It is soft and has low Mechanical properties (bending and compressive strength, hardness, stiffness, shock and splitting resistance, and nail- and screw-holding abilities).

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(32%) <sup>a</sup>	0.29 <sup>b</sup>	28 <sup>c</sup>	449
12%	0.31 <sup>b</sup>	22 <sup>c</sup>	352
Ovendry	0.32 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$0.64 \times 10^6$ in/lb <sup>2</sup>	4.41 GPa	$0.80 \times 10^6$ in/lb <sup>2</sup>	5.52 GPa
MOR	$4.20 \times 10^3$ in/lb <sup>2</sup>	29.0 MPa	$6.50 \times 10^3$ in/lb <sup>2</sup>	44.8 MPa
C <sub>  </sub>	$1.99 \times 10^3$ in/lb <sup>2</sup>	13.7 MPa	$3.96 \times 10^3$ in/lb <sup>2</sup>	27.3 MPa
C <sub>⊥</sub>	$0.23 \times 10^3$ in/lb <sup>2</sup>	1.59 MPa	$0.31 \times 10^3$ in/lb <sup>2</sup>	2.14 MPa
WML	5.7 in-in/lb <sup>3</sup>	39.3 kJ/m <sup>3</sup>	4.8 in-in/lb <sup>3</sup>	33.1 kJ/m <sup>3</sup>
Hardness	230 lbf	1020 N	320 lbf	1420 N
Shear <sub>  </sub>	$0.62 \times 10^3$ in/lb <sup>2</sup>	4.27 MPa	$0.85 \times 10^3$ in/lb <sup>2</sup>	5.86 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>a</sup>	6% MC <sup>b</sup>	20% MC <sup>b</sup>
Tangential	4.9	3.9	1.6
Radial	2.2	1.8	0.7
Volumetric	7.2	5.8	2.4

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock <sup>b</sup>
Standard	T12-B4	NA	T11-B3	NA	NA	J

<sup>a</sup>References (28, 185).

<sup>b</sup>Reference (74).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	409	NA	NA	NA

<sup>a</sup>References (28, 185).

**Working Properties:** It is easy to work with using hand tools and is average in machinability. It is dimensionally stable, glues well, and holds paint well.

**Durability:** The heartwood is resistant to subterranean termites and resistant to very resistant to decay (56).

**Preservation:** Northern white-cedar is resistant to extremely resistant to preservative treatments (74).

**Uses:** Rustic fencing and posts, cabin logs, lumber, poles, shingles, shipping containers, piling, lagging, pails, tubs, ties, boat building (especially canoe ribs), tanks, novelties, wooden wares, and pulp wood.

**Toxicity:** Can cause allergic bronchial asthma, dermatitis, and rhinitis (71, 158, 214).

**Additional Reading:** 8, 18, 44, 51, 82, 84, 120.

***Thuja plicata***  
**Donn ex D. Don**  
**Cupressaceae**  
**Western Redcedar**

The word *thuja* comes from the Greek *thuia*, an aromatic wood (probably a juniper). The word *plicata* is derived from *pligate* (folded into plaits) most likely from the flat, folded appearance of the scale-like leaves.

**Other Common Names:** Albero della vita di Lobb, Amerikanskt livstrad, Amerikanskt livstrad, arbol de la vida, arborvitae, British Columbia red cedar, British Columbia cedar, California cedar, canoe-cedar, cedar, cedro rojo del Pacifico, cedro rosso del Pacifico, columinar giant arborvitae, giant arbor, giant arborvitae, giant-cedar, giant thuja, gigantic cedar, gigantic red cedar, grand arbre de vie, Idaho cedar, jatte-tuja, Lobb's arborvitae, northwestern red cedar, Oregon cedar, pacific arbor, Pacific arborvitae, Pacific redcedar, red cedar, red cedar of the west, red cedar pine, reuzen-thuja, reuzenthuja, riesen-lebensbaum, riesenlebensbaum, riesenthuja, shinglewood, thuja geant, thuya de Lobb, thuya geant, thuya oriental, tuia gigantesca, Washington cedar, Washington red cedar, Westamerikaanse levensboom, western arborvitae, western cedar, western red redcedar.

**Distribution:** Western redcedar grows in the Pacific Northwest and along the Pacific coast to Alaska. Western redcedar lumber is produced principally in Washington, followed by Oregon, Idaho, and Montana. The tree has been planted in Great Britain and New Zealand.

**The Tree:** Western redcedar trees reach heights of 200 ft (60.96 m), with diameters of 16 ft (4.88 m). The trunk of older trees is buttressed, fluted, and quite tapered.

**General Wood Characteristics:** The heartwood of western redcedar is reddish or pinkish brown to dull brown and the sapwood nearly white. The sapwood is narrow, often not more than 1 in. (2.54 cm) in width. The wood is generally straight grained and has a uniform but rather coarse texture. It has very low shrinkage. This species is light in weight, moderately soft, low in strength when used as beams or posts, and low in shock resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(58%) <sup>a</sup>	0.31 <sup>b</sup>	27 <sup>c</sup>	433
12%	0.32 <sup>b</sup>	23 <sup>c</sup>	368
Ovendry	0.34 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	$0.94 \times 10^6$ in/lb <sup>2</sup>	6.48 GPa	$1.11 \times 10^6$ in/lb <sup>2</sup>	7.65 GPa
MOR	$5.20 \times 10^3$ in/lb <sup>2</sup>	35.8 MPa	$7.50 \times 10^3$ in/lb <sup>2</sup>	51.7 MPa
C <sub>  </sub>	$2.77 \times 10^3$ in/lb <sup>2</sup>	19.1 MPa	$4.56 \times 10^3$ in/lb <sup>2</sup>	31.4 MPa
C <sub>⊥</sub>	$0.24 \times 10^3$ in/lb <sup>2</sup>	1.65 MPa	$0.46 \times 10^3$ in/lb <sup>2</sup>	3.17 MPa
WML	5.0 in-in/lb <sup>3</sup>	34.5 kJ/m <sup>3</sup>	5.8 in-in/lb <sup>3</sup>	40.0 kJ/m <sup>3</sup>
Hardness	260 lbf	1160 N	350 lbf	1560 N
Shear <sub>  </sub>	$0.77 \times 10^3$ in/lb <sup>2</sup>	5.31 MPa	$0.99 \times 10^3$ in/lb <sup>2</sup>	6.83 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	5.0	4.0	1.7
Radial	2.4	1.9	0.8
Volumetric	6.8	5.4	2.3

<sup>a</sup>Heavy stock may have uneven moisture content, collapse, honeycomb, chemical stains, iron stains and/or resin exudate, possibly as a result of wetwood (sinker stock), and/or extractives (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

#### Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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						
Light Weight	T9-A6	NA	NA	NA	NA	NA
Heavy Weight	NA	NA	NA	NA	NA	NA
Upper grades						
Light Weight	T10-B5	NA	T10- B3	T7- A2	T7- A2	J
Heavy Weight	T5-F4	NA	T5-F3	NA	NA	NA

<sup>a</sup>References (28, 185).

#### Conventional temperature/time-controlled schedules<sup>a</sup>

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	290	290	289	290	290	296	NA

<sup>a</sup>Reference (28).

**Working Properties:** The wood works well with both hand tools and machine operations. It may splinter when worked on the end grain (e.g., mortising). It is subject to compression during planing and molding. It nails and screws well and takes both stains and paint satisfactorily (74).

**Durability:** The heartwood of western redcedar is resistant to very resistant to decay (187). It is not immune to attack by termites and furniture beetles (74).

**Preservation:** It is resistant to preservative treatment.

**Uses:** Western redcedar is used principally for shingles, saunas, outdoor furniture, decking, fencing, lumber, poles, posts, and piles. The lumber is used for exterior siding, interior finish, greenhouse construction, ship and boat building, boxes and crates, sash, doors, and millwork.

**Toxicity:** Can cause bronchial asthma and/or contact dermatitis (71, 158, 214).

**Additional Reading:** 5, 56, 60, 76, 140, 150, 160, 164, 197.

***Tsuga* spp. (Endl.)**  
**Carr. Pinaceae**  
**Hemlock**

The genus *Tsuga* contains about 14 species native to North America [4] and southern and eastern Asia [10]. The wood of all species in this genus looks alike microscopically. The word *tsuga* is the Japanese name for the native hemlocks of Japan. The species native to North America are listed below. An asterisk means that technical information is available on this species and is included in this text.

Scientific name	Trade name
<i>Tsuga canadensis</i> *	Eastern Hemlock
<i>Tsuga caroliniana</i>	Carolina Hemlock
<i>Tsuga heterophylla</i> *	Western Hemlock
<i>Tsuga mertensiana</i> *	Mountain Hemlock



***Tsuga canadensis*  
(L.) Carr.  
Pinaceae  
Eastern Hemlock**

The word *tsuga* is the Japanese name for the native hemlocks of Japan. The word *canadensis* means “of Canada.”

**Other Common Names:** Abete del Canada, American hemlock, black hemlock, Canada hemlock, Canadese hemlock, Canadese hemlock-den, Canadian hemlock, hemlock spruce, Huron pine, Kanadensisk tsuga, New England hemlock, Pennsylvania hemlock, perusse, pine, pruche de l’est, pruche prusse, red hemlock, sapin du Canada, schierlingstanne, spruce, spruce hemlock, spruce pine, tsuga Canadese, tsuga del Canada, tsuga du Canada, vanlig hemlock, water hemlock, water spruce, West Virginia hemlock, white hemlock, Wisconsin white hemlock.

**Distribution:** Eastern hemlock is native to Cape Breton Islands, Nova Scotia, Prince Edward Island, New Brunswick, the Gaspé Peninsula of southern Quebec and Maine, west to southern Ontario, northern Michigan, Wisconsin, and eastern Minnesota, south to Indiana and east to Ohio, Pennsylvania, Maryland and New Jersey and south in the mountains to northwestern South Carolina, northern Georgia and northern Alabama. The production of eastern hemlock lumber is divided fairly evenly between the New England States, the Middle Atlantic States, and the Lake States.

**The Tree:** Mature eastern hemlock trees commonly reach heights of 100 ft (30.48 m), with diameters of 3 ft (0.91 m). A record tree was recorded at a height of 160 ft (48.77 m), a diameter of 7 ft (2.13 m), and 988 year old.

**General Wood Characteristics:** The heartwood of eastern hemlock is pale brown with a reddish hue. The sapwood is not distinctly separated from the heartwood but may be lighter in color. The wood is coarse and uneven in texture (old trees tend to have considerable shake); it is moderately light in weight, moderately hard, moderately low in strength, moderately limber, and moderately low in shock resistance.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(97%) <sup>a</sup>	0.38 <sup>b</sup>	50 <sup>c</sup>	801
12%	0.40 <sup>b</sup>	28 <sup>c</sup>	449
Ovendry	0.43 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.07 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.38 GPa	1.20 × 10 <sup>6</sup> in/lb <sup>2</sup>	8.27 GPa
MOR	6.40 × 10 <sup>3</sup> in/lb <sup>2</sup>	44.1 MPa	8.90 × 10 <sup>3</sup> in/lb <sup>2</sup>	61.4 MPa
C <sub>  </sub>	3.08 × 10 <sup>3</sup> in/lb <sup>2</sup>	21.2 MPa	5.41 × 10 <sup>3</sup> in/lb <sup>2</sup>	37.3 MPa
C <sub>⊥</sub>	0.36 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.48 MPa	0.65 × 10 <sup>3</sup> in/lb <sup>2</sup>	4.48 MPa
WML	6.7 in-in/lb <sup>3</sup>	46.2 kJ/m <sup>3</sup>	6.8 in-in/lb <sup>3</sup>	46.9 kJ/m <sup>3</sup>
Hardness	400 lbf	1780 N	500 lbf	2220 N
Shear <sub>  </sub>	0.85 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.86 MPa	1.06 × 10 <sup>3</sup> in/lb <sup>2</sup>	7.10 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	6.8	5.4	2.3
Radial	3.0	2.4	1.0
Volumetric	9.7	7.8	3.2

<sup>a</sup>May contain uneven moisture content, warp or ring shake, possibly as a result of wetwood and/or compression wood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-C4	NA	T11-C3	T8-A3	T8-A2	K

<sup>a</sup>References (28, 185).

**Working Properties:** Eastern hemlock splinters easily when worked with tools. It is low in splitting resistance and average in nail-holding capacity. It glues easily and is moderate in paint-holding ability.

**Durability:** The heartwood of eastern hemlock is slightly resistant to nonresistant to decay (56).

**Preservation:** It is resistant to preservative treatment (74).

**Uses:** Eastern hemlock is used principally for lumber and pulpwood. The lumber is used in building construction for framing, sheathing, subflooring, and roof boards, and in the manufacture of boxes, pallets, and crates.

**Toxicity:** Working with eastern hemlock can cause dermatitis (71, 158).

**Additional Reading:** 33, 44, 51, 62.

***Tsuga heterophylla*  
(Raf.) Sarg.  
Pinaceae  
Western Hemlock**

The word *tsuga* is the Japanese name for the native hemlocks of Japan. The word *heterophylla* means “with other (different or various-sized) leaves.”

**Other Common Names:** Alpine hemlock, alpine spruce, berg-hemlock, black hemlock, mountain hemlock, Olympic fir, Pacific hemlock, Pacific Coast hemlock, Patton’s hemlock, Patton’s spruce, Prince Albert’s fir, tsuga de California, tsuga de Californie, tsuga de l’ouest, tsuga de Patton, tsuga di California, vastamerikansk berg-hemlock, weeping spruce, westAmerikanische hemlocktanne, west coast hemlock, western hemlock spruce, Williamson’s spruce.

**Distribution:** Western hemlock is native to the Pacific Coast region from southern Alaska (Kenai Peninsula) southeast through southeastern Alaska and western British Columbia to western Washington, western Oregon, and northwestern California. It is also found in the Rocky Mountain region from southeastern British Columbia south to northeastern Washington, northern Idaho, and northwestern Montana.

**The Tree:** Western hemlock trees reach heights of 200 ft (60.96 m), with diameters of 3 ft (0.91 m). An exceptional specimen was recorded at a height of 259 ft (78.94 m), with a diameter of 9 ft (2.74 m).

**General Wood Characteristics:** The heartwood and sapwood of western hemlock are almost white with a purplish tinge. The sapwood, which is sometimes lighter in color, is generally not more than 1 in. (2.54 cm) thick. The wood often contains small, sound, black knots that are usually tight and stay in place. Dark streaks are often found in the lumber; these are caused by hemlock bark maggots and generally do not reduce strength. Western hemlock is moderately light in weight and moderate in strength. It is moderate in its hardness, stiffness, and shock resistance. It has moderately high shrinkage, about the same as Douglas-fir. Green hemlock lumber contains considerably more water than Douglas-fir, and requires longer kiln drying time. Trees may contain wetwood and/or have ring shake.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green(85%) <sup>a</sup>	0.42 <sup>b</sup>	41 <sup>c</sup>	657
12%	0.45 <sup>b</sup>	29 <sup>c</sup>	465
Ovendry	0.44 <sup>c</sup>	NA	NA

<sup>a</sup>Reference (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.31 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.03 GPa	1.63 × 10 <sup>6</sup> in/lb <sup>2</sup>	11.2 GPa
MOR	6.60 × 10 <sup>3</sup> in/lb <sup>2</sup>	45.5 MPa	11.3 × 10 <sup>3</sup> in/lb <sup>2</sup>	77.9 MPa
C <sub>  </sub>	3.36 × 10 <sup>3</sup> in/lb <sup>2</sup>	23.2 MPa	7.20 × 10 <sup>3</sup> in/lb <sup>2</sup>	49.6 MPa
C <sub>⊥</sub>	0.28 × 10 <sup>3</sup> in/lb <sup>2</sup>	1.93 MPa	0.55 × 10 <sup>3</sup> in/lb <sup>2</sup>	3.79 MPa
WML	6.9 in-in/lb <sup>3</sup>	47.6 kJ/m <sup>3</sup>	8.3 in-in/lb <sup>3</sup>	57.2 kJ/m <sup>3</sup>
Hardness	410 lbf	1820 N	540 lbf	2400 N
Shear <sub>  </sub>	0.86 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.93 MPa	1.29 × 10 <sup>3</sup> in/lb <sup>2</sup>	8.89 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC <sup>b</sup>	6% MC <sup>c</sup>	20% MC <sup>c</sup>
Tangential	7.8	6.3	2.6
Radial	4.2	3.4	1.4
Volumetric	12.4	9.5	4.0

<sup>a</sup>May contain uneven moisture content, warp, chemical stains, shake or iron stains, possibly as a result of wetwood (185).

<sup>b</sup>Reference (56).

<sup>c</sup>Reference (192).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

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	T11-E5	NA	T11-E5	NA	NA	NA
Upper grades	T12-C5	T11-C5	T11-C4	T8-A4	T8-A3	K

<sup>a</sup>References (28, 185).

<sup>b</sup>Maximum wet-bulb depression 20°F(-7°C). Reference (185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	294	294	294	288

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400/415	NA

<sup>a</sup>References (28, 185).

**Working Properties:** The wood is intermediate in nail-holding ability and has a tendency to split when nailed. It glues, stains, polishes, varnishes, and paints satisfactorily.

**Durability:** The heartwood of hemlock is slightly resistant to nonresistant to decay (56).

**Preservation:** Western hemlock is resistant to preservative treatment (74).

**Uses:** Western hemlock is used for pulpwood, lumber, roof decking, laminating stock, mouldings, architectural trim, general construction, newsprint, and plywood. The lumber is used extensively for building material, such as sheathing, siding, subflooring, joists, studing, planking, and rafters. Considerable quantities are used in the manufacture of boxes, pallets, crates, and flooring, and smaller amounts for furniture and ladders.

**Toxicity:** Can cause dermatitis (71, 158, 214).

**Additional Reading:** 44, 51, 63, 73, 880, 120, 143, 158, 187.

***Tsuga mertensiana***  
**(Bong.) Carr.**  
**Pinaceae**  
**Mountain Hemlock**

The word *tsuga* is the Japanese name for the native hemlocks of Japan. The word *mertensiana* is named for Karl Heinrich Mertens (1796–1830), German naturalist and physician, who discovered it at Sitka, Alaska.

**Other Common Names:** Alpine hemlock, alpine spruce, berg-hemlock, black hemlock, Olympic fir, Pacific Coast hemlock, Patton’s hemlock, Patton’s spruce, Prince Albert’s fir, tsuga de California, tsuga de Californie, tsuga de l’ouest, tsuga de Patton, tsuga di California, vastamerikansk berg-hemlock, weeping spruce, westAmerikanische hemlocktanne, western hemlock, western hemlock spruce, Williamson’s spruce.

**Distribution:** Mountain hemlock is native to the Pacific Coast region from southern Alaska (Kenai Peninsula) southeast through southeastern Alaska and western British Columbia and south in the mountains from western Washington to western Oregon and the Sierra Nevada to central California. It is also found in the Rocky Mountain region from southwestern British Columbia south to northeast Oregon, northern Idaho, and northwest Montana.

**The Tree:** Mountain hemlock trees reach heights of 50 to 150 ft (15.24 to 45.72 m), with diameters of 1 to 5 ft (0.30 to 1.52 m). A record tree is reported at a height of 113 ft (34.44 m), with a diameter of 88 in. (2.22 m).

**General Wood Characteristics:** The heartwood is near white, sometimes with a purple tinge, and the sapwood is somewhat lighter in color. The wood is moderately light in weight and moderate in strength, hardness, stiffness, and shock resistance. Trees may contain wetwood and/or have ring shake. Mountain hemlock has approximately the same density as western hemlock but is somewhat lower in bending strength and stiffness.

**Weight**

Moisture content	Specific gravity	Weight	
		lb/ft <sup>3</sup>	kg/m <sup>3</sup>
Green	0.42 <sup>a</sup>	44 <sup>b</sup>	705
12%	0.45 <sup>a</sup>	33 <sup>b</sup>	529
Ovendry	0.51 <sup>b</sup>	NA	NA

<sup>a</sup>Reference (56).

<sup>b</sup>Reference (192).

**Mechanical properties<sup>a</sup>**

Property	Green		Dry	
MOE	1.04 × 10 <sup>6</sup> in/lb <sup>2</sup>	7.17 GPa	1.33 × 10 <sup>6</sup> in/lb <sup>2</sup>	9.17 GPa
MOR	6.30 × 10 <sup>3</sup> in/lb <sup>2</sup>	43.4 MPa	11.5 × 10 <sup>3</sup> in/lb <sup>2</sup>	79.3 MPa
C <sub>  </sub>	2.88 × 10 <sup>3</sup> in/lb <sup>2</sup>	19.9 MPa	6.44 × 10 <sup>3</sup> in/lb <sup>2</sup>	44.4 MPa
C <sub>⊥</sub>	0.37 × 10 <sup>3</sup> in/lb <sup>2</sup>	2.55 MPa	0.86 × 10 <sup>3</sup> in/lb <sup>2</sup>	5.93 MPa
WML	11.0 in-in/lb <sup>3</sup>	75.8 kJ/m <sup>3</sup>	10.4 in-in/lb <sup>3</sup>	71.7 kJ/m <sup>3</sup>
Hardness	470 lbf	2090 N	680 lbf	3020 N
Shear <sub>  </sub>	0.93 × 10 <sup>3</sup> in/lb <sup>2</sup>	6.41 MPa	1.54 × 10 <sup>3</sup> in/lb <sup>2</sup>	10.6 MPa

<sup>a</sup>Reference (56) (2-in. (5-cm) standard).

### Drying and shrinkage<sup>a</sup>

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.1	NA	NA
Radial	4.4	NA	NA
Volumetric	11.1	NA	NA

<sup>a</sup>Reference (56).

### Kiln drying schedules

Conventional temperature/moisture content-controlled schedules<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	10/4 stock	12/4 stock	British schedule 4/4 stock
Standard	T12-C5	T11-C5	T11-C4	T8-A4	T8-A3	K

<sup>a</sup>References (28, 185).

Conventional temperature/time-controlled schedules<sup>a</sup>

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	291	291	NA	NA	NA	NA

<sup>a</sup>References (28, 185).

High temperature<sup>a</sup>

Condition	4/4, 5/4 stock	6/4 stock	8/4 stock	Other products
Standard	400	400	400	NA

<sup>a</sup>References (28, 185).

**Working Properties:** The wood is intermediate in nail-holding ability and has a tendency to split when nailed. It glues, stains, polishes, varnishes, and paints satisfactorily.

**Durability:** The heartwood of hemlock is slightly resistant to nonresistant to decay (56).

**Preservation:** Mountain hemlock is resistant to preservative treatment (74).

**Uses:** Mountain hemlock serves some of the same uses as western hemlock, although the quantity available is much less. Western hemlock is used for pulpwood, lumber, roof decking, laminating stock, mouldings, architectural trim, general construction, newsprint, and plywood. The lumber is used for building material, such as sheathing, siding, subflooring, joists, studding, planking, and rafters. Considerable quantities are used in the manufacture of boxes, pallets, crates, and flooring, and smaller amounts for furniture and ladders.

**Toxicity:** Can cause dermatitis (71, 158, 214).

**Additional Reading:** 44, 51, 120, 149, 187, 209.

## References

1. Albala, H. 1965. Mechanical and associated properties of *Pinus radiata* wood. Santiago, Chile: Instituto Forestal.
2. Alexander, R.R.; Shepperd, W.D. 1990. *Picea engelmannii* Parry ex Engelm., Engelmann spruce. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 187–203.
3. Alexander, R.R.; Shearer, R.C.; Shepperd, W.D. 1990. *Abies lasiocarpa* (Hook.) Nutt., subalpine fir. Agric. Handb. 654. In: Burns, R.M. and Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 60–70.
4. Anderson, A.B.; Zavarin E. 1965. The influence of extractives on tree properties III. Incense cedar (*Libocedrus decurrens* Torrey). Journal of the Institute of Wood Science. 15: 3–24.
5. Anon. 1936. *Thuja plicata*: western red cedar. Wood. 1(4): 176–177.
6. Anon. 1937. *Pinus palustris*: pitch pine. Wood. 2(1): 17–18.
7. Anon. 1956. *Picea* (spruces), white spruce. Agric. Handb. 271, FS–152. Washington, DC: U.S. Department of Agriculture, Forest Service.
8. Anon. 1956. *Thuja* (thujas or arborvitae). Agric. Handb. 271. FS–207. Washington, DC: U.S. Department of Agriculture, Forest Service.
9. Back, E.A.; Rabak, F. 1922. Red cedar chests as protectors against moth damage. Bull. 1051. Washington, DC: U.S. Department of Agriculture.
10. Baker, J.B.; Langdon, O.G. 1990. *Pinus taeda* L., loblolly pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 497–512.
11. Bender, F. 1967. Canada balsam: its preparation and uses. Ottawa, Canada: Forestry Branch, Canada Department of Forestry and Rural Development.
12. Berni, C.A.; Bolza, E.; Christensen, F.J. 1979. South American timbers—the characteristics, properties and uses of 190 species. Melbourne, Australia: Division of Building Research, Commonwealth Scientific and Industrial Research Organization.
13. Betts, H.S. 1937. Alaska-cedar (*Chamaecyparis nootkatensis*). Washington, DC : U.S. Department of Agriculture, Forest Service, American Woods.
14. Betts, H.S. 1937. Eastern red cedar (*Juniperus virginiana*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods.
15. Betts, H.S. 1939. Sitka spruce (*Picea sitchensis*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods Series.
16. Betts, H.S. 1945. Eastern spruce. Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods.
17. Betts, H.S. 1945. Noble fir (*Abies procera*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO 669274–45.
18. Betts, H.S. 1945. Northern white-cedar (*Thuja occidentalis*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO 663820–45.
19. Betts, H.S. 1945. Port Orford white-cedar (*Chamaecyparis lawsoniana*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO O–940474.
20. Betts, H.S. 1945. Redwood. Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO O–940471.
21. Betts, H.S. 1954. Eastern white pine (*Pinus strobus*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO 301226–54.
22. Betts, H.S. 1960. Baldcypress (*Taxodium distichum*). Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO 540424–60.
23. Betts, H.S. 1960. Sugar pine. Washington, DC: U.S. Department of Agriculture, Forest Service, American Woods, USGPO 540525–60.

24. Bier, H. 1985. Bending properties of structural timber from a 28-year-old stand of New Zealand *Pinus radiata*. New Zealand Journal of Forestry Science. 15(2): 233–250.
25. Blum, B.B. 1990. *Picea rubens* Sarg., red spruce. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 250–259.
26. Boas, I.H. 1947. The commercial timbers of Australia: their properties and uses. Melbourne, Australia: Council for Scientific and Industrial Research, Commonwealth of Australia.
27. Bolsinger, C.L.; Jaramillo, A.E. 1990. *Taxus brevifolia* Nutt., Pacific yew. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 573–579.
28. Boone, R.S.; Kozlik, C.J.; Bois, P.J.; Wengert, E.M. 1988. Dry kiln schedules for commercial woods—temperate and tropical. FPL–GTR–57. Madison, WI: U.S. Department of Agriculture, Forest Service.
29. Bormann, B.T. 1984. Douglas-fir an American wood. FS–235. Washington, DC: U.S. Department of Agriculture, Forest Service.
30. Boyer, W.D. 1990. *Pinus palustris* Mill., longleaf pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 405–412.
31. Bramlett, D.L. 1990. *Pinus serotina* Michx., pond pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 470–475.
32. Brendemuehl, R.H. 1990. *Pinus clausa* (Chapm. ex Engelm.) Vasey ex Sarg., sand pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 294–301.
33. Brisbin, R.L. 1970. Eastern hemlock, an American wood. FS–239. Washington, DC: U.S. Department of Agriculture, Forest Service.
34. Burns, R.M.; Honkala, B.H. 1990. Silvics of North America, Vol. 1, conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service.
35. Campbell, R.N.; Clark, J.W. 1960. Decay resistance of baldcypress heartwood. Forest Products Journal. May: 250–253.
36. Carter, K.K.; Snow, A.G., Jr. 1990. *Pinus virginiana* Mill., Virginia pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 513–519.
37. Cary, N.L. 1922. Sitka spruce: its uses, growth, and management. Washington, DC: Government Printing Office, U.S. Department of Agriculture.
38. Chidester, G.H.; Schafer, E.R. 1954. Pulping of Latin-American woods. Latin-American Conference on Pulp and Paper; 1954 October 18–November 2; Buenos Aires, Argentina. Buenos Aires, Argentina: FAO/Economic Commission for Latin America/Technical Assistance Administration for Latin America; Rept. 2012.
39. Childs, M.R. 1957. Treating second growth baldcypress for fence posts. Res. Note 19. Lufkin, TX: U.S. Department of Agriculture, Texas Forest Service.
40. Chudnoff, M. 1984. Tropical timbers of the world. Agric. Handb. 607. Washington, DC: U.S. Department of Agriculture, Forest Service.
41. Cockrell, R.A. 1943. Some observations on density and shrinkage of ponderosa pine wood. Transactions of the ASME . 10 p.
42. Cockrell, R.A. 1959. Mechanical properties of California-grown Monterey pine. Hilgardia. 28(8): 227–238.



43. Cooper, R.W.; Schopmeyer, C.S.; McGregor, W.H.D. 1959. Sand pine regeneration on the Ocala National Forest. Production Res. Rep. 30. Washington, DC: U.S. Department of Agriculture, Forest Service.
44. Crawford, P.D.; Oliver, C.D. 1990. *Abies amabilis* Dougl. ex Forbes, Pacific silver fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 17–25.
45. Critchfield, W.B.; Little, E.L., Jr. 1971. Geographic distribution of the pines of the world. Misc. Pub. 991. Washington, DC: U.S. Department of Agriculture, Forest Service.
46. Dallimore, W.; Jackson, A.B. 1966. A handb. of coniferae and ginkgoaceae. London, UK: Edward Arnold (Publishers) Ltd.
47. Dealy, J.E. 1990. *Juniperus occidentalis* Hook., western juniper. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 109–115.
48. Della-Bianca, L. 1990. *Pinus pungens* Lamb., Table Mountain pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 425–432.
49. Ditchburne, N.; Kloot, N.H.; Rumball, B. 1975. The mechanical properties of Australian-grown *Pinus radiata* D. Don. Melbourne, Australia: CSIRO Division of Building Res. Tech. Pap. 9 (second series).
50. Dohr, A.W.; Drow, J.T. 1946. The mechanical properties of Insignis pine (*Pinus radiata*) from Chile. Unpub. Rep. Madison, Wisconsin: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.
51. DPI. 1990. Radiata pine. Queensland, Australia: DPI, Queensland Forest Service, Timber Species 22.
52. Drow, J.T. 1960. Mechanical properties of Engelmann spruce. FPL Rep. 1944–4. Madison, Wisconsin: U.S. Department of Agriculture, Forest Service.
53. Elias, T.S. 1980. The complete trees of North America. Field guide and natural history. New York, NY: Van Nostrand Reinhold Company.
54. Englerth, G.H.; Hansbrough, J.R. 1945. The significance of the discolorations in aircraft lumber: Noble fir and western hemlock. Madison, WI: U.S. Department of Agriculture, Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration.
55. Foiles, M.W.; Graham, R.T.; Olson, D.F., Jr. 1990. *Abies grandis* (Dougl. ex D. Don) Lindl., grand fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 52–59.
56. Forest Products Laboratory. 1987. Wood handbook: Wood as an engineering material. Agric. Handb. 72. (Rev.) Washington, DC: U.S. Department of Agriculture. 466 p.
57. Frank, R.M. 1990. *Abies balsamea* (L.) Mill., balsam fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 26–35.
58. Franklin, J.F. 1990. *Abies procera* Rehd., noble fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 80–87.
59. Fraser, D.A. 1966. Vegetative and reproductive growth of black spruce [*Picea mariana* (Mill.) BSP.] at Chalk River, Ontario, Canada. Canadian Journal of Botany 44: 567–580.
60. Gaby, L.I. 1985. The southern pines, an American wood. FS–256. Washington, DC: U.S. Department of Agriculture, Forest Service.

61. Gardner, J.A.F. 1963. The chemistry and utilization of western red cedar. Pub. 1023. Ottawa, Canada: Canada Department of Forestry, Forest Products Research Branch, Department of Forestry.
62. Gerry, E. 1953. Southern cypress terminology. Information leaflet. Madison, WI: Forest Products Laboratory, U.S. Department of Agriculture, Forest Service.
63. Gerry, E. 1943. Western hemlock "floccosoids" (white spots or streaks). Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. Pub. 1392.
64. Godman, R.M.; Lancaster, K. 1990. *Tsuga canadensis* (L.)Carr., eastern hemlock. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 604–612.
65. Graham, R.T. 1990. *Pinus monticola* Dougl. ex D.Don., western white pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 385–394.
66. Harris, A.S. 1984. Alaska-cedar, an American wood. FS-224. Washington, DC: U.S. Department of Agriculture, Forest Service.
67. Harris, A.S. 1984. Sitka spruce, an American wood. FS-265. Washington, DC: U.S. Department of Agriculture, Forest Service.
68. Harris, A.S. 1990. *Chamaecyparis nootkatensis* (D. Don) Spach., Alaska-cedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 97–102.
69. Harris, A.S. 1990. *Picea sitchensis* (Bong.) Carr., Sitka spruce. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 260–267.
70. Haslett, A.N. 1986. Properties and utilization of exotic specialty timbers grown in New Zealand, Part III: cypresses. FRI Bull. 119. Rotorua, New Zealand: Forest Research Institute, New Zealand Forest Service.
71. Hausen, B.M. 1981. Woods injurious to human health. A manual. New York, NY: Walter de Gruyter.
72. Heinselman, M.L. 1959. Natural regeneration of swamp black spruce in Minnesota under various cutting systems. Production Res. Rep. 32. Washington, DC: U.S. Department of Agriculture, Forest Service.
73. Hemmerly, T.E. 1970. Economic uses of eastern red cedar. Economic Botany. 24(1): 39–41.
74. Henderson, F.Y. 1977. A handbook of softwoods. London, UK: Her Majesty's Stationery Office.
75. Hofmann, J.V. 1922. Engelmann spruce. The timberman. 23(9): 33–36.
76. Holdridge, L.R.; Teesdale, L.V.; Meyer, J.E.; [and others]. 1947. The forests of western and central Ecuador. Special Latin American Forest Resources Project. Washington, DC: U.S. Department of Agriculture, Forest Service.
77. Hyam, R.; Pankhurst, R. Plant [and others]. 1995. A concise dictionary. Oxford, UK: Oxford University Press.
78. Instituto Forestal de Chile. 1966. Chile, exportador de pino insigne. Santiago, Chile: Instituto Forestal de Chile.
79. Jenkinson, J.L. 1990. *Pinus jeffreyi* Grev. & Balf., Jeffrey pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 359–369.

80. Johnson, R.P.A.; Bradner, M.I. 1932. Properties of western larch and their relation to uses of the wood. Tech. Bull. 285. Washington, DC: U.S. Department of Agriculture, Forest Service.
81. Johnson, R.P.A.; Gibbons, W.H. 1929. Properties of western hemlock and their relation to uses of the wood. Tech. Bull. 139. Washington, DC: U.S. Department of Agriculture, Forest Service.
82. Johnston, W.F. 1990. *Larix laricina* (Du Roi) K. Koch, tamarack. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 141–151.
83. Johnston, W.F. 1990. *Thuja occidentalis* L., northern white-cedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 580–589.
84. Johnston, W.F.; Carpenter, E.M. 1985. Tamarack, an American wood. FS–268. Washington, DC: U.S. Department of Agriculture, Forest Service.
85. Johnston, W.F.; Hyvarinen, M.J. 1979. Northern white-cedar, an American wood. FS–227. Washington, DC: U.S. Department of Agriculture, Forest Service.
86. Kallio, E.; Benzie, J.W. 1980. Red pine, an American wood. FS–255. Washington, DC: U.S. Department of Agriculture, Forest Service.
87. Kennedy, H.E., Jr. 1972. Baldcypress, an American wood. FS–218. Washington, DC: U.S. Department of Agriculture, Forest Service.
88. Kinloch, B.B., Jr. 1984. Sugar pine, an American wood. FS–257. Washington, DC: U.S. Department of Agriculture, Forest Service.
89. Kinloch, B.B., Jr.; Scheuner, W.H. 1990. *Pinus lambertiana* Dougl., sugar pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 370–378.
90. Kloot, H. 1974. Reassessment of radiata pine for structural purposes. Victoria, Australia: CSIRO Forest Products Newsletter 399.
91. Koch, P. 1972. Utilization of the southern pines. I. The raw material. II. Processing. Agric. Handb. 420. Washington, DC: U.S. Department of Agriculture, Forest Service.
92. Kossuth, S.V.; Michael, J.L. 1990. *Pinus glabra* Walt., spruce pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 355–358.
93. Kraemer, J.H. 1951. The effects of three factors upon the cross-breaking strength and stiffness of red pine. Lafayette, Station Bull. 560. In: Purdue University, Agricultural Experiment Station.
94. Laacke, R.J. 1990. *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr., subalpine fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 36–46.
95. Laacke, R.J. 1990. *Abies magnifica* A. Murr., California red fir. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 71–79.
96. Laderman, A.D.; Ward, D.B. 1987. Appendix A. Flora associated with *Chamaecyparis thyoides*: A checklist with common synonyms. in: Laderman, A.D., ed. Atlantic white cedar wetlands. Boulder, CO: Westview Press. p. 385–400.
97. Lawson, E.R. 1985. Eastern redcedar, an American wood. FS–260. Washington, DC: U.S. Department of Agriculture, Forest Service.
98. Lawson, E.R. 1990. *Pinus echinata* Mill., shortleaf pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 316–326.

99. Lindquist, J.L. 1974. Redwood, an American wood. FS-262. Washington, DC: U.S. Department of Agriculture, Forest Service.
100. Little, Jr. E.L. 1938. Alligator juniper. Res. Note 30. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station.
101. Little, E.L., Jr. 1938. Food analysis of pinon nuts, a compilation of existing data. Res. Note 48. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station.
102. Little, E.L., Jr. 1938. Stages of growth of pinons in 1938. Res. Note 50. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Experiment Station.
103. Little, E.L., Jr. 1940. Suggestions for selection cutting of pinon trees. Res. Note 90. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station.
104. Little, E.L., Jr. 1941. Managing woodlands for pinon nuts. *Chronica Botanica*. 6(15):348-349.
105. Little, E.L., Jr. 1941. Some preliminary notes on southwestern corky barks. Res. Rep. 3. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Experiment Station.
106. Little, E.L., Jr. 1947. A collection of tree specimens from western Ecuador. *Caribbean Forester*. 8(3): 215-298.
107. Little, E.L., Jr. 1948. New species of trees from western Ecuador. *Journal of the Washington Academy of Sciences*. 38(3): 87-105.
108. Little, E.L., Jr. 1948. Trees of Ecuador. *Foreign Agriculture*. 12: 54-59.
109. Little, E.L., Jr. 1953. A natural hybrid spruce in Alaska. *Journal of Forestry*. October: 745-747.
110. Little, E.L., Jr. 1961. Sixty trees from foreign lands. *Agric. Handb.* 212. Washington, DC: U.S. Department of Agriculture, Forest Service.
111. Little, E.L., Jr. 1962. Key to Mexican species of pines. *Caribbean Forester*. 23(2):72-81.
112. Little, E.L., Jr. 1971. Atlas of United States trees. Vol. 1. Misc. Pub. 1146. Conifers and important hardwoods. Washington, DC: U.S. Department of Agriculture, Forest Service.
113. Little, E.L., Jr. 1975. Rare and local conifers in the United States. *Conservation Res. Rep.* 19. Washington, DC: U.S. Department of Agriculture, Forest Service.
114. Little, E.L., Jr. 1976. Atlas of United States trees. Vol. 3. Minor western hardwoods. Misc. Pub. 1314. Washington, DC: U.S. Department of Agriculture, Forest Service.
115. Little, E.L., Jr. 1976. Rare tropical trees of South Florida. CRR 20. Washington, DC: U.S. Department of Agriculture, Forest Service.
116. Little, E.L., Jr. 1977. Atlas of United States trees. Vol. 4. Minor eastern hardwoods. Misc. Pub. 1342. Washington, DC: U.S. Department of Agriculture, Forest Service.
117. Little, E.L., Jr. 1978. Atlas of United States trees. Vol. 5. Florida. Misc. Pub. 1361. Washington, DC: U.S. Department of Agriculture, Forest Service.
118. Little, E.L., Jr. 1978. Important forest trees of the United States. *Agric. Handb.* 519. Washington, DC: U.S. Department of Agriculture, Forest Service.
119. Little, E.L., Jr. 1979. Checklist of United States trees (native and naturalized). *Agric. Handb.* 541. Washington, DC: USDA, Forest Service.
120. Little, E.L., Jr. 1980. The audubon society field guide to North American trees. Eastern region. New York: Alfred A. Knopf, Inc.
121. Little, E.L., Jr. 1980. The audubon society field guide to North American trees. Western region. New York: Alfred A. Knopf, Inc.
122. Little, E.L., Jr. 1981. Atlas of United States trees. Vol. 6. Supplement. Misc. Pub. 1410. Washington, DC: U.S. Department of Agriculture, Forest Service.

123. Little, E.L., Jr. 1983. Forest communities of Esmeraldas Province, Ecuador. Rome, Italy: FAO, United Nations.
124. Little, E.L., Jr. 1986. Arboles Comunes de Venezuela, Ciataceas–Podocarpaceas–Cupresaceas–Gramineas–Palmeras. Merida, Venezuela: Universidad de Los Andes, Consejo de Desarrollo Cientifico, Humanistico y Tecnologico, Consejo de Publicaciones, Serie Agro–Forestal 7.02.
125. Little, E.L., Jr. 1986. Arboles Comunes de Venezuela, Introduccion General a la Obra. Merida, Venezuela: Universidad de Los Andes, Consejo de Desarrollo Cientifico, Humanistico y Tecnologico, Consejo de Publicaciones, Serie Agro–Forestal 7.01.
126. Little, E.L., Jr. 1986. Arboles Comunes de Venezuela, Moraceas–Urticaceas–Proteaceas. Merida, Venezuela: Universidad de Los Andes, Consejo de Desarrollo Cientifico, Humanistico y Tecnologico, Consejo de Publicaciones, Serie Agro–Forestal No 7.04.
127. Little, E.L., Jr. 1986. Arboles Comunes de Venezuela, Piperaceas–Clorantaceas–Casuarinaceas–Salicaceas–Miricaceas–Juglandaceas–Betulaceas–Ulmaceas. Merida, Venezuela: Universidad de Los Andes, Consejo de Desarrollo Cientifico, Humanistico y Tecnologico, Consejo de Publicaciones, Serie Agro–Forestal 7.03.
128. Little, E.L., Jr. 1986. The audubon society field guide to North American trees. Western region. New York, NY: Alfred A. Knopf, Inc.
129. Little, E.L., Jr. 1988. The audubon society field guide to North American trees. Eastern region. New York, NY: Alfred A. Knopf, Inc.
130. Little, E.L., Jr.; Critchfield, W.B. 1969. Subdivisions of the genus *Pinus* (pines). Mis. Pub. 1144. Washington, DC: U.S. Department of Agriculture, Forest Service.
131. Little, E.L., Jr.; Dixon, R.G. 1983. Arboles comunes de la provincia de Esmeraldas Ecuador. Rome, Italy: FAO, Peace Corps.
132. Little, E.L., Jr.; Dorman, K.W. 1954. Slash pine (*Pinus elliottii*), including south Florida slash pine, nomenclature and description. Station Pap. 36. Washington, DC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station.
133. Little, E.L., Jr.; Honkala, B.H. 1976. Trees and shrubs of the United States: a bibliography for identification. Misc. Pub. 1336. Washington, DC: U.S. Department of Agriculture, Forest Service.
134. Little, E.L., Jr.; Righter, F.I. 1965. Botanical descriptions of forty artificial pine hybrids. Washington, DC: U.S. Department of Agriculture, Forest Service, USGPO.
135. Little, E.L., Jr.; Skolmen, R.G. 1989. Common forest trees of Hawaii, USA. Native and naturalized. American Journal of Botany. 76(6 suppl.): 257.
136. Little, E.L., Jr.; Wadsworth, F.H. 1964. Common trees of Puerto Rico and the Virgin Islands. Agric. Handb. 249. Washington, DC: U.S. Department of Agriculture, Forest Service.
137. Little, E.L., Jr.; Wadsworth, F.H. 1989. Common trees of Puerto Rico and the Virgin Islands. Agric. Handb. 249, 2nd printing. Washington, DC: U.S. Department of Agriculture, Forest Service.
138. Little, E.L., Jr.; Woodbury, R.O. 1980. Rare and endemic trees of Puerto Rico and the Virgin Islands. Conservation Res. Rep. 27. Washington, DC: U.S. Department of Agriculture, Forest Service.
139. Little, E.L., Jr.; Woodbury, R.O.; Wadsworth, F.H. 1974. Trees of Puerto Rico and the Virgin Islands. Agric. Handb. 449. Vol. 2. Washington, DC: U.S. Department of Agriculture, Forest Service.
140. Little, S.; Garrett, P.W. 1990. *Pinus rigida* Mill., pitch pine. Agric. Handb. 654. In: Burns, R.M. and Honkala, B. H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 456–462.

141. Lohrey, R.E.; Kossuth, S.V. 1990. *Pinus elliottii* Engelm., slash pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 338–347.
142. Lotan, J.E.; Critchfield, W.B. 1990. *Pinus contorta* Dougl. ex. Loud., lodgepole pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 302–315.
143. Lotan, J.E.; Perry, D.A. 1983. Ecology and regeneration of lodgepole pine. Agric. Handb. 606. Washington, DC: U.S. Department of Agriculture, Forest Service.
144. Lowery, D.P. 1984. Lodgepole pine, an American wood. FS–253. Washington, DC: U.S. Department of Agriculture, Forest Service.
145. Lowery, D.P. 1984. Ponderosa pine, an American wood. FS–254. Washington, DC: U.S. Department of Agriculture, Forest Service.
146. Lowery, D.P. 1984. Western Larch, an American wood. FS–243. Washington, DC: U.S. Department of Agriculture, Forest Service.
147. Lowery, D.P. 1984. Western redcedar, an American wood. FS–261. Washington, DC: U.S. Department of Agriculture, Forest Service.
148. Lowery, D.P. 1984. Western white pine, an American wood. FS–258. Washington, DC: U.S. Department of Agriculture, Forest Service.
149. Luxford, R.F.; Markwardt, L.J. 1932. The strength and related properties of redwood. Tech. Bull. 305. Washington, DC: U.S. Department of Agriculture, Forest Service.
150. Luxford, R.F.; Wood, L.W.; Gerry, E. 1943. “Black streak” in western hemlock: its characteristics and influence on strength. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.
151. Markstrom, D.C.; Alexander, R.R. 1984. Engelmann spruce, an American wood. FS–264. Washington, DC: U.S. Department of Agriculture, Forest Service.
152. Markstrom, D.C.; McElderry, S.E. 1984. White Fir, an American wood. FS–237. Washington, DC: U.S. Department of Agriculture, Forest Service.
153. Markwardt, L.J.; Wilson, T.R.C. 1935. Strength and related properties of woods grown in the United States. Tech. Bull. 479. Washington, DC: U.S. Department of Agriculture, Forest Service.
154. Marriott, F.G.; Greaves, C. 1947. Canada balsam, its preparation and uses. Mimeograph 123. Ottawa, Canada: Canada Department of Mines and Resources, Lands Parks and Forests Branch, Dominion Forest Service, Forest Products Laboratories.
155. McDonald, P.M. 1973. Incense-cedar, an American wood. FS–226. Washington, DC: U.S. Department of Agriculture, Forest Service.
156. Means, J.E. 1990. *Tsuga mertensiana* (Bong.) Carr., mountain hemlock. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 623–634.
157. Minore, D. 1990. *Thuja plicata* Donn ex D. Don., western redcedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service.
158. Mitchell, J.; Rook, A. 1979. Botanical dermatology: plants and plant products injurious to the skin. Vancouver, BC, Canada: Greengrass Ltd.
159. Mitchell, R.L.; Ritter, G.J. 1953. Galactan in western larch wood. Forest Products Journal. 2:1–3.
160. Nienstaedt, H.; Zasada, J.C. 1990. *Picea glauca* (Moench) Voss., white spruce. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 204–226.

161. NLMA. 1950. Northeastern white pine, its grades and uses. New York, NY: National Lumber Manufacturers Association.
162. Ohmann, J.L. 1984. Port-Orford-Cedar, an American wood. FS-228. Washington, DC, USA.: U.S. Department of Agriculture, Forest Service.
163. Olson, D.F., Jr.; Roy, D.F.; Walters, G.A. 1990. *Sequoia sempervirens* (D. Don.) Endl., redwood. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 541–551.
164. Ostrander, M.D. 1974. Eastern Spruce, an American wood. FS-263. Washington, DC: U.S. Department of Agriculture, Forest Service.
165. Packee, E.C. 1990. *Tsuga heterophylla* (Raf.) Sarg., western hemlock. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 613–622.
166. Perez, V.A.G.; Martinez, L.B.; Del Rio, E.E. 1973. Classification of *Pinus radiata* D. Don. according to endurance. Santiago, Chile: Instituto Forestal.
167. PFI. 1959. Laminated western red cedar roof decking. Lewiston, ID: Potlach Forests, Inc., AIA File 19-B-3.
168. Port Orford Cedar Products Company and Dant and Russell, Inc. 1929. Port Orford cedar: its properties and uses. Portland, OR: Port Orford Cedar Products Company.
169. Powers, R.F.; Oliver, W.W. 1990. *Libocedrus decurrens* Torr., incense-cedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 173–180.
170. Pratt, M.B. 1922. Shade and ornamental trees of California. California State Board of Forestry.
171. Record, S.J.; Hess, R.W. 1943. Timbers of the new world. New Haven, CT: Yale University Press.
172. Reid, R.W.; Watson, J.A. 1966. Sizes, distributions, and numbers of vertical resin ducts in lodgepole pine. Canadian Journal of Botany. 44: 519–525.
173. Rendle, B.J. 1970. World timbers. London, UK: Ernest Benn Limited.
174. Robinson, A.I. 1938. Canada balsam. The Microscope. 2(6):141–143.
175. Ronco, Jr. F.P. 1990. *Pinus edulis* Engelm., pinyon. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 327–337.
176. Rudolf, P.O. 1990. *Pinus resinosa* Ait., red pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 442–455.
177. Rudolph, T.D. 1985. Jack pine, an American wood. FS-252. Washington, DC: U.S. Department of Agriculture, Forest Service.
178. Rudolph, T.D.; Laidly, P.R. 1990. *Pinus banksiana* Lamb., jack pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 280–293.
179. Rudolph, T.D.; Yeatman, C.W. 1982. Genetics of jack pine. Res. Pap. WO-38. Washington, DC.: U.S. Department of Agriculture, Forest Service.
180. Sangüesa, H.A. 1965. Mechanical properties of the wood of *Pinus radiata*.. Santiago, Chile: Instituto Forestal.
181. Schmidt, W.C.; Shearer, R.C. 1990. *Larix occidentalis* Nutt., western larch. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 160–172.

182. Schroeder, J.G.; Taras, M.A. 1985. Atlantic white-cedar, an American wood. FS-225. Washington, DC: U.S. Department of Agriculture, Forest Service.
183. Scott, C.W. 1960. *Pinus radiata*. No. 14. Rome, Italy: FAO Forestry and Forest Products Studies.
184. Show, S.B.; Stuart, R.Y. 1932. Timber growing and logging practice in the coast redwood region of California. Tech. Bull. 283. Washington, DC: U.S. Department of Agriculture, Forest Service.
185. Simpson, W.T. 1991. Dry kiln operator's manual. Agric. Handb. 188. Madison, WI: U.S. Department of Agriculture, Forest Service.
186. Sonderman, D.L. 1970. Balsam Fir, an American wood. FS-234. Washington, DC: U.S. Department of Agriculture, Forest Service.
187. Steele, R. 1990. *Pinus flexilis* James., limber pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 348-354.
188. Stern, E.G.S, 1943. Strength properties of red spruce from West Virginia. Blacksburg, VA: Bulletin of the Virginia Polytechnic Institute, Engineering Experiment Station Series 55.
189. Sternitzke, H.S. 1971. Baldcypress: endangered or expanding species? Economic Botany. 25: 130-134.
190. Sternitzke, H.S.; Nelson, T.C. 1970. The southern pines of the United States. Economic Botany. 24(2): 142-150.
191. Sudworth, G.B. 1915. The cypress and juniper trees of the Rocky Mountain region. Bulletin 207. Washington, DC: U.S. Department of Agriculture.
192. Summitt, R.; Sliker, A. 1980. CRC Handb. of materials science, IV: wood. Boca Raton, FL: CRC Press, Inc.
193. Taras, M.A. 1971. Atlantic white-cedar, an American wood. FS-225. Washington, DC: U.S. Department of Agriculture, Forest Service.
194. Taylor, R.J. 1972. The relationship and origin of *Tsuga heterophylla* and *Tsuga mertensiana* based on phytochemical and morphological interpretations. American Journal of Botany. 59(2): 149-157.
195. USDA, Forest Service. [n.d.] Virgin Port Orford cedar tract reserved a "Natural Area." U.S. Department of Agriculture, Forest Service 22(1): 8.
196. Viereck, L.A.; Johnston, W.F. 1990. *Picea mariana* (Mill.) B.S.P., black spruce. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 227-237.
197. Viereck, L.A.; Little, E.L., Jr. 1975. Atlas of United States trees. Vol. 2, Alaska trees and common shrubs. Misc. Pub. 1293. Washington, DC: U.S. Department of Agriculture, Forest Service.
198. Viereck, L.A.; Little, E.L., Jr. 1974. Guide to Alaska trees. Agric. Handb. No 472. Washington, DC: U.S. Department of Agriculture, Forest Service.
199. von Schrenk, H. 1931. The American bald cypress. Jacksonville, FL: Southern Cypress Manufacturers' Association.
200. Ward, D.B.; Clewell, A.F. 1989. Atlantic white cedar (*Chamaecyparis thyoides*) in the southern states. Florida Scientist. 52(1): 8-47.
201. Welo, L.A. 1919. Emergency seasoning of sitka spruce. Scientific American. Supplement. 2269: 404-405.
202. Wendel, G.W.; Smith, H.C. 1990. *Pinus strobus* L., eastern white pine. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 476-488.



203. Wentling, J.P. 1938. Western red cedar, the ideal pole. Minneapolis, MN: Western Red and Northern White Cedar Association.
204. West Coast Lumbermen's Association. [n.d.] Western red cedar lumber: grades and uses. Portland, OR: West Coast Lumbermen's Association.
205. Western, H.V. 1953. Natural occurrence of baldcypress on Theodore Roosevelt Island, Washington, DC *Journal of Forestry*. 51(6): 446–447.
206. Western Pine Association. [n.d.] Facts about lodgepole pine. Portland, OR: Western Pine Association.
207. Western Pine Association. 1936. Sugar pine: a genuine white pine. Portland, OR: Western Pine Association.
208. Western Pine Association. 1942. Sugar pine for perfect patterns. Portland, OR: Western Pine Association.
209. Western Pine Association. 1948. Larch of the western pine region. Portland, OR: Western Pine Association.
210. Western Pine Association. 1957. Engelmann spruce of the western pine region. Portland, OR: Western Pine Association.
211. Wikstrom, J.H. 1957. Lodgepole pine—a lumber species. Res. Pap. 46. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.
212. Wilhite, L.P. 1990. *Juniperus silicicola* (Small) Bailey, southern redcedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. *Silvics of North America*. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 127–130.
213. Willits, S.; Fahey, T.D. 1991. Sugar pine utilization: a 30-year transition. Portland, OR: Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service.
214. Woods, B.; Calnan, C.D. 1976. Toxic woods. *British Journal of Dermatology*. 95(13): 1–97.
215. Youngs, R.L. 1963. Strength and related properties of mountain hemlock. FPL Res. Pap. 3. Madison, WI: U.S. Department of Agriculture, Forest Service.
216. Zobel, D.B. 1990. *Chamaecyparis lawsoniana* (A. Murr.) Parl., Port-Orford-cedar. Agric. Handb. 654. In: Burns, R.M.; Honkala, B.H., tech. coords. *Silvics of North America*. Vol. 1, Conifers. Washington, DC: U.S. Department of Agriculture, Forest Service: p. 88–96.

## Glossary

**Airdry**—See moisture content.

**Air drying**—The process of drying green lumber by exposure to prevailing atmospheric conditions.

**Annual growth ring**—The growth layer added to the tree each year in temperate climates or each growing season in other climates; each ring includes earlywood and latewood.

**Bark**—Outer layer of a tree, which consists of a thin, living inner part and a dry, dead outer part that is generally resistant to moisture movement.

**Board**—(1) Yard lumber that is less than 2 in. (50 mm) thick and  $\geq 2$  in. wide. (2) A term usually applied to 1-in.- (25.4-mm-) thick lumber of all widths and lengths.

**Bole**—The stem or trunk of a tree of size sufficient to yield lumber, veneer, or poles.

**Bolt**—(1) A short section of a tree trunk or limb, (2) a short log of a length suitable for peeling in a lathe for veneer, or (3) a short portion of a log prepared for production of shingles, staves, etc.

**Bow**—The distortion of a piece of lumber in which there is a deviation in a direction perpendicular-to-the- flat face from a straight line from end to end of the piece.

**Burl**—(1) A hard, woody outgrowth on a tree, more or less rounded in form, usually resulting from the entwined growth of a cluster of adventitious buds; (2) in wood or veneer, a localized severe distortion of the grain generally rounded in outline, usually resulting from overgrowth of dead branch stubs, varying from less than a half inch to several inches in diameter; frequently includes one or more clusters of several small contiguous conical protuberances, each usually having a core of pith but no appreciable amount of end grain (in tangential view) surrounding it.

**Cambium**—The layer of tissue between the bark and wood that repeatedly subdivides to form new wood and bark cells.

**Canal, resin**—*See* Resin canal.

**Cell**—In wood anatomy, a general term for the minute units of wood structure having distinct cell walls and cell cavities. Includes tracheids, parenchyma, and other elements of diverse structure and function.

**Cellulose**—The carbohydrate that is the principal constituent of wood and forms the framework of the wood cells.

**Characteristic**—A distinguishing feature or trait.

**Check**—*Syn:* Cracks, drying check, checking. A separation of the wood fibers within or on a log, timber, lumber, or other wood product resulting from tension stresses set up during drying, (usually the early stages of drying).

**Chemical Brown Stain**—A chemical discoloration of wood, which can occur during the air drying or kiln drying of several softwood species, caused by the concentration and modification of extractives.

**Clear wood**—Wood without knots, defects, or imperfections.

**Collapse**—The flattening of single cells or rows of cells during the drying or pressure treatment of wood, characterized by a caved-in or corrugated appearance.

**Compression parallel to grain**—Compression, endwise (parallel to the grain). The imposition of a compressive stress that acts in a direction parallel to the grain of the wood, as in a column.

**Compression perpendicular to grain**—Compression, sidewise (perpendicular to the grain). The imposition of a compressive stress that acts in a direction approximately perpendicular to the grain of the wood, as in a railroad tie.

**Compression wood**—Abnormal wood formed on the lower side of branches and inclined trunks of softwood trees. Compression wood is identified by its relatively wide annual rings (usually eccentric when viewed on cross section of branch or trunk), relatively large amount of latewood, sometimes more than 50% of the width of the annual rings in which it occurs, and its lack of demarcation between earlywood and latewood in the same annual rings. Compression wood shrinks excessively lengthwise when compared with normal wood.

**Conifer**—A tree belonging to the order Coniferae, usually evergreen, with cones and needle-shaped or scale-like leaves, and producing wood known commercially as “softwood.”

**Crook**—A distortion of a piece of lumber in which there is a deviation in a direction perpendicular to the edge from a straight line from end to end of the piece.

**Cross section**—*Syn*: Transverse section. A section of a board or log taken at right angles to the grain.

**Cup**—A form of board warp in which there is a deviation from a straight line across the width.

**Cut stock**—A term for softwood lumber, indicating that the product generally has been manufactured to dimensions suitable for a fabricating operation with little additional processing required.

**Decay**—*Syn*: Rot, dote. The decomposition of wood substance by fungi. In advanced (or typical) decay, destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ring-shaked, pitted, or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

**Advanced (or typical) decay**—the older stage of decay in which the destruction is readily recognized because the wood has become punky, soft and spongy, stringy, ring-shaked, pitted or crumbly. Decided discoloration or bleaching of the rotted wood is often apparent.

**Early (or incipient) decay**—refers to the stage at which the decay has not proceeded far enough to soften or otherwise perceptibly impair the hardness of the wood. Early decay is usually accompanied by a slight discoloration or bleaching of the wood.

**Defect**—An irregularity or imperfection in a tree, log, bolt, or lumber that reduces its volume or quality or lowers its durability, strength, or utility value. Defects may result from knots and other growth conditions and abnormalities, insect or fungus attack, and milling, drying, machining, or other processing procedures.

**Density**—The weight of a body per unit volume, usually expressed in pounds per cubic foot (grams per cubic centimeter). In wood, density changes relative to moisture content.

**Discoloration**—*Syn*: Stain. Change in the color of lumber resulting from fungal and chemical stains, weathering, or heat treatment.

**Dry**—Seasoned: in softwood lumber, the abbreviation S-Dry means not in excess of 19% moisture content at time of surfacing, in accordance with recognized standards.

**Dry-bulb temperature**—The temperature indicated by the dry-bulb thermometer of a psychrometer.

**Dry kiln**—A room, chamber, or tunnel in which the temperature and relative humidity of air circulated through parcels of lumber and veneer govern drying conditions.

**Drying**—The process of removing moisture from wood to improve its serviceability in use.

**Drying or kiln schedule**—The prescribed schedule of dry-bulb temperature and wet-bulb temperature or relative humidity used in drying; sometimes expressed in terms of wet-bulb depression or equilibrium moisture content (EMC). In kiln drying, air velocity is an important aspect.

**Durability**—A general term for permanence or resistance to deterioration. Frequently used to refer to the degree of resistance of a species of wood to attack by wood-destroying fungi under conditions that favor such attack. In this connection, the term “decay resistance” is more specific.

**Earlywood**—*Syn*: Springwood. Wood formed during the early period of annual growth; usually less dense and mechanically weaker than wood formed later.

**Equilibrium moisture content (EMC)**—Wood moisture content at which it neither gains nor loses moisture to the surrounding air.

**Extractives**—Substances in wood, not an integral part of the cellular structure, that can be removed by solution in hot or cold water, ether, benzene, or other solvents that do not react chemically with wood substances.

**Figure**—The pattern produced in a wood surface by annual growth rings, rays, knots, deviations from regular grain such as interlocked and wavy grain, and irregular coloration.

**Flatsawn**—Lumber sawed in a plane approximately perpendicular to a radius of the log.  
*See* Grain.

**Fungi**—Low forms of plants consisting mostly of microscopic threads that may traverse wood in all directions, converting the wood to materials the plants use for their own growth. Fungi cause decay and staining of lumber.

**Fungicide**—A chemical that is toxic to fungi.

**Grade**—A classification or designation of the quality of manufactured pieces of wood or logs and trees.

**Grain**—The direction, size, arrangement, appearance, or quality of the fibers in lumber. When used with qualifying adjectives, the term designates the orientation of fibers and/or growth rings in lumber.

**Close grain**—(1) narrow, inconspicuous annual rings. The term is sometimes used to designate wood having small and closely spaced pores, but, in this sense, the term “fine textured” is more often used. (2) in stress grading, wood averaging on one end or the other of each piece not less than 6 nor more than 30 annual rings per inch. Pieces averaging at least 5 or more than 30 rings per inch are accepted as close grain if containing a third or more of latewood.

**Coarse grain**—wide conspicuous annual rings in which there is considerable difference between earlywood and latewood. The term is sometimes used to designate wood with large pores, such as oak, ash, chestnut, and walnut, but, in this sense, the term “coarse textured” is more often used.

**End grain**—The ends of wood pieces that are cut perpendicular to the fiber direction.

**Flat grain**—*Syn*: Flatsawn, plain grain, plainsawn, tangential cut. Lumber sawn or split in a plane approximately perpendicular to the radius of the log. Lumber is considered flatgrained when the annual growth rings make an angle of less than 45° with the surface of the piece.

**Medium grain**—Used in stress grading to denote wood averaging on one end or the other of a piece not less than four annual rings per inch.

**Straight grain**—Lumber in which the fibers and other longitudinal elements run parallel to the axis of a piece.

**Green lumber**—(1) In general, lumber as cut from freshly felled trees. (2) In accordance with the American Softwood Lumber Standard, lumber containing >19% moisture content.

**Green volume**—Cubic content of green wood.

**Growth ring**—A layer of wood (as an annual ring) produced during a single period of growth.

**Growth rate**—The rate at which a tree has laid on wood, measured radially in the tree trunk or in the radial direction in lumber. The unit of measure in use is the number of annual growth rings per inch.

**Hardwood**—Generally, a botanical group of trees that has broad leaves (e.g., oak, elm, basswood); in contrast to the conifers or softwoods. Also, the wood produced from such trees. (The term has no reference to the actual hardness of the wood.)

**Heartwood**—The inner layers of wood in growing trees that have ceased to contain living cells and in which the reserve materials (e.g., starch) have been removed or converted into resinous substances. Heartwood is generally darker than sapwood, although the two are not always clearly differentiated.

**Infection**—The invasion of wood by fungi or other micro-organisms.

**Infestation**—The establishment of insects or other animals in wood.

**Juvenile wood**—The initial wood formed adjacent to the pith, often characterized by lower specific gravity, less strength, greater longitudinal shrinkage, and different microstructure than that of mature wood.

**Kiln**—A chamber or tunnel used for drying and conditioning lumber, veneer, and other wood products in which the temperature and relative humidity are controlled.

**Kiln drying**—The process of drying lumber in a closed chamber in which the temperature and relative humidity of the circulated air can be controlled.

**Knot**—That portion of a branch or limb that has been surrounded by subsequent growth of the wood of the trunk or other portions of the tree. A knot hole is merely a section of the entire knot; its shape depends upon the direction of the cut.

**Latewood**—*Syn*: Summerwood. The portion of the annual growth ring that is formed after the earlywood formation has ceased. Latewood is usually denser and mechanically stronger than earlywood.

**Lumber**—The product of the sawmill and planing mill that is not further manufactured except by sawing, resawing, passing lengthwise through a standard planing machine, cross cutting to length, and matching.

**Lumber, boards**—Lumber less than 2 in. (50 mm) thick and 2 or more in. wide.

**Lumber, dimension**—Lumber from 2 in. (50 mm) up to 5 in. (127 mm) thick and 2 or more in. wide, includes joists, rafters, studs, planks, and small timbers.

**Lumber, timbers**—Lumber  $\geq 5$  in. ( $\geq 127$  mm) in the smallest dimension. Includes beams, stringers, posts, caps, sills, girders, and purlins.

**Lumen**—In wood anatomy, the cell cavity.

**Moisture content, wood**—Weight of water contained in the wood, expressed as a percentage of the weight of the oven-dry wood.

**Air dried**—Wood having an average moisture content of 25% or less, with no material more than 30%.

**Green**—Freshly sawn wood or wood that essentially has received no formal drying.

**Kiln dried**—Dried in a kiln or by some other refined method to an average moisture content specified or understood to be suitable for a certain use. Kiln-dried lumber can be specified to be free of drying stresses.

**Partly air-dried**—Wood with an average moisture content between 25% and 45%, with no material greater than 50%.

**Shipping dry**—Lumber partially dried to prevent stain or mold in brief periods of transit, preferably with the outer 1/8 in. (3 mm) dried.

**Mold**—A fungus growth on lumber at or near the surface, not typically resulting in deep discolorations.

**Naval stores**—A term applied to the oils, resins, tars, and pitches derived from oleoresin contained in, exuded by, or extracted from trees chiefly of the pine species (genus *Pinus*) or the wood of such trees.

**Old growth**—Timber in or from a mature, naturally established forest. When the trees have grown during most, if not all, of their lives in active competition with other trees for sunlight and moisture, the timber is usually straight and relatively free of knots.

**Oven-dry**—Term used to describe wood that has been dried in a ventilated oven at 100°F to 105°F (37°C to 40°C) until there is no additional loss in weight.

**Pith**—The small, soft core at the original center of a tree around which the wood forms.

**Plainsawn**—Another term for flatsawn or flatgrained lumber.

**Post**—Short timber used in upright position for supporting structures of fencing. It may be round, split, or sawn.

**Preservative**—Any substance that is effective, for a reasonable length of time, in preventing the development and action of wood-rotting fungi, borers of various kinds, and harmful insects that deteriorate wood.

**Pressure-treated wood**—Wood treated by applying pressure to force the preservative into the wood.

**Pulpwood**—Any wood cut or prepared primarily for the production of wood pulp.

**Quartersawn**—Another term for edge-grained lumber, showing the radial surface of the wood.

**Radial surface**—A longitudinal surface or plane extending wholly or in part from the pith to the bark.

**Ray**—A ribbon-like grouping of cells extending radially across the grain, so oriented that the face of the ribbon is exposed as a fleck on the surface.

**Refractory**—In wood, implies difficulty in processing or manufacturing by ordinary methods, difficulty in drying, resistance to penetration of preservatives, or difficulty in machining.

**Relative humidity**—The amount of water vapor in the atmosphere, expressed as a percentage of the maximum quantity that the atmosphere could hold at a given temperature. The amount of water vapor that can be held in the atmosphere increases with the temperature.

**Resin canal (or duct)**—An intercellular passage that contains and transmits resinous materials. Resin canals extend vertically or radially in a tree.

**Ring, annual growth:** *See* Annual growth ring.

**Ring failure** (or separation)—A separation of the wood during drying. Occurs along the grain and parallel to the annual rings, either within or between rings; called honeycomb and ring check in some localities. *See* Shake.

**Rot**—Decay.

**Sap**—The moisture in green wood, containing nutrients and other chemicals in solution.

**Sapwood**—The outer zone of wood in a tree, next to the bark. In a living tree, sapwood contains some living cells (the heartwood contains none) as well as dead and dying cells. In most species, it is lighter colored than the heartwood. In all species, it lacks resistance to decay.

**Season**—To dry lumber and other wood items to the desired final moisture content and stress condition for their intended use.

**Second growth**—Timber that has grown after the removal, whether by cutting, fire, wind, or other agency, of all or a large part of the previous stand.

**Shake**—A separation along the grain, the greater part of which occurs between and within growth rings. Found in stumps and ends of freshly cut logs and green lumber. *See* Ring failure.

**Shear**—A condition of stress or strain where parallel planes slide relative to one another.

**Shingle**—A thin, rectangular piece of wood with one end thinner than the other, which is lapped lengthwise to cover roofs and outer walls of buildings. Can be sawn or split.

**Shook**—A set of parts for assembling a barrel or packing box.

**Shrinkage**—The contraction of wood fibers caused by drying below the fiber saturation point. Shrinkage (radial, tangential, and volumetric) is usually expressed as a percentage of the dimension of the wood when green.

**Sill**—The lowest horizontal wood member of the framework of a construction (e.g., window, door, bridge).

**Small timbers**—A term used mostly to designate square or near square dimension and timber sizes >2 in. and <9 in. in nominal thickness.

**Softwood**—Generally, one botanical group of trees that, in most cases, have needle- to scale-like leaves; the conifers. Also, the wood produced by such trees. (The term has no reference to the actual hardness of the wood.)

**Sound wood**—Wood free from insect damage or any form of decay (incipient or advanced).

**Species**—A group of individual plants of a particular kind; that is, a group of individuals sharing many of the same characteristics. Species is lower in classification than the genus, but greater than the variety.

**Specific gravity**—The ratio of the oven-dry weight of a piece of wood to the weight of an equal volume of water at 39°F (4°C). Specific gravity of wood is usually based on the green volume and oven-dry weight.

**Split**—A separation of the wood parallel to the fiber direction, caused by the tearing apart of wood cells.

**Springwood**—*See* Earlywood.

**Stain**—A discoloration in wood that may be caused by micro-organisms, metal, or chemicals. The term also applies to materials used to impart color to wood.

**Blue stain**—A bluish or grayish discoloration of the sapwood caused by the growth of certain dark colored fungi on the surface and in the interior of the wood; made possible by the same conditions that favor the growth of other fungi.

**Brown stain**—A rich brown to deep chocolate brown discoloration of the sapwood of some pines caused by a fungus that acts much like blue stain fungi.

**Chemical brown stain**—A chemical discoloration of wood, which sometimes occurs during the air drying or kiln drying of several species, apparently caused by the concentration and modification of extractives.

**Sap stain**—*See* Stain.

**Sticker stain**—A brown or blue stain that develops in seasoning lumber where it has been in contact with the stickers.

**Stem**—The bole or trunk of a tree.

**Stickers**—Strips or boards used to separate the layers of lumber in a pile, thus improving air circulation.

**Strength**—The term in its broad sense includes all the properties of wood that enable it to resist different forces or loads. In its more restricted sense, strength may apply to any one of the mechanical properties.

**Strength-reducing defects**—Imperfections affecting strength, such as checks, compression wood, cross grain, decay, knots, shakes, and splits.

**Stress**—Force per unit of area.

**Stud**—One of a series of slender wood structural members used as supporting elements in walls and partitions.

**Stump**—The part of a tree (above and below ground) remaining after the main stem is cut off.

**Summerwood**—*See* Latewood.

**Swelling**—Increase in the dimensions of wood caused by increased moisture content. Swelling occurs tangentially, radially, and, to a lesser extent, longitudinally.

**Tangential**—Strictly, coincident with a tangent at the circumference of a tree or log or parallel to such a tangent. In practice, however, tangential often means roughly coincident with a growth ring. A tangential section is a longitudinal section through a tree or limb and is perpendicular to a radius. Flat-grained and plainsawn lumber are sawn tangentially.

**Texture**—A term often used interchangeably with grain; sometimes used to combine the concepts of density and degree of contrast between earlywood and latewood. In this publication, texture refers to the finer structure of the wood (*See* Grain) rather than the annual rings.

**Transverse**—Directions in wood at right angles to the wood fibers. Includes radial and tangential directions. A transverse section is a section through a tree or timber at right angles to the pith.

**Treatment**—The act or manner of treating wood; the quality of preservative or other substance specified or used to treat wood.

**Tree**—A woody plant having one well-defined stem and a more or less definitely formed crown, usually attaining a height of at least 8 ft.

**Trunk**—The main stem or bole of a tree.

**Twist**—A warp distortion caused by the turning or winding of the edges of a board so that the four corners of any face are no longer in the same plane.

**Virgin growth**—The original growth of mature trees.

**Warp**—Distortion in lumber causing departure from its original plane, usually developed during drying. Warp includes cup, bow, crook, twist, and kinks or any combination thereof.

**Weathering**—The mechanical or chemical disintegration and discoloration of the surface of lumber that is caused by exposure, light, the action of dust and sand carried by winds, and the alternate shrinking and swelling of the surface fibers with continual variation in moisture content brought by changes in the atmosphere. Weathering does not include decay.

**Wet-bulb temperature**—The temperature indicated by the wet-bulb thermometer of a psychrometer.

**Wetwood**—Green wood with an abnormally high moisture content that generally results from infections in living trees by anaerobic bacteria, but may also result from water logging during log ponding. Wetwood can occur in both softwoods and hardwoods; green lumber is usually difficult to dry without defects. Wood with this defect is also difficult to glue. Although difficult to recognize, wetwood is often characterized by a translucent, water-soaked appearance and a sour or rancid odor.

**White-speck**—In western softwoods, pockets of decay caused by the fungus *Fomes pini*.

**Wide ring**—A rate of growth of less than four annual rings per inch. A growth rate faster than that described by medium grain.

**Wood**—*Syn:* Xylem. The tissues of the stem, branches, and roots of a woody plant lying between the pith and cambium, serving for water conduction, mechanical strength, and food storage, and characterized by the presence of tracheids or vessels.

**Wood-destroying organisms**—Fungi, beetles, termites, carpenter ants, marine borers.

**Wood, reaction**—In wood anatomy, wood with more or less distinctive anatomical characteristics; formed in parts of leaning or crooked stems and branches. Reaction wood consists of tension wood in hardwoods and compression wood in softwoods.

**Workability**—The degree of ease and smoothness of cut obtainable with sharp hand or machine tools.

**Xylem**—The tissues of the stem, branches, and roots of a woody plant lying between the pith and cambium, serving for water conduction, mechanical strength, and food storage, and characterized by the presence of tracheids or vessels.



## Abbreviations Used to Identify Properties and Measurement Terms

Term	Definition
2 by 4's	Nominal 2 by 4 in. (38 by 90 mm)
2 by 10's	Nominal 2 by 10 in. (38 by 240 mm)
4 by 4's	Nominal 4 by 4 in. (90 by 90 mm)
4/4	Nominal 1-in. (standard 25.4-mm) thickness
5/4	Nominal 1-1/4-in. (standard 32-mm) thickness
6/4	Nominal 1-1/2-in. (standard 38-mm) thickness
8/4	Nominal 2-in. (standard 51-mm) thickness
10/4	Nominal 2-1/2-in. (standard 64-mm) thickness
12/4	Nominal 3-in. (standard 76-mm) thickness
16/4	Nominal 4-in. (standard 102-mm) thickness
$C_{  }$	Compression parallel to grain, maximum crushing strength
$C_{\perp}$	Compression perpendicular to grain, stress at proportional limit
Dry	12% moisture content
Hardness	Side hardness
MC	Moisture content
MOE	Modulus of elasticity
MOR	Modulus of rupture
NA	Information not available
$Shear_{  }$	Shear parallel to grain, maximum shearing strength
SG	Specific gravity
WML	Work to maximum load

## Appendix—Trade Name Index

Trade name	Scientific name
Alaska-cedar	<i>Chamaecyparis nootkatensis</i>
Atlantic white cedar	<i>Chamaecyparis thyoides</i>
Baldcypress	<i>Taxodium distichum</i>
Balsam fir	<i>Abies balsamea</i>
Black spruce	<i>Picea mariana</i>
California red fir	<i>Abies magnifica</i>
Cedar, Alaska	<i>Chamaecyparis nootkatensis</i>
Cedar, Atlantic white	<i>Chamaecyparis thyoides</i>
Cedar, Eastern Red	<i>Juniperus virginiana</i>
Cedar, Incense	<i>Libocedrus decurrens</i>
Cedar, Northern White	<i>Thuja occidentalis</i>
Cedar, Port-Orford-	<i>Chamaecyparis lawsoniana</i>
Cedar, Southern Red	<i>Juniperus silicicola</i>
Cedar, Western Red	<i>Thuja plicata</i>
Cypress, Bald	<i>Taxodium distichum</i>
Douglas-fir	<i>Pseudotsuga menziesii</i>
Eastern Hemlock	<i>Tsuga canadensis</i>
Eastern Redcedar	<i>Juniperus virginiana</i>
Eastern White Pine	<i>Pinus strobus</i>
Engelmann Spruce	<i>Picea engelmannii</i>
Fir, Balsam	<i>Abies balsamea</i>
Fir, California Red	<i>Abies magnifica</i>
Fir, Douglas-	<i>Pseudotsuga menziesii</i>
Fir, Grand	<i>Abies grandis</i>
Fir, Noble	<i>Abies procera</i>
Fir, Pacific Silver	<i>Abies amabilis</i>
Fir, Subalpine	<i>Abies lasiocarpa</i>
Fir, White	<i>Abies concolor</i>
Grand Fir	<i>Abies grandis</i>
Hemlock, Eastern	<i>Tsuga canadensis</i>
Hemlock, Mountain	<i>Tsuga mertensiana</i>
Hemlock, Western	<i>Tsuga heterophylla</i>
Incense Cedar	<i>Libocedrus decurrens</i>
Jack Pine	<i>Pinus banksiana</i>
Jeffrey Pine	<i>Pinus jeffreyi</i>
Juniper, Western	<i>Juniperus occidentalis</i>
Larch, Western	<i>Larix occidentalis</i>
Limber Pine	<i>Pinus flexilis</i>
Loblolly Pine	<i>Pinus taeda</i>
Lodgepole Pine	<i>Pinus contorta</i>
Longleaf Pine	<i>Pinus palustris</i>
Monterey Pine	<i>Pinus radiata</i>
Mountain Hemlock	<i>Tsuga mertensiana</i>
Noble Fir	<i>Abies procera</i>
Northern White Cedar	<i>Thuja occidentalis</i>
Pacific Silver Fir	<i>Abies amabilis</i>
Pacific Yew	<i>Taxus brevifolia</i>
Pine, Eastern White	<i>Pinus strobus</i>
Pine, Jack	<i>Pinus banksiana</i>
Pine, Jeffrey	<i>Pinus jeffreyi</i>
Pine, Limber	<i>Pinus flexilis</i>
Pine, Loblolly	<i>Pinus taeda</i>
Pine, Lodgepole	<i>Pinus contorta</i>
Pine, Longleaf	<i>Pinus palustris</i>

Pine, Monterey	<i>Pinus radiata</i>
Pine, Pitch	<i>Pinus rigida</i>
Pine, Pond	<i>Pinus serotina</i>
Pine, Ponderosa	<i>Pinus ponderosa</i>
Pine, Radiata	<i>Pinus radiata</i>
Pine, Red	<i>Pinus resinosa</i>
Pine, Sand	<i>Pinus clausa</i>
Pine, Shortleaf	<i>Pinus echinata</i>
Pine, Slash	<i>Pinus elliottii</i>
Pine, Spruce	<i>Pinus glabra</i>
Pine, Sugar	<i>Pinus lambertiana</i>
Pine, Table Mountain	<i>Pinus pungens</i>
Pine, Virginia	<i>Pinus virginiana</i>
Pine, Western White	<i>Pinus monticola</i>
Pinyon	<i>Pinus edulis</i>
Pitch Pine	<i>Pinus rigida</i>
Pond Pine	<i>Pinus serotina</i>
Ponderosa Pine	<i>Pinus ponderosa</i>
Port-Orford-Cedar	<i>Chamaecyparis lawsoniana</i>
Redcedar, Eastern	<i>Juniperus virginiana</i>
Redcedar, Southern	<i>Juniperus silicicola</i>
Redcedar, Western	<i>Thuja plicata</i>
Red Fir, California	<i>Abies magnifica</i>
Red Pine	<i>Pinus resinosa</i>
Red Spruce	<i>Picea rubens</i>
Redwood	<i>Sequoia sempervirens</i>
Sand Pine	<i>Pinus clausa</i>
Shortleaf Pine	<i>Pinus echinata</i>
Silver Fir, Pacific	<i>Abies amabilis</i>
Sitka Spruce	<i>Picea sitchensis</i>
Slash Pine	<i>Pinus elliottii</i>
Southern Redcedar	<i>Juniperus silicicola</i>
Spruce Pine	<i>Pinus glabra</i>
Spruce, Black	<i>Picea mariana</i>
Spruce, Engelmann	<i>Picea engelmannii</i>
Spruce, Red	<i>Picea rubens</i>
Spruce, Sitka	<i>Picea sitchensis</i>
Spruce, White	<i>Picea glauca</i>
Subalpine Fir	<i>Abies lasiocarpa</i>
Sugar Pine	<i>Pinus lambertiana</i>
Table Mountain Pine	<i>Pinus pungens</i>
Tamarack	<i>Larix laricina</i>
Virginia Pine	<i>Pinus virginiana</i>
Western Hemlock	<i>Tsuga heterophylla</i>
Western Juniper	<i>Juniperus occidentalis</i>
Western Larch	<i>Larix occidentalis</i>
Western Redcedar	<i>Thuja plicata</i>
Western White Pine	<i>Pinus monticola</i>
White Cedar, Atlantic	<i>Chamaecyparis thyoides</i>
White Cedar, Northern	<i>Thuja occidentalis</i>
White Fir	<i>Abies concolor</i>
White Pine, Eastern	<i>Pinus strobus</i>
White Pine, Western	<i>Pinus monticola</i>
White Spruce	<i>Picea glauca</i>
Yew, Pacific	<i>Taxus brevifolia</i>