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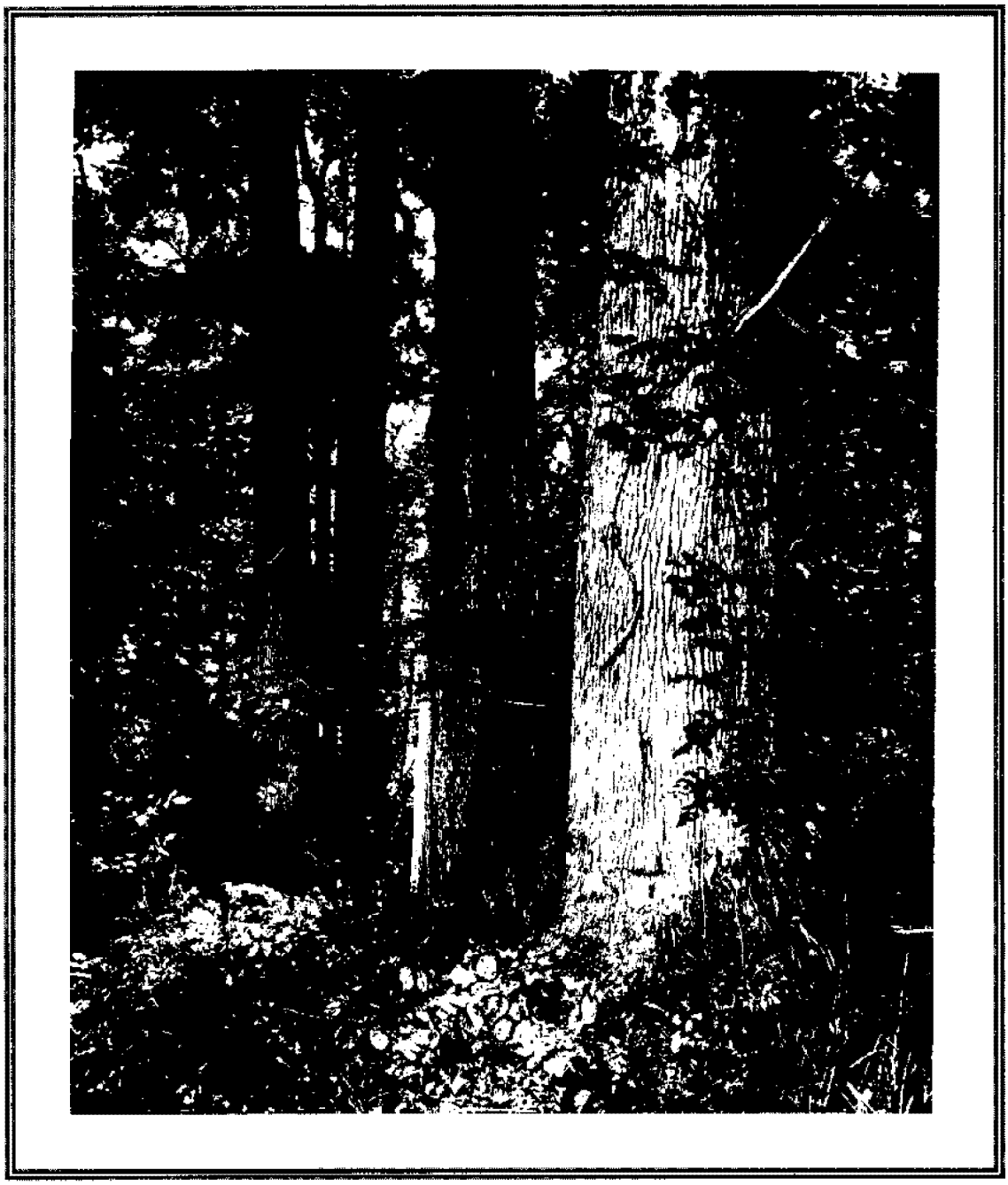
Hardwoods of North America

Harry A. Alden



Abstract

This report describes 53 taxa of hardwoods of North America, which are organized alphabetically by genus. Descriptions include scientific name, trade name, distribution, tree characteristics, wood characteristics (general, weight, mechanical properties, drying, shrinkage, working properties, durability, preservation, toxicity and uses) and additional sources for information. Data were compiled from existing literature, mostly from research done at the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, WI.

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This book is dedicated to the memory of Martin Chudnoff.

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Hardwoods of North America

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Introduction

Every week, the 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 many different sources over many years. Responding to technology transfer 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* (USDA Forest Service, Agriculture Handbook 607, 1984). 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, *Hardwoods of North America* is the first installment of these compilations, covering both commercial and noncommercial hardwoods. Most taxa listed are temperate species native to North America, north of Mexico, but some (e.g., mesquite) could be considered tropical and have distributions that extend into Mexico. An extensive treatment of the many tropical hardwoods native to Mexico and Central America is beyond the scope of this publication.

The format for this report is almost identical to that used in Chudnoff's *Tropical Timbers of the World*. Aspects of toxicity, such as dermatitis and bronchial problems, are included. 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 described in the Glossary.

The data are arranged alphabetically by the genus and species binomial name (e.g., American chestnut is *Castanea dentata*). Where two or more species in a genus make up a commercial grouping, the composite is designated by spp. (e.g., *Quercus* spp., the oaks). To further complete botanical affinities, family names 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 wood characteristics. Wood characteristics include weight (plus moisture content [MC] and specific gravity [SG]), mechanical properties, drying and shrinkage, working properties, durability, preservation, toxicity, and uses. Finally, additional sources of information are cited.

Other Common Names: The scientific name is followed by one or more trade names or common names. The most generally used common name (trade name) is in bold face. These names were taken from our database of common names and our work in conjunction with the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. While this database is vast (over 160,000 names), it will never be complete, as new common names appear constantly.

Distribution: Information on native or introduced growth ranges is noted.

The Tree: Tree form and size are described.

General Wood Characteristics: This section describes the appearance of wood of individual species and species groupings: sapwood and heartwood colorations 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 same 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.

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.

Basic specific gravity (noted as green values in tables) is the ratio of wood density to the density of water at 39ºF (4ºC) and is calculated from the ovendry weight and volume in the green condition. This may range from less than 0.34 for balsam poplar, *Populus balsamifera*, to about 0.88 for live oak, *Quercus virginiana*. Density calculated from weight and volume when the woods are green or when air dry, usually at a moisture content of 12 percent, is also given. This value may range from about 20 to 55 lb/ft^3 or 320 to 881 kg/m^3.

Mechanical Properties: It must be emphasized that the mechanical properties presented here by species are 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, the 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 the strength data were obtained are referenced by numbers in parentheses and listed in the Additional Reading and References Cited sections.

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

Drying and Shrinkage: The response of individual woods to air-drying and kiln-drying is noted as well as the absence or presence of degrade due to checking, warp, or collapse. Percentage of shrinkage values (volumetric, radial, tangential) from the green to ovendry condition (0 percent moisture content) or green to various air-dry conditions (6, 12 or 20 percent moisture content) are given. If no kiln schedules were found in the literature, none is recommended.

Working Properties: Much of the information given on working properties of individual species is highly subjective. Described are ease of working with hand and machine tools, tendencies to 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 well suited for these purposes.

Durability: Resistance of the wood to attack by decay fungi, insects, and marine borers is described. Wood kept constantly dry does not decay. Further, if it is kept continuously submerged in water even for long periods of time, it is not decayed significantly by the common decay fungi regardless of the wood species or the presence of sapwood. Bacteria and certain soft-rot fungi can attack submerged wood but the resulting deterioration is very slow. A large proportion of wood in use is kept so dry at all times that it lasts indefinitely. Moisture and temperature, which vary greatly with local conditions, are the principal factors affecting rate

of decay. When exposed to conditions that favor decay, wood deteriorates more rapidly in warm, humid areas than in cool, dry areas. High altitudes, as a rule, are less favorable to decay than are low altitudes because the average temperatures and available moisture are lower. If not in ground contact and kept dry, most woods remain free of rot and have an extended service life.

The heartwoods of common native species of wood have varying degrees of natural decay resistance. Untreated sapwood of substantially all species has low resistance to decay and usually has a short service life under decay-producing conditions. The decay resistance of heartwood is greatly affected by differences in the preservative qualities of the wood extractives, the attacking fungus, and the conditions of exposure. Considerable difference in service life may be obtained from pieces of wood cut from the same species. There are further complications because, for some woods, heartwood and sapwood are so similar in color that they cannot be easily distinguished. Also, the marketable sizes of some species are becoming largely second growth and contain a high percentage of sapwood. Consequently, substantial quantities of heartwood lumber of these species are not easily available.

Precise ratings of decay resistance of heartwood of different species are not possible because of differences within species and the variety 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. The groups are exceptionally resistant, very resistant, moderately resistant, and slightly 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 of the more resistant species than for the slightly 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 more severe decay hazards, pressure treatments are often required; even the very decay-resistant species may require preservative treatment for important structural uses or other uses where failure would endanger life or require expensive repairs.

Consideration is also given to vulnerability to attack by Lyctus beetles, subterranean and dry-wood termites, and other insects. If data are available, resistance to such attack is reported here.

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

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. Use categories, then, should not be considered restrictive. If a tree is noted for the yield of products other than wood (gums, latex, fiber, tannins, nuts and fruits, etc.), this is also indicated.

Toxicity: Wood as a material is not considered toxic or carcinogenic by the Environmental Protection Agency (EPA), but sawdust is. However, almost all woods, including United States native white pine and paper birch, have constituents that are allergenic or toxic to someone. Most people, though, are unaffected by most woods. Dust generated in

woodworking may irritate skin and mucous membranes and even cause nosebleeds and respiratory disorders. Timbers that are particularly toxic are noted when information is available. If no information on toxicity is available, this does not mean that the wood or wood byproducts are not toxic. If working with the wood is reputed to cause skin or mucous membrane irritations, this is noted.

Cited References and Additional Reading: References are cited by a number or numbers in parentheses and listed at the end of the report. The references can be used to trace the sources of the reported measurements to determine how representative the data may be. For instance, for some species data from only one tree may have been available, while for others, wood from many trees may have been tested. At the end of each wood description, references for additional information are cited.

Acer negundo Aceraceae Boxelder

Boxelder is a member of the Maple Family. The word *acer* is the classical Latin name of maple. The word *negundo* is from the Malayan common name of *Vitex negundo* L., negundo chastetree, later applied to this species.

Other Common Names: acecincle, acero Americano, acero negundo, acezintle, arce, arce fresno, arce negundo, ashleaf maple, ash-leaved maple, ash maple, asklonn, aune-buis, black ash, boxelder maple, California boxelder, Californian boxelder, californische esdoorn, cut-leafed maple, erable a feuilles de frene, erable aux feuilles de frene, erable negundo, eschenblattriger ahorn, inland boxelder, manitoba maple, maple ash, negundo, negundo maple, palo de venagre, plaine a guiger, raxoch, red river maple, soft maple, stinking ash, sugar ash, threeleafed maple, veder-esdoorn, western boxelder.

Distribution: Lower elevations in North America, extending through Mexico into Guatemala, excluding Pacific Coast states and south central Canada.

The Tree: Boxelder is a maple which can reach a height of 70 ft (21 m) and a diameter of 3 ft (1 m). The trunk can be short and poorly formed, dividing into several main branches. Boxelder is fast growing, short lived and easily transplanted. The tree is prone to injury from wind, heart rot and insects. It has green twigs and compound leaves (ash-like), separating it from other maples. It grows best in lowland areas along rivers and grows with cottonwood, willow, maple, sycamore and tupelo.

General Wood Characteristics: The heartwood is yellowish brown, while the sapwood is greenish yellow to creamy white. Red streaks are composed of a pigment from a fungus (*Fusarium negundi*). The wood is light, soft, porous, close-grained and weak. It is susceptible to heart rot. It can contain a curly figure.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.416	32	513
12%	0.457	NA	NA
Ovendry	0.501	NA	NA

[a]Reference (90).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.87×10^6 lbf/in^2	5.998 GPa	NA	NA
MOR	5.22×10^3 lbf/in^2	35.992 MPa	NA	NA
$C_{\parallel}$	2.37×10^3 lbf/in^2	16.341 MPa	4.95×10^3 lbf/in^2	34.130 MPa
$C_{\perp}$	0.34×10^3 lbf/in^2	2.344 MPa	0.78×10^3 lbf/in^2	5.378 MPa
WML	0.90 in-lbf/in^3	63.434 kJ/m^3	NA	NA
Hardness	540 lbf	2,401.92 N	720 lbf	3,202.56 N
$Shear_{\parallel}$	0.94×10^3 lbf/in^2	6.481 MPa	1.36×10^3 lbf/in^2	9.377 MPa

[a]Reference (90).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.4	NA	NA
Radial	3.9	NA	NA
Volumetric	14.8	NA	9.4

[a] Boxelder seasons well without checking. Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-D4	T6-C3	T5-C2	NA	NA

[a]References (6, 86).

Working Properties: Boxelder is workable with both hand tools and machine tools.

Durability: Boxelder is nonresistant to heartwood decay, being susceptible to heart rot and insects.

Preservation: No information available at this time.

Uses: Boxelder is currently used for inexpensive furniture, wooden ware, boxes, crates, wood pulp, charcoal, fuel and cooperage.

Toxicity: Suspected to cause allergic bronchial asthma and rhinitis (*Acer* spp.) (40).

Additional Reading: 29, 55, 68, 74.

Acer spp.
Aceraceae
Maple

Maple (*Acer* spp.) contains about 120 species native to Asia [16], North America [13], Mexico and Guatemala [1], and the European/Mediterranean region [6], with the rest in Eurasia, Malaysia and northern Africa. The Maples can be separated into two groups based on the ray widths of their microscopic anatomy, the soft maple group and the hard maple group. Species within each group look alike microscopically. *Acer* is the classical Latin name of maple.

Acer barbatum	hammock maple, **Florida maple**, southern sugar maple, sugar maple
Acer circinatum	**vine maple**, mountain maple
Acer glabrum	bark maple, California mountain maple, Douglas maple, dwarf maple, mountain maple, New Mexico maple, **rocky mountain maple**, shrubby maple, sierra maple, soft maple
Acer grandidentatum	bigtooth maple, **canyon maple**, hard maple, large-toothed maple, sugar maple, ultravioletalde bigtooth maple, western sugar maple
Acer leucoderme	**chalk maple**, palebark maple, sugar maple, whitebark maple
*Acer macrophyllum**	big-leaf, **bigleaf maple**, broadleaf maple, broadleaved maple, bugleaf maple, Californian maple, Oregon maple, pacific maple, white maple
*Acer negundo**	ash maple, ashleaf maple, black ash, **boxelder**, boxelder maple, California boxelder, cut-leaved maple, inland boxelder, manitoba maple, negundo maple, red river maple, stinking ash, sugar ash, three-leaved maple, western boxelder
*Acer nigrum**	**black maple**, black sugar maple, hard maple, rock maple, sugar maple, white maple
Acer pennsylvaticum	buckwood, goose-foot maple, moosewood, mountain alder, northern maple, Pennsylvanian maple, striped dogwood, **striped maple**, whistlewood
*Acer rubrum**	Carolina red maple, drummond maple, drummond red maple, Oregon maple, **red maple**, scarlet maple, shoe-peg maple, silver maple, soft maple, southern soft maple, swamp maple, three-pointed-leaf maple, three-toothed red maple, water maple, white maple
*Acer saccharinum**	creek maple, papascowood, river maple, **silver maple**, silverleaf maple, soft maple, swamp maple, water maple, white maple
*Acer saccharum**	bird's-eye maple, black maple, curly maple, hard maple, rock maple, rough maple, sugar, **sugar maple**, sugar-tree, sweet maple, thumbnail maple
Acer spicatum	goose-foot maple, low maple, moose maple, **mountain maple**, mountain maple-bush, spiked maple, water maple

*commercial species

Distribution: Throughout most of North America, with commercial species in the eastern United States and Canada and the western coast of the United States (bigleaf maple).

The Tree: Maples grow to heights of 120 ft (36 m), with a diameter of 3 ft (1 m). Forest grown trees may have a clear bole of 60 ft (18 m).

General Wood Characteristics: Maple lumber comes principally from the Middle Atlantic and Lake States, which together account for about two-thirds of the production. The wood of sugar maple and black maple is known as hard maple; that of silver maple, red maple, and boxelder as soft maple. The sapwood of the maples is commonly white with a slight reddish-brown tinge; the heartwood is light reddish brown, but sometimes is considerably darker. The sapwood is from 3 to 5+ inches (76 to 127+ mm) thick.

Hard maple has a fine, uniform texture, turns well on a lathe, is resistant to abrasion and has no characteristic odor or taste. It is heavy, strong, stiff, hard, and resistant to shock, and it has large shrinkage. Sugar maple is generally straight grained but the grain also occurs as "birds-eye," "curly," and "fiddleback" grain.

The wood of soft maples resembles that of hard maples but is not as heavy, hard and strong, the better grade of soft maple has been substituted for hard maple in furniture. The sapwood in the soft maples is considerably wider than that in the hard maples and has a lighter heart-wood color.

Maple lumber sometimes has olive or greenish black discolored areas known as mineral streak or mineral stain, which may be due to injury. Maple wood stains well and takes a high polish. It is intermediate in gluing and has low decay resistance.

Weight

			Weight[b]	
Species	MC	SG[a]	lb/ft^3	kg/m^3
Acer macrophyllum	Green	0.44	47	753
(bigleaf maple)	12%	0.48	34	545
	Ovendry	0.51	NA	NA
Acer nigrum	Green	0.52	54	865
(black maple)	12%	0.57	40	641
	Ovendry	0.62	NA	NA
Acer pennsylvaticum	Green[b]	0.44	37	593
(striped maple)	12%[c]	0.46	32	513
	Ovendry	NA	NA	NA
Acer rubrum	Green	0.49	50	801
(red maple)	12%	0.54	38	609
	Ovendry	0.55	NA	NA
Acer saccharinum	Green	0.44	45	721
(silver maple)	12%	0.47	33	529
	Ovendry	0.51	NA	NA
Acer saccharum	Green	0.56	56	897
(sugar maple)	12%	0.63	44	705
	Ovendry	0.68	NA	NA

[a]Data for green and 12% conditions taken from reference (98); ovendry data from reference (59).
[b]Data from reference (59).

Mechanical properties[a]

Property	Green		Dry	
Acer macrophyllum (bigleaf maple)				
MOE	1.10×10^6 lbf/in^2	7.584 GPa	1.45×10^6 lbf/in^2	9.998 GPa
MOR	7.4×10^3 lbf/in^2	51.023 MPa	10.7×10^3 lbf/in^2	73.777 MPa
$C_{\|\|}$	3.24×10^3 lbf/in^2	22.340 MPa	5.95×10^3 lbf/in^2	41.025 MPa
$C_{\perp}$	0.45×10^3 lbf/in^2	3.103 MPa	0.75×10^3 lbf/in^2	5.171 MPa
WML	8.7 in-lbf/in^3	59.987 kJ/m^3	7.8 in-lbf/in^3	53.781 kJ/m^3
Hardness	620 lbf	2,757.76 N	850 lbf	3,780.80 N
$Shear_{\|\|}$	1.11×10^3 lbf/in^2	7.653 MPa	1.73×10^3 lbf/in^2	11.928 MPa
Acer nigrum (black maple)				
MOE	1.33×10^6 lbf/in^2	9.170 GPa	1.62×10^6 lbf/in^2	11.170 GPa
MOR	7.9×10^3 lbf/in^2	54.471 MPa	13.3×10^3 lbf/in^2	91.704 MPa
$C_{\|\|}$	3.27×10^3 lbf/in^2	22.547 MPa	6.68×10^3 lbf/in^2	46.059 MPa
$C_{\perp}$	0.60×10^3 lbf/in^2	4.137 MPa	1.02×10^3 lbf/in^2	7.033 MPa
WML	12.8 in-lbf/in^3	88.256 kJ/m^3	12.5 in-lbf/in^3	86.188 kJ/m^3
Hardness	840 lbf	3,736.32 N	1,180 lbf	5,248.64 N
$Shear_{\|\|}$	1.13×10^3 lbf/in^2	7.791 MPa	1.82×10^3 lbf/in^2	12.548 MPa
Acer rubrum (red maple)				
MOE	1.39×10^6 lbf/in^2	9.584 GPa	1.64×10^6 lbf/in^2	11.308 GPa
MOR	7.7×10^3 lbf/in^2	53.092 MPa	13.4×10^3 lbf/in^2	92.393 MPa
$C_{\|\|}$	3.28×10^3 lbf/in^2	22.616 MPa	6.54×10^3 lbf/in^2	45.093 MPa
$C_{\perp}$	0.40×10^3 lbf/in^2	2.758 MPa	1.00×10^3 lbf/in^2	6.895 MPa
WML	11.4 in-lbf/in^3	78.603 kJ/m^3	12.5 in-lbf/in^3	86.188 kJ/m^3
Hardness	700 lbf	3,113.60 N	950 lbf	4,225.60 N
$Shear_{\|\|}$	1.15×10^3 lbf/in^2	7.929 MPa	1.85×10^3 lbf/in^2	12.755 MPa
Acer saccharinum (silver maple)				
MOE	0.94×10^6 lbf/in^2	6.481 GPa	1.14×10^6 lbf/in^2	7.860 GPa
MOR	5.8×10^3 lbf/in^2	39.991 MPa	8.9×10^3 lbf/in^2	61.366 MPa
$C_{\|\|}$	2.49×10^3 lbf/in^2	17.169 MPa	5.22×10^3 lbf/in^2	35.992 MPa
$C_{\perp}$	0.37×10^3 lbf/in^2	2.551 MPa	0.74×10^3 lbf/in^2	5.102 MPa
WML	11.0 in-lbf/in^3	75.845 kJ/m^3	8.3 in-lbf/in^3	57.229 kJ/m^3
Hardness	590 lbf	2,624.32 N	700 lbf	3,113.60 N
$Shear_{\|\|}$	1.05×10^3 lbf/in^2	7.239 MPa	1.48×10^3 lbf/in^2	10.204 MPa
Acer saccharum (sugar maple)				
MOE	1.55×10^6 lbf/in^2	10.687 GPa	1.83×10^6 lbf/in^2	12.618 GPa
MOR	9.4×10^3 lbf/in^2	64.813 MPa	15.8×10^3 lbf/in^2	108.941 MPa
$C_{\|\|}$	4.02×10^3 lbf/in^2	27.718 MPa	7.83×10^3 lbf/in^2	53.988 MPa
$C_{\perp}$	0.64×10^3 lbf/in^2	4.413 MPa	1.47×10^3 lbf/in^2	10.136 MPa
WML	13.3 in-lbf/in^3	91.704 kJ/m^3	16.5 in-lbf/in^3	113.768 kJ/m^3
Hardness	970 lbf	4,314.56 N	1,450 lbf	6,449.60 N
$Shear_{\|\|}$	1.46×10^3 lbf/in^2	10.066 MPa	2.33×10^3 lbf/in^2	16.065 MPa

[a]Reference (98).

Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC[a]	6% MC[b]	20% MC[b]
Tangential			
Acer macrophyllum (bigleaf maple)	7.1	5.7	2.4
Acer nigrum (black maple)	9.3	7.4	3.1
Acer pennsylvaticum (striped maple)	8.6	NA	NA
Acer rubrum (red maple)	8.2	6.6	2.7
Acer saccharinum (silver maple)	7.2	5.8	2.4
Acer saccharum (sugar maple)	9.9	7.6	3.2
Radial			
Acer macrophyllum (bigleaf maple)	3.7	3.0	1.2
Acer nigrum (black maple)	4.8	3.8	1.6
Acer pennsylvaticum (striped maple)	3.2	NA	NA
Acer rubrum (red maple)	4.0	3.2	1.3
Acer saccharinum (silver maple)	3.0	2.4	1.0
Acer saccharum (sugar maple)	4.8	3.9	1.6
Volumetric			
Acer macrophyllum (bigleaf maple)	11.6	9.3	3.9
Acer nigrum (black maple)	14.0	11.2	4.7
Acer pennsylvaticum (striped maple)	12.3	NA	NA
Acer rubrum (red maple)	12.6	10.5	4.4
Acer saccharinum (silver maple)	12.0	9.6	4.0
Acer saccharum (sugar maple)	14.7	11.9	5.0

[a]Reference (98).
[b]Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Soft maples[b]	T8-D4	T6-C3	T5-C2	T3-B2	NA
Hard maples[c]	T8-C3	T5-C2	T3-B2	T3-A1	T3-A1

[a]References (6, 86).
[b]Bigleaf, red and silver.
[c]Black and sugar.

Working Properties: The wood turns well, is harder to work than softer woods, and has high nail-holding ability. It stains and polishes well, but is intermediate in gluing.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Moderately resistant to penetration with preservatives.

Uses: Lumber, distillation, veneer, crossties, paper pulp, flooring, furniture, pallets, boxes and crates, shoe lasts, handles, woodenware, novelties, spools and bobbins, bowling alleys, dance floors, piano frames, bowling pins, cutting blocks, pulpwood and turnery.

Toxicity: May cause allergic bronchial asthma, dermatitis and rhinitis (40).

Additional Reading: 5, 29, 55, 68, 74.

Aesculus octandra
Hippocastanaceae
Yellow Buckeye

The genus Aesculus contains 13 species, which grow in the United States [6], Mexico [1] and Eurasia [6]. Species cannot be separated based on microanatomy. The name *aesculus* is a Latin name of a European oak or other mast-bearing tree.

Other Species:

Aesculus californica	**California buckeye**, horsechestnut
*Aesculus glabra**	American horsechestnut, buckeye, fetid buckeye, **Ohio buckeye**, sevenleaf buckeye, smooth buckeye, sticking buckeye, stinking buckeye, Texas buckeye, white buckeye
Aesculus glabra var. *glabra*	**Ohio buckeye** (typical)
Aesculus glabra var. *arguta*	**Texas buckeye**, white buckeye
Aesculus hippocastanum	buckeye, common horsechestnut, conker-tree, European horsechestnut, **horse chestnut** (Europe)
*Aesculus octandra**	big buckeye, buckeye, large buckeye, Ohio buckeye, sweet buckeye, **yellow buckeye**
Aesculus parviflora	**bottlebrush buckeye**, shrubby buckeye
Aesculus pavia	buckeye, firecracker plant, **red buckeye**, red-flowered buckeye, red pavia, scarlet buckeye, woolly, woolly buckeye
Aesculus sylvatica	dwarf buckeye, Georgia buckeye, **painted buckeye**

*commercial species

Distribution: In the United States, buckeye ranges from the Appalachians of Pennsylvania, Virginia, and North Carolina westward to Kansas, Oklahoma, and Texas. Buckeye is not customarily separated from other species when manufactured into lumber and can be

utilized for the same purposes as aspen, basswood, and sap yellow-poplar. The following description is for yellow buckeye (*Aesculus octandra*).

The Tree: Buckeye is a tree 30 to 70 ft (9 to 21 m) high and 2 ft (0.6 m) in diameter. It grows best in rich moist soil along the banks of streams and in river bottoms. Buckeye matures in 60 to 80 years. It is one of the initial trees to leaf-out in the spring. The twigs have a foul odor when broken.

General Wood Characteristics: The white sapwood of buckeye merges gradually into the creamy or yellowish white heartwood. The wood is uniform in texture, generally straight-grained, light in weight, weak when used as a beam, soft, and low in shock resistance. It is rated low on machinability such as shaping, mortising, boring, and turning. The centers of logs can be discolored to grayish brown.

Weight[a]

		Weight	
Moisture content	Specific gravity	(lb/ft^3)	(kg/m^3)
Green	0.33	49	785
12%	0.36	25	401
Ovendry	0.38	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.98×10^6 lbf/in^2	6.757 GPa	1.17×10^6 lbf/in^2	8.067 GPa
MOR	4.80×10^3 lbf/in^2	33.096 MPa	7.50×10^3 lbf/in^2	51.713 MPa
$C_{\parallel}$	2.05×10^3 lbf/in^2	14.135 MPa	4.17×10^3 lbf/in^2	28.752 MPa
$C_{\perp}$	0.21×10^3 lbf/in^2	1.448 MPa	0.44×10^3 lbf/in^2	3.034 MPa
WML	5.4 × in-lbf/in^3	37.233 kJ/m^3	5.9 × in-lbf/in^3	40.681 kJ/m^3
Hardness	290 × lbf	1,289.92 N	350 × lbf	1,556.80 N
$Shear_{\parallel}$	0.66×10^3 lbf/in^2	4.551 MPa	0.96×10^3 lbf/in^2	6.619 MPa

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	8.1	6.5	2.7
Radial	3.6	2.9	1.2
Volumetric	12.5	10.0	4.2

[a]References: 0% MC (98), 6% and 20% MC (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-F4	T8-F3	NA	NA	NA

[a]References (6, 86).

Working Properties: No information available at this time.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Furniture, artificial limbs, splints, boxes and crates, caskets and coffins, paper pulp, signs, trunks, valises, scientific instruments, wooden ware, novelties, food containers, strips woven into summer hats, and planing mill products.

Toxicity: The nuts and twigs are poisonous, containing aescin, a cytotoxin (54).

Additional Reading: 9, 19, 24, 27, 29, 35, 37, 51, 55, 66, 68, 74, 79.

Ailanthus altissima Simarubaceae Tree-of-Heaven

The genus *Ailanthus* contains about 10 species, native to Asia and northern Australia. It was introduced into England from China in the mid-18th century as an ornamental. It was subsequently introduced from England to the United States in 1874. The word *ailanthus* is from the Moluccan name *aylanto*, meaning tree-of-heaven and referring to the height of the tree. The word *altissima* means very tall.

Other Common Names: Ailante, ailanthus, ailanto, ailantus, albero del paradiso, arbol el cielo, a tree grows in Brooklyn, Chinese tree-of-heaven, Chinese sumac, copal tree, falso zumaque, gotterbaum, gudstrad, heavenwood, hemelboom, paradise tree, piede di cavallo, stinking chun.

Distribution: Native to northern China, the tree was introduced in the 19th century throughout eastern United States (Missouri to Pennsylvania) and the south to California.

The Tree: *Ailanthus* grows rapidly, even in poor soils or environments. It grows to 80 ft (24 m), with a diameter of 2 ft (0.6 m). It is a pioneer species, crowding out other tree species. The leaves and flowers have a foul odor.

General Wood Characteristics: Heartwood is pale green to yellow with dark streaks, while the sapwood is wide and cream color. It is ring-porous with wide rays, superficially resembling ash.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green	NA	NA	NA
12%	0.531	NA	NA
Ovendry	NA	33.5–38.5	537–617

[a]References: specific gravity (65), weight (73).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.92×10^6 lbf/in^2	6.343 GPa	1.52×10^6 lbf/in^2	10.480 GPa
MOR	6.00×10^3 lbf/in^2	41.370 MPa	11.8×10^3 lbf/in^2	81.361 MPa
$C_{\parallel}$	2.4×10^3 lbf/in^2	16.548 MPa	5.26×10^3 lbf/in^2	36.268 MPa
$C_{\perp}$	0.38×10^3 lbf/in^2	2.620 MPa	1.13×10^3 lbf/in^2	7.791 MPa
WML	NA in-lbf/in^3	NA kJ/m^3	NA in-lbf/in^3	NA kJ/m^3
Hardness	701 lbf	3,118.05 N	1,731 lbf	7,699.49 N
$Shear_{\parallel}$	1.05×10^3 lbf/in^2	7.239 MPa	2.24×10^3 lbf/in^2	15.444 MPa

[a]Reference (65).

Drying & Shrinkage: Volumetric shrinkage is 10.81% from green (65).

Working Properties: Easily worked with tools and glues; takes a finish well.

Durability: Resistant to insects.

Preservation: No information available at this time.

Uses: Ornamental tree (shade, screen, water edge, erosion control), fuel, home crafts, turnery, pulp.

Toxicity: Pruning may cause vesicular eruptions (105).

Additional Reading: 1, 2, 3, 15, 17, 22, 23, 26, 28, 29, 42, 43, 44, 48, 50, 55, 56, 68, 72, 73, 74, 79, 92, 97, 102.

Alnus rubra
Betulaceae
Red Alder

Alder (*Alnus* spp.) is represented by 20 to 30 species, with 15 species in North and Tropical America and 15 species in Eurasia. All species look alike microscopically. The word *alnus* is the classical Latin name of alder.

Red alder (*Alnus rubra*) is the only commercial species in North America. Red alder is the most common hardwood in the Pacific Northwest and the largest of the American alders. It is a fast-growing, pioneer species and has nitrogen-fixing nodules on its roots. The wood is diffuse porous, moderately light, and soft.

Other Common Names: Amerikaanse rode els, aliso Americano, aune d'Oregon, ontano dell'Oregon , Oregon-al, Oregon alder, Oregon erle, Pacific Coast alder, western alder.

Other American Species:

Alnus maritima	**seaside alder**
Alnus oblongifolia	**Arizona alder**, lanceleaf alder, Mexican alder, New Mexican alder, oblong-leaved alder
*Alnus rhombifolia**	Oregon-al, sierra alder, **white alder**
Alnus rugosa	gray alder, hazel alder, hoary alder, smooth alder, **speckled alder**, tag alder
Alnus serrulata	black alder, common alder, **hazel alder**, smooth alder, tag alder
Alnus sinuata	green alder, mountain alder, northern alder, **sitka alder**, wavyleaf alder

Alnus tenuifolia al amerikansk, aliso Americano, aune du canada, California alder, **mountain alder**, ontano American, river alder, rhombic-leaved alder, thinleaf alder, western alder, white alder

* commercial species

Distribution: North America: Pacific coast region from southeastern Alaska to western British Columbia and south through western Washington and western Oregon to southern California. The range of red alder extends from southern California (latitude 34ºN) to southeastern Alaska (60ºN). Red alder is not commonly found east of the Cascade or Sierra Nevada Ranges, although there are several isolated populations in northern Idaho. The species develops best at low elevations of less than 1,500 ft (457 m) in northern Oregon, Washington, and British Columbia. In the central part of its range, scattered trees occur as high as 3,300 ft (1,006 m), but most stands are below 2,500 ft (762 m).

The Tree: On good sites, red alder can attain heights of 100 to 130 ft (30 to 40 m) and diameters of 22 to 30 inches (56 to 76 cm). In closed stands, the trees typically have clear, slightly tapered boles and narrow, domelike crowns. The light gray bark is thin and smooth. Red alder forms extensive, fibrous root systems. The roots have numerous nitrogen-fixing nodules, which are a symbiotic association between the tree and beneficial bacteria belonging to the genus *Frankia*.

General Wood Characteristics: Red alder wood is almost white when freshly cut but quickly changes to a light tan or light brown with a yellow or reddish tinge when exposed to the air. Heartwood is formed only in trees of advanced age, and there is no visible boundary between heartwood and sapwood.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.37	46	737
12%	0.41	28	449
Ovendry	0.43[b]	NA	NA

[a]References: specific gravity (98), weight (59).
[b]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.17×10^6 lbf /in^2	8.067 GPa	1.38×10^6 lbf/in^2	9.515 GPA
MOR	6.50×10^3 lbf/in^2	44.818 MPa	9.80×10^3 lbf/in^2	67.571 MPa
$C_{\parallel}$	2.96×10^3 lbf/in^2	20.409 MPa	5.82×10^3 lbf/in^2	40.129 MPa
$C_{\perp}$	0.25×10^3 lbf/in^2	1.724 MPa	0.44×10^3 lbf/in^2	3.034 MPa
WML	8.0 in-lbf/in^3	55.160 kJ/m^3	8.4 in-lbf/in^3	57.918 kJ/m^3
Hardness	440 lbf	1,957.12 N	590 lbf	2,624.32 N
Shear$_{\parallel}$	0.77×10^3 lbf/in^2	5.309 MPa	1.08×10^3 lbf/in^2	7.446 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.3	5.8	2.4
Radial	4.4	3.5	1.5
Volumetric	12.6	10.1	4.2

[a]References: 0% MC (98), 6% and 20% MC (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-D4	T8-D3	T6-C3	T6-D3	NA
Darker	T11-D3	NA	NA	NA	NA
Lighter	T5-D5	NA	NA	NA	NA

[a]References (6, 86).

Working Properties: Red alder is excellent for turning and polishing and takes glue, paint and stain well.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Logs should be processed quickly, particularly during warm weather, as decay proceeds rapidly. If processing must be delayed, the logs should be stored in water. Green lumber should be carefully stacked for air-drying or promptly kiln-dried to prevent damage from microbial stain.

Uses: Nonstructural lumber, factory appearance-grade lumber, chips for pulp and paper, furniture, cabinets, pallets, core stock for plywood, interior finishing, fuelwood, charcoal, chips for smoke curing.

Toxicity: Can cause dermatitis (64).

Additional Reading: 7, 29, 32, 38, 39, 55, 62, 68, 74, 75, 77, 99, 106.

Amelanchier spp. Rosaceae Serviceberry

The genus *Amelanchier* contains about 16 species native to North America [5], Mexico [2], and Eurasia to northern Africa [4]. The word *amelanchier* is derived from the French common name *amelanche* of the European serviceberry, *Amelanchier ovalis*.

Amelanchier alnifolia	juneberry, Pacific serviceberry, pigeonberry, rocky mountain servicetree, sarvice, sarviceberry, saskatoon, saskatoon serviceberry, western service, **western serviceberry**, western shadbush
Amelanchier arborea	Allegheny serviceberry, apple shadbush, **downy serviceberry**, northern smooth shadbush, shadblow, shadblown serviceberry, shadbush, shadbush serviceberry
Amelanchier bartramiana	**Bartram serviceberry**

Amelanchier canadensis	American lancewood, currant-tree, downy serviceberry, Indian cherry, Indian pear, Indian wild pear, juice plum, juneberry, may cherry, sugar plum, sarvice, servicetree, shadberry, shadblow, shadbush, shadbush serviceberry, shadflower, **thicket serviceberry**
Amelanchier florida	**Pacific serviceberry**
Amelanchier interior	**inland serviceberry**
Amelanchier sanguinea	Huron serviceberry, roundleaf juneberry, **roundleaf serviceberry**, shore shadbush
Amelanchier utahensis	**Utah serviceberry**

Distribution: In North America throughout upper elevations and temperate forests.

The Tree: Serviceberry is a shrub or tree that reaches a height of 40 ft (12 m) and a diameter of 2 ft (0.6 m). It grows in many soil types and occurs from swamps to mountainous hillsides. It flowers in early spring, producing delicate white flowers, making it a good ornamental shrub. It produces smooth to scaly bark, and red to purple pear-shaped fruits.

General Wood Characteristics: The wood of serviceberry is brown and is as hard and heavy as persimmon, but of smaller size. It is close grained and takes a satiny finish. The heartwood is reddish brown, marked with red streaks, and has a lighter colored sapwood.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.66	61	977
12%	0.74	52	833
Ovendry	0.79	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.64×10^6 lbf/in^2	11.307 GPa	1.88×10^6 lbf/in^2	12.963 GPa
MOR	9.60×10^3 lbf/in^2	66.192 MPa	16.9×10^3 lbf/in^2	116.526 MPa
$C_{\parallel}$	4.08×10^3 lbf/in^2	28.132 MPa	8.77×10^3 lbf/in^2	60.469 MPa
$C_{\perp}$	0.78×10^3 lbf/in^2	5.378 MPa	1.79×10^3 lbf/in^2	12.342 MPa
WML	16.2 in-lbf/in^3	111.699 kJ/m^3	18.9 in-lbf/in^3	130.316 kJ/m^3
Hardness	1,240 lbf	5,515.52 N	1,800 lbf	8,006.40 N
$Shear_{\parallel}$	1.26×10^3 lbf/in^2	8.687 MPa	159×10^3 lbf/in^2	10.963 MPa

[a]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	10.8	NA	NA
Radial	6.7	NA	NA
Volumetric	18.7	NA	NA

[a] Reference (59).

Kiln Drying Schedule: 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: Tool handles, fishing rods.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Arbutus spp. Ericaceae Madrone

The genus *Arbutus* contains about 15 species with 5 in North America and about 10 in Europe and western Asia. The name *arbutus* is the classical Latin name of *Arbutus unedo* L., strawberry madrone, of southern Europe.

Arbutus arizonica	**Arizona madrone,** Arizona madroño, madroña
*Arbutus menziesii**	arbuti tree, coast madrone, laurel, laurelwood, madroña, madroña burr, madrone, madrone laurel, madrone tree, madroño, madroña, manzanita, **Pacific madrone**, strawberry-tree
Arbutus texana	laurel, madroña, madrone, madrone tree, manzanita, **Texas madrone**, Texas madroño
Arbutus unedo	**strawberry tree** (Europe)

*commercial species

The following data are for *Arbutus menziesii*.

Distribution: Southwestern British Columbia and southward through Washington, Oregon and California in the coastal mountains and wet slopes of the Sierra Nevada.

The Tree: Pacific madrone grows to 80 ft (24 m) tall, with a diameter of 2 to 3 ft (0.6 to 1 m). It has orange branches with shiny leaves, small white flowers in clusters, and orange–red fruits.

General Wood Characteristics: Pacific madrone sapwood is a pinkish-cream color, while the heartwood is light pink to red-brown with patches of deep red. It resembles fruit woods in color and texture.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green	0.58	60	961
12%	0.65	45	721
Ovendry	0.69	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.88×10^6 lbf/in^2	6.0667 GPa	1.23×10^6 lbf/in^2	8.481 GPA
MOR	7.60×10^3 lbf/in^2	52.402 MPa	10.4×10^3 lbf/in^2	71.708 MPa
$C_{\parallel}$	3.32×10^3 lbf/in^2	22.891 MPa	6.88×10^3 lbf/in^2	47.438MPa
$C_{\perp}$	0.78×10^3 lbf/in^2	5.378 MPa	1.62×10^3 lbf/in^2	11.170 MPa
WML	11.2 in-lbf/in^3	77.224 kJ/m^3	8.8 in-lbf/in^3	60.676 kJ/m^3
Hardness	940 lbf	4,181.12 N	1,460 lbf	6,494.08 N
Shear$_{\parallel}$	1.42×10^3 lbf/in^2	9.791 MPa	1.81×10^3 lbf/in^2	12.480 MPa

[a]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)[b]		
	0% MC	6% MC	20% MC
Tangential	12.4	9.9	4.1
Radial	5.6	4.5	1.9
Volumetric	18.1	14.5	6.0

[a]Pacific madrone is difficult to season because it warps and checks easily. Schedules for drying the wood green from the saw have been published (30,93). Smith (88) suggests air drying, followed by kiln drying.
[b]References: 0% MC (98), 6% and 20% MC (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T4-B2	T3-B1	NA	NA	NA

[a]References (6, 86).

Working Properties: Pacific madrone works well with all tools and polishes well, but it is not easily glued. The wood is easily worked with tools and compares with hard maple and eastern white oak in ease of machining (25). Work at the Forest Products Laboratory has indicated that rotary cutting of veneer is feasible (84).

Durability: The wood is nonresistant to heartwood decay; fence posts had an average service life of 6 years in the untreated condition (36).

Preservation: No information available at this time.

Uses: Turnery, bowls, novelties, souvenirs, tool handles, mathematical instruments, furniture and bowls. Burls are used for pipes and decorative veneers; charcoal for gunpowder.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 67, 68, 74, 83.

Avicennia spp. Avicenniaceae (Verbenaceae) Black Mangrove

The genus *Avicennia* contains about 15 species which grow along tropical and subtropical shores. It is commonly included with the family Verbenaceae. The genus *Avicennia* was dedicated in honor of Abu Sina, Latinized as *Avicennia* (980–1036 AD), of Bokhara, Arab physician and philosopher.

Avicennia alba	**baen**
Avicennia germinans	**black mangrove**, black-tree, blackwood, honey mangrove, mangle blanco, saltbush
Avicennia marina	**blackwood**, mangle nero, mangle prieto, manglecito, parwa

Distribution: This genus grows in pure, dense stands on mud flats along the coast and estuaries, in brackish coastal swamps, and on river banks along lower brackish parts.

The Tree: The tree sometimes reaches a height of 75 ft (23 m), although normally only 25 ft (8 m), with a 2-ft (0.6-m) diameter. Towards the northern end of its limit (Dog Island, Florida) it is shrubby. Black mangroves have long heavy roots which grow extensions (pneumatophores) that aid in gas exchange and coincidentally trap silt to extend the shoreline. Seeds mature and germinate on the tree and then fall to the mud.

General Wood Characteristics: The sapwood of mangrove is wide, yellow–gray to brown–yellow. The heartwood is dark yellow–brown to very dark brown with an oily appearance. The luster is low and the wood has no distinct odor or taste. The grain is irregular and interlocked, and the texture is coarse and uneven. The wood may contain a yellow powdery substance called lapachol. The bole is 20 to 40 ft (6 to 12 m) long and unbutressed, but it is swollen due to numerous pneumatophores (aerial roots). The woods of all species are practically identical, with concentric, anastomosing layers of secondary phloem (bast).

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.83	74	1,185
12%	0.83	58	929
Ovendry	0.96	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.55×10^6 lbf/in^2	10.687 GPa	2.09×10^6 lbf/in^2	14.411 GPA
MOR	11.1×10^3 lbf/in^2	76.535 MPa	16.4×10^3 lbf/in^2	113.078 MPa
$C_{\parallel}$	4.94×10^3 lbf/in^2	34.061 MPa	8.34×10^3 lbf/in^2	57.504 MPa
$C_{\perp}$	1.87×10^3 lbf/in^2	12.894 MPa	2.36×10^3 lbf/in^2	16.272 MPa
WML	12.3 in-lbf/in^3	84.809 kJ/m^3	17.9 in-lbf/in^3	123.421 kJ/m^3
Hardness	1,700 lbf	7,561.60 N	NA	NA
$Shear_{\parallel}$	1.37×10^3 lbf/in^2	9.446 MPa	NA	NA MPa

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)[b]		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	9.7	NA	NA
Radial	6.2	NA	NA
Volumetric	15.6	NA	NA

[a]The wood air-dries well; kiln drying requires a slow schedule to prevent warping.
[b]Reference (59).

Working Properties: The wood saws well, but it is not easy to work with because of the interlocked grain. It glues well, but nail holes must be prebored to prevent splitting.

Durability: Very susceptible to termite and marine borer attack. Resistance to impregnation variable.

Preservation: No information available at this time.

Uses: Used in the round (poles and posts for netting), underground foundations (pilings), pulp (soda process), fuel, charcoal, tannin from bark.

Toxicity: No information available at this time.

Additional Reading: 4, 14, 29, 45, 55, 68, 74, 80, 101.

Betula spp. Betulaceae American Birch

Birch (*Betula* spp.) is composed of 30 to 50 species growing in Asia [12], North America [4] and Europe [4]. All species look alike microscopically. The word *betula* is the classical Latin name of birch. The important species are yellow birch (*Betula alleghaniensis*), sweet birch (*B. lenta*), and paper birch (*B. papyrifera*). Other birches of some commercial importance are river birch (*B. nigra*), gray birch (*B. populifolia*), and western paper birch (*B. papyrifera* var. *commutata*).

*Betula alleghaniensis**	black birch, Canadian silky wood, gray birch, hard birch, Quebec birch, silver birch, swamp birch, white birch, witch hazel, **yellow birch**
*Betula lenta**	black birch, black cherry birch, cherry birch, mahogany, mahogany birch, mountain birch, mountain mahogany, red birch, river birch, spice birch, yellow birch, **sweet birch**
Betula nana	**swamp birch**
*Betula nigra**	black birch, red birch, **river birch**, water birch
Betula occidentalis	black birch, canyon birch, cherry birch, mountain birch, red birch, red canyon birch, spring birch, swamp birch, sweet birch, **water birch**, western birch, western paper birch, western red birch
*Betula papyrifera**	black birch, canoe birch, gray birch, large white birch, northwestern paper birch, **paper birch**, red birch, silver birch, western birch, western paper birch, white birch
Betula papyrifera var. *papyrifera*	paper birch (typical)
Betula papyrifera var. *commutata*	western paper birch
Betula papyrifera var. *cordifolia*	mountain paper birch
Betula papyrifera var. *kenaica*	Kenai birch
Betula papyrifera var. *neoalaskana*	Alaska paper birch
Betula papyrifera var. *subcordata*	northwestern paper birch
Betula pendula	**silver birch**, white birch
*Betula populifolia**	blue birch, blueleaf birch, broom birch, fire birch, **gray birch**, oldfield birch, pin birch, poplar-leaved birch, poverty birch, small white birch, white birch, wire birch
Betula pumila	**dwarf birch**
Betula uber	Ashe's birch, Virginia birch, **Virginia roundleaf birch**

*commercial species

Distribution: North America. Yellow birch, sweet birch, and paper birch grow principally in the Northeastern and Lake States. Yellow and sweet birch also grow along the Appalachian Mountains to northern Georgia. Paper birch is also found throughout Canada and Alaska. Yellow, sweet, and paper birch are the source of most birch lumber and veneer.

The Tree: Birches can reach a height of 70 ft (21m), with a diameter of more than 2 ft (0.6 m).

General Wood Characteristics: The wood varies slightly among species. The wood of yellow birch and sweet birch is heavy, hard and strong, while that of paper birch is lighter, and less hard, strong and stiff. All birches have a fine, uniform texture. Paper birch is easy to work with hand tools; sweet birch and yellow birch are difficult to work with hand tools and difficult to glue, but easily machined.

Yellow birch has white sapwood and light reddish-brown heartwood. Sweet birch has light-colored sapwood and dark brown heartwood tinged with red.

Weight[a]

Moisture content	Specific gravity	Weight lb/ft^3	Weight kg/m^3
B. alleghaniensis (yellow birch)			
Green	0.55	57	913
12%	0.62	43	689
Ovendry	0.66	NA	NA
B. lenta (sweet birch)			
Green	0.60	57	913
12%	0.65	46	737
Ovendry	0.71	NA	NA
B. nigra (river birch)			
Green	0.49[b]	NA	NA
12%	NA	NA	NA
Ovendry	NA	NA	NA
B. papyrifera (paper birch)			
Green	0.48	50	801
12%	0.55	38	609
Ovendry	0.60	NA	NA
B. papyrifera var. neoalaskana (Alaska paper birch)			
Green	0.49[c]	48	48
12%	0.55[c]	38	38
Ovendry	0.59	NA	NA
B. populifolia (gray birch)			
Green	0.45[c]	46	737
12%	0.51[c]	35	561
Ovendry	0.55	NA	NA

[a]Unless otherwise noted, references are as follows: specific gravity at green and 12% moisture content, (98); ovendry specific gravity, (59); weight, (59).
[b]Reference (90).
[c]Reference (59).

Mechanical properties

Property	Green		Dry	
B. alleghaniensis (yellow birch)[a]				
MOE	1.50×10^6 lbf/in^2	10.342 GPa	2.01×10^6 lbf/in^2	13.859 GPa
MOR	8.30×10^3 lbf/in^2	57.229 MPa	16.6×10^3 lbf/in^2	114.457 MPa
$C_{\|\|}$	3.38×10^3 lbf/in^2	23.305 MPa	8.17×10^3 lbf/in^2	56.332 MPa
$C_{\perp}$	0.43×10^3 lbf/in^2	2.965 MPa	0.97×10^3 lbf/in^2	6.688 MPa
WML	16.1 in-lbf/in^3	111.010 kJ/m^3	20.8 in-lbf/in^3	143.416 kJ/m^3
Hardness	780 lbf	3,469.44 N	1,260 lbf	5,604.48 N
$Shear_{\|\|}$	1.11×10^3 lbf/in^2	7.653 MPa	1.88×10^3 lbf/in^2	12.962 MPa
B. lenta (sweet birch)[a]				
MOE	1.65×10^6 lbf/in^2	11.376 GPa	2.17×10^6 lbf/in^2	14.962 GPa
MOR	9.40×10^3 lbf/in^2	64.813 MPa	16.9×10^3 lbf/in^2	116.526 MPa
$C_{\|\|}$	3.74×10^3 lbf/in^2	25.787 MPa	8.54×10^3 lbf/in^2	58.883 MPa
$C_{\perp}$	0.47×10^3 lbf/in^2	3.241 MPa	1.08×10^3 lbf/in^2	7.447 MPa
WML	15.7 in-lbf/in^3	108.252 kJ/m^3	18.0 in-lbf/in^3	124.110 kJ/m^3
Hardness	970 lbf	4,314.56 N	1,470 lbf	6,538.56 N
$Shear_{\|\|}$	1.24×10^3 lbf/in^2	8.549 MPa	2.24×10^3 lbf/in^2	15.444 MPa
B. papyrifera (paper birch)[a]				
MOE	1.17×10^6 lbf/in^2	8.067 GPa	1.59×10^6 lbf/in^2	10.963 GPa
MOR	6.40×10^3 lbf/in^2	44.128 MPa	12.3×10^3 lbf/in^2	84.809 MPa
$C_{\|\|}$	2.36×10^3 lbf/in^2	16.272 MPa	5.69×10^3 lbf/in^2	39.233 MPa
$C_{\perp}$	0.27×10^3 lbf/in^2	1.862 MPa	0.60×10^3 lbf/in^2	4.137 MPa
WML	16.2 in-lbf/in^3	111.699 kJ/m^3	16.0 in-lbf/in^3	110.320 kJ/m^3
Hardness	560 lbf	2,490.88 N	910 lbf	4,047.68 N
$Shear_{\|\|}$	0.84×10^3 lbf/in^2	5.792 MPa	1.21×10^3 lbf/in^2	8.343 MPa
B. papyrifera var. neoalaskana (Alaska paper birch)[b]				
MOE	1.35×10^6 lbf/in^2	9.308 GPa	1.9×10^6 lbf/in^2	13.101 GPa
MOR	7.1×10^3 lbf/in^2	48.955 MPa	13.6×10^3 lbf/in^2	93.772 MPa
$C_{\|\|}$	3.03×10^3 lbf/in^2	20.892 MPa	7.45×10^3 lbf/in^2	51.368 MPa
	0.43×10^3 lbf/in^2	2.965 MPa	0.82×10^3 lbf/in^2	5.654 MPa
WML	11.6 in-lbf/in^3	79.982 kJ/m^3	13.9 in-lbf/in^3	95.841 kJ/m^3
Hardness	560 lbf	2,490.88 N	830 lbf	3,691.84 N
$Shear_{\|\|}$	0.92×10^3 lbf/in^2	6.343 MPa	1.4×10^3 lbf/in^2	9.653 MPa
B. populifolia (gray birch)[b]				
MOE	NA $\times 10^6$ lbf/in^2	NA GPa	1.15×10^6 lbf/in^2	7.929 GPa
MOR	NA $\times 10^3$ lbf/in^2	NA MPa	9.80×10^3 lbf/in^2	67.571 MPa
$C_{\|\|}$	NA $\times 10^3$ lbf/in^2	NA MPa	4.87×10^3 lbf/in^2	33.579 MPa
$C_{\perp}$	NA $\times 10^3$ lbf/in^2	NA MPa	0.92×10^3 lbf/in^2	6.343 MPa
WML	NA in-lbf/in^3	NA kJ/m^3	10.8×10^3 lbf/in^2	74.466 kJ/m^3
Hardness	NA lbf	NA	760 lbf	3,380.48 N
$Shear_{\|\|}$	NA $\times 10^3$ lbf/in^2	NA MPa	1.34×10^3 lbf/in^2	9.239 MPa

[a]Reference (98).
[b]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential			
B. alleghaniensis (yellow birch)	9.5	7.4	3.1
B. lenta (sweet birch)	9.0	NA	NA
B. nigra (river birch)	9.2	NA	NA
B. papyrifera (paper birch)	8.6	6.9	2.9
B. papyrifera var. neoalaskana (Alaska paper birch)	9.9	NA	NA
B. populifolia (gray birch)	NA	NA	NA
Radial			
B. alleghaniensis (yellow birch)	7.3	5.8	2.4
B. lenta (sweet birch)	6.5	NA	NA
B. nigra (river birch)	4.7	NA	NA
B. papyrifera (paper birch)	6.3	5.0	2.1
B. papyrifera var. neoalaskana (Alaska paper birch)	6.5	NA	NA
B. populifolia (gray birch)	5.2	NA	NA
Volumetric			
B. alleghaniensis (yellow birch)	16.8	13.4	5.6
B. lenta (sweet birch)	15.6	NA	NA
B. nigra (river birch)	13.5	NA	NA
B. papyrifera (paper birch)	16.2	13.0	5.4
B. papyrifera var. neoalaskana (Alaska paper birch)	16.7	NA	NA
B. populifolia (gray birch)	14.7	NA	NA

[a]Birch shrinks considerably during drying. References: 0% MC (98), 6% and 20% MC (90).

Kiln drying schedule[a]

Condition[b]	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
B. lenta (sweet birch), B. nigra (river birch), B. populifolia (gray birch) and B. papyrifera (paper birch).					
Standard	T10-C4	T8-D3	NA	NA	NA
1-in. squares	T10-C6		NA	NA	NA
Whiter 1-in. squares	T5-C6				
2-in. squares	T8-C4				
Whiter 2-in. squares	T5-C4				
B. alleghaniensis (yellow birch)					
Standard	T8-C4	T5-C3	T5-B3	T3-B2	T3-A1
1-in. squares	T8-C5				
2-in. squares	T5-C4				

[a]References (6, 86).
[b]1 in. = 25.4 mm.

Working Properties: Working properties may vary with species. In general, birches split during nailing; if successfully nailed, they have good nail-holding properties.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Yellow and sweet birch lumber and veneer are used principally in the manufacture of furniture, boxes, baskets, crates, woodenware, cooperage, interior finish, and doors. Birch veneer goes into plywood used for flush doors, furniture, paneling, radio and television cabinets, aircraft, and other specialty uses. Paper birch is used for turned products, including spools, bobbins, small handles, and toys. Also used for pulp wood, fuel wood, turnery, distillation products, toothpicks, ice cream sticks and tongue depressors.

Toxicity: Birches can cause dermatitis (40, 64, 105).

Additional Reading: 8, 29, 55, 68, 74.

Carpinus caroliniana Betulaceae American Hornbeam

The genus *Carpinus* is represented by about 30 species which grow in the New World [1] and Eurasia [30]. *Carpinus* is the classical Latin name.

Carpinus betulus — avenbok, carpe, carpe blanco, carpen, carpino biannco, charme, charme commun, charme comun, charrlle, charrlle commun, common hornbeam, dyed hornbeam, **European hornbeam**, gemeine-weib-buche, gem weissbuche, gewone haagbeuk, grab, gyertyan, haagbeuk, habr obecny, hagabuche, hage-buche, hainbuche, hojaranzo, hornbaum, hornbeam, horn-buche, steinbuch, vitavenbok, vit-bok, weissbuche, witch elm

Carpinus caroliniana	**American hornbeam**, blue beech, broomwood, hophornbeam, ironwood, musclewood, o-tan-tahr-te-weh, smoothbark ironwood, water beech
Carpinus carpinoides	hornbeam, kuma-shide
Carpinus caucasia	caucasian hornbeam
Carpinus cordata	ggachibagdal, Russian hornbeam, sawashiba
Carpinus distegocarpus	kuma-shide
Carpinus hebestroma	taroko-sidi
Carpinus japonica	kuma-shide, soya
Carpinus laxiflora	aka-shide, hornbeam, seo-namu, soro shide
Carpinus orientalis	carpinella, charme d'orient, eastern hornbeam, hojaranzo, oosterse haagbeuk, **oriental hornbeam**, orientalisk avenbok
Carpinus polyneura	Chinese hornbeam
Carpinus pubescens	giau do
Carpinus rankanensis	rankan-side
Carpinus schuschaensis	Iran hornbeam
Carpinus seki	Taiwan-akashide
Carpinus tschonoskii	gaeseo-namu, inu-shide, Korean hornbeam

Distribution: North America, from central Maine to southern Quebec, southern Ontario, northern Iowa, Missouri, eastern Oklahoma, eastern Texas, and east to central Florida. Northeastern Mexico (Tamaulipas) and from southern Mexico to Guatemala and Honduras.

The Tree: The American hornbeam is a small tree that can reach a height of 13–26 ft (4–8 m), with a diameter of 4–12 inches (10–30 cm) that grows in mixed deciduous forests in the shade of taller hardwoods in bottom lands and river margins. It grows in association with oaks, sweetgum, hickories, maple and basswood. The tree grows slowly and is short lived. It masts every 3 to 5 years, producing large amounts of seed. Imperfect flowers are produced on separate catkins on the same tree.

General Wood Characteristics: The tree's name (horn=tough and beam~baum=tree) describes the wood, which is tough, hard and heavy. Colonial settlers in America used hornbeam for bowls and dishes because it rarely split or cracked. Hornbeam has a thick, nearly white sapwood and a heartwood that is pale yellow to tan. It has no characteristic odor or taste. The wood is heavy and hard.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.58	53	849
12%	0.70	49	785
Ovendry	0.72	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.99×10^6 lbf/in^2	6.826 GPa	1.08×10^6 lbf/in^2	7.447 GPa
MOR	6.8×10^3 lbf/in^2	46.886 MPa	12.2×10^3 lbf/in^2	84.119 MPa
$C_{\parallel}$	2.67×10^3 lbf/in^2	18.410 MPa	5.68×10^3 lbf/in^2	39.164 MPa
$C_{\perp}$	0.73×10^3 lbf/in^2	5.033 MPa	2.00×10^3 lbf/in^2	13.790 MPa
WML	19.1 in-lbf/in^3	131.695 kJ/m^3	37.1 in-lbf/in^3	255.805 kJ/m^3
Hardness	940 lbf	4181.12 N	1,780 lbf	7917.44 N
$Shear_{\parallel}$	1.16×10^3 lbf/in^2	7.998 MPa	2.41×10^3 lbf/in^2	16.616 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	12% MC
Tangential	11.4	NA	7
Radial	5.7	NA	5
Volumetric	19.1	NA	NA

[a] Hornbeam checks and warps severely in seasoning. References: 0% MC, (59); 12% MC, (31).
[b]Data are for 0% and 6% MC, C. caroliana; 12% MC, C. betulus.

Kiln Drying Schedule: British Schedule E (31).

Working Properties: Hornbeam is difficult to work.

Durability: The wood is nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Tool handles, levers, parts for farm machinery, fuel wood.

Toxicity: The wood is said to have irritant effects (64).

Additional Reading: 29, 55, 68, 74.

Carya spp. Juglandaceae Hickory

Hickory (*Carya* spp.) is composed of at least 16 species native to Asia [4], Central America [4] and North America [1]). The word *carya* is from the Greek name for nut. This group can be split into the true hickories and the pecans based on microanatomy.

True Hickory Group (earlywood with parenchyma bands):

Carya glabra	bitternut, black hickory, broom hickory, brown hickory, coast pignut hickory, false shagbark, hard shell, little pignut, little shagbark, nutmeg hickory, oval pignut hickory, pignut, **pignut hickory**, red hickory, redheart hickory, small fruited hickory, small pignut, smoothbark hickory, swamp hickory, sweet hickory, sweet pignut, sweet pignut hickory, switch-bud hickory, true hickory, white hickory
Carya lacinosa	big shagbark, big shagbark hickory, big shellbark, big shellbark hickory, bigleaf shagbark hickory, bottom shellbark, king nut, ridge hickory, **shellbark hickory**, thickbark hickory, thick shellbark, thick shellbark hickory, true hickory, western shellbark
Carya ovata	bird's eye hickory, Carolina hickory, curly hickory, littlenut shagbark hickory, little pignut, little shagbark, mockernut hickory, red hickory, redheart hickory, scalybark hickory, shagbark, **shagbark hickory**, shagbark walnut, shellbark, shellbark hickory, shellbark tree, skid hickory, small pignut, small pignut hickory, southern hickory, southern shagbark hickory, southern shellbark, sweet walnut, true hickory, upland hickory, white hickory, whiteheart hickory, white walnut
Carya tomentosa	big-bud, big hickory, black hickory, bullnut, common hickory, hardbark hickory, hickory-nut, hognut, mockernut, **mockernut hickory**, red hickory, true hickory, white hickory, whiteheart hickory

Pecan Hickory Group (earlywood without parenchyma bands):

Carya aquatica	bitter pecan, bitter water hickory, faux hickory, lowground hickory, lowland hickory, noot hickory, not hickory, pecan, pecan hickory, pignut hickory, swamp hickory, water bitternut, **water hickory**, wild pecan
Carya cordiformis	bitter hickory, bitternut, **bitternut hickory**, bitter pecan tree, bitter pignut, butternut, butternut hickory, highland hickory, pig hickory, pignut, pignut hickory, pig walnut, redheart hickory, swamp hickory, white hickory, yellowbud hickory
*Carya floridana**	Florida hickory, **scrub hickory**
Carya illinoensis	faux hickory, **pecan**, pecan hickory, pecan nut, pecan tree, sweet pecan
Carya myristicaeformis	bitter water hickory, bitter waternut, blasted pecan, **nutmeg hickory**, scalybark hickory, shagbark, shagbark hickory, shellbark hickory, swamp hickory, upland hickory
Carya pallida	pale hickory, paleleaf hickory, pallid hickory, pignut hickory, **sand hickory**
Carya texana	**black hickory**, buckley hickory, pignut hickory, Texas hickory

* not commercial

Distribution: Eastern to midwestern United States.

The Tree: Hickory trees can reach a height of 140 ft (43 m), with a diameter of 4 ft (1.2 m).

General Wood Characteristics: The sapwood of hickory is white, tinged with brown, while the heartwood is pale to reddish brown. The wood is known for its strength and shock resistance. It is difficult to dry or season. It rates above average in most working properties, except in shaping and nail-holding ability. The wood of pecans is rated slightly below that of true hickories.

Weight[a]

Moisture content	Specific gravity	Weight lb/ft^3	Weight kg/m^3
True Hickory Group			
Carya glabra (pignut hickory)			
Green	0.66	63	1,009
12%	0.75	52	833
Ovendry	NA	NA	NA
Carya lacinosa (shellbark hickory)			
Green	0.62	62	993
12%	0.69	48	769
Ovendry	NA	NA	NA
Carya ovata (shagbark hickory)			
Green	0.64	64	1,025
12%	0.72	50	801
Ovendry	NA	NA	NA
Carya tomentosa (mockernut hickory)			
Green	0.64	64	1,025
12%	0.72	51	817
Ovendry	NA	NA	NA
Pecan Hickory Group			
Carya aquatica (water hickory)			
Green	0.61	68	1,089
12%	0.62	43	689
Ovendry	NA	NA	NA
Carya cordiformis (bitternut hickory)			
Green	0.60	63	1,009
12%	0.66	46	737
Ovendry	NA	NA	NA
Carya illinoensis (pecan)			
Green	0.60	61	977
12%	0.66	46	737
Ovendry	0.69	NA	NA
Carya myristicaeformis (nutmeg hickory)			
Green	0.56	60	961
12%	0.60	42	673
Ovendry	NA	NA	NA

[a]References: specific gravity, (98); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
True Hickory Group				
Carya glabra (pignut hickory)				
MOE	1.65×10^6 lbf/in^2	11.376 GPa	2.26×10^6 lbf/in^2	15.583 GPa
MOR	11.7×10^3 lbf/in^2	80.672 MPa	20.1×10^3 lbf/in^2	138.590 MPa
$C_{\|\|}$	4.81×10^3 lbf/in^2	33.165 MPa	9.19×10^3 lbf/in^2	63.365 MPa
$C_{\perp}$	0.92×10^3 lbf/in^2	6.343 MPa	1.98×10^3 lbf/in^2	13.652 MPa
WML	31.7 in-lbf/in^3	218.572 kJ/m^3	30.4 in-lbf/in^3	209.608 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	1.37×10^3 lbf/in^2	9.446 MPa	2.15×10^3 lbf/in^2	14.824 MPa
Carya lacinosa (shellbark hickory)				
MOE	1.34×10^6 lbf/in^2	9.239 GPa	1.89×10^6 lbf/in^2	13.032 GPa
MOR	10.5×10^3 lbf/in^2	72.398 MPa	18.1×10^3 lbf/in^2	124.800 MPa
$C_{\|\|}$	3.92×10^3 lbf/in^2	27.028 MPa	8.00×10^3 lbf/in^2	55.160 MPa
$C_{\perp}$	0.81×10^3 lbf/in^2	5.585 MPa	1.80×10^3 lbf/in^2	12.411 MPa
WML	29.9 in-lbf/in^3	206.161 kJ/m^3	23.6 in-lbf/in^3	162.722 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	1.19×10^3 lbf/in^2	8.205 MPa	2.11×10^3 lbf/in^2	14.548 MPa
Carya ovata (shagbark hickory)				
MOE	1.57×10^6 lbf/in^2	10.825 GPa	2.16×10^6 lbf/in^2	14.893 GPa
MOR	11.0×10^3 lbf/in^2	75.845 MPa	20.2×10^3 lbf/in^2	139.279 MPa
$C_{\|\|}$	4.58×10^3 lbf/in^2	31.579 MPa	9.21×10^3 lbf/in^2	63.503 MPa
$C_{\perp}$	0.84×10^3 lbf/in^2	5.792 MPa	1.76×10^3 lbf/in^2	12.135 MPa
WML	23.7 in-lbf/in^3	163.412 kJ/m^3	25.8 in-lbf/in^3	177.891 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	1.52×10^3 lbf/in^2	10.480 MPa	2.16×10^3 lbf/in^2	14.893 MPa
Carya tomentosa (mockernut hickory)				
MOE	1.57×10^6 lbf/in^2	10.825 GPa	2.22×10^6 lbf/in^2	15.307 GPa
MOR	11.1×10^3 lbf/in^2	76.535 MPa	19.2×10^3 lbf/in^2	132.384 MPa
$C_{\|\|}$	4.48×10^3 lbf/in^2	30.890 MPa	8.94×10^3 lbf/in^2	61.641 MPa
$C_{\perp}$	0.81×10^3 lbf/in^2	5.585 MPa	1.73×10^3 lbf/in^2	11.928 MPa
WML	26.1 in-lbf/in^3	179.960 kJ/m^3	22.6 in-lbf/in^3	155.827 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	1.28×10^3 lbf/in^2	8.825 MPa	1.74×10^3 lbf/in^2	11.997 MPa

Mechanical properties—con.

Property	Green		Dry	
Pecan Hickory Group				
Carya aquatica (water hickory)				
MOE	1.56×10^6 lbf/in^2	10.756 GPa	2.02×10^6 lbf/in^2	13.928 GPa
MOR	10.7×10^3 lbf/in^2	73.777 MPa	17.8×10^3 lbf/in^2	122.731 MPa
$C_{\parallel}$	4.66×10^3 lbf/in^2	32.131 MPa	8.60×10^3 lbf/in^2	59.297 MPa
$C_{\perp}$	0.88×10^3 lbf/in^2	6.068 MPa	1.55×10^3 lbf/in^2	10.687 MPa
WML	18.8 in-lbf/in^3	129.626 kJ/m^3	19.3 in-lbf/in^3	133.074 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	1.44×10^3 lbf/in^2	9.928 MPa	NA	NA
Carya cordiformis (bitternut hickory)				
MOE	1.40×10^6 lbf/in^2	9.653 GPa	1.79×10^6 lbf/in^2	12.342 GPa
MOR	10.3×10^3 lbf/in^2	71.019 MPa	17.1×10^3 lbf/in^2	117.905 MPa
$C_{\parallel}$	4.57×10^3 lbf/in^2	31.510 MPa	9.04×10^3 lbf/in^2	62.331 MPa
$C_{\perp}$	0.80×10^3 lbf/in^2	5.516 MPa	1.68×10^3 lbf/in^2	11.584 MPa
WML	20.0 in-lbf/in^3	137.900 kJ/m^3	18.2 in-lbf/in^3	125.489 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	1.24×10^3 lbf/in^2	8.549 MPa	NA	NA
Carya illinoensis (pecan)				
MOE	1.37×10^6 lbf/in^2	9.446 GPa	1.73×10^6 lbf/in^2	11.928 GPa
MOR	9.80×10^3 lbf/in^2	67.571 MPa	13.7×10^3 lbf/in^2	94.462 MPa
$C_{\parallel}$	3.99×10^3 lbf/in^2	27.511 MPa	7.85×10^3 lbf/in^2	54.126 MPa
$C_{\perp}$	0.78×10^3 lbf/in^2	5.378 MPa	1.72×10^3 lbf/in^2	11.859 MPa
WML	14.6 in-lbf/in^3	100.667 kJ/m^3	13.8 in-lbf/in^3	95.151 kJ/m^3
Hardness	1,310 lbf	5826.88 N	1,820 lbf	8095.36
$Shear_{\parallel}$	1.48×10^3 lbf/in^2	10.204 MPa	2.08	14.341
Carya myristicaeformis (nutmeg hickory)				
MOE	1.29×10^6 lbf/in^2	8.894 GPa	1.70×10^6 lbf/in^2	11.722 GPa
MOR	9.10×10^3 lbf/in^2	62.745 MPa	16.6×10^3 lbf/in^2	114.457 MPa
$C_{\parallel}$	3.98×10^3 lbf/in^2	27.442 MPa	6.91×10^3 lbf/in^2	47.644 MPa
$C_{\perp}$	0.76×10^3 lbf/in^2	5.240 MPa	1.57×10^3 lbf/in^2	10.825 MPa
WML	22.8 in-lbf/in^3	157.206 kJ/m^3	25.1 in-lbf/in^3	173.065 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	1.03×10^3 lbf/in^2	7.102 MPa	NA	NA

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential			
True Hickory Group			
Carya glabra (pignut hickory)	11.5	9.2	3.8
Carya lacinosa (shellbark hickory)	12.6	10.1	4.2
Carya ovata (shagbark hickory)	10.5	8.0	3.3
Carya tomentosa (mockernut hickory)	11.0	8.8	3.7
Pecan Hickory Group			
Carya aquatica (water hickory)	NA	NA	NA
Carya cordiformis (bitternut hickory)	NA	NA	NA
Carya illinoensis (pecan)	8.9	NA	NA
Carya myristicaeformis (nutmeg hickory)	NA	NA	NA
Radial			
True Hickory Group			
Carya glabra (pignut hickory)	7.2	5.8	2.4
Carya lacinosa (shellbark hickory)	7.6	6.1	2.5
Carya ovata (shagbark hickory)	7.0	5.6	2.3
Carya tomentosa (mockernut hickory)	7.7	6.2	2.6
Pecan Hickory Group			
Carya aquatica (water hickory)	NA	NA	NA
Carya cordiformis (bitternut hickory)	NA	NA	NA
Carya illinoensis (pecan)	4.9	NA	NA
Carya myristicaeformis (nutmeg hickory)	NA	NA	NA
Volumetric			
True Hickory Group			
Carya glabra (pignut hickory)	17.9	14.3	6.0
Carya lacinosa (shellbark hickory)	19.2	15.4	6.4
Carya ovata (shagbark hickory)	16.7	13.4	5.6
Carya tomentosa (mockernut hickory)	17.8	14.3	6.0
Pecan Hickory Group			
Carya aquatica (water hickory)	13.6	NA	NA
Carya cordiformis (bitternut hickory)	13.6	NA	NA
Carya illinoensis (pecan)	13.6	NA	NA
Carya myristicaeformis (nutmeg hickory)	NA	NA	NA

[a]References: 0% MC, (98); 6% and 20%, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-D3	T6-D1	NA	NA	NA

[a]References (6, 86).

Working Properties: Hickory is considered difficult to machine and glue. It holds nails well, but it tends to split. It is susceptible to bird peck.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Extremely resistant.

Uses: Tool handles, furniture, cabinetry, ladder rungs, dowels, sporting goods (including baseball bats, skis and archery equipment), flooring, veneer, plywood, fuelwood, charcoal.

Toxicity: No information available at this time.

Additional Reading: 18, 29, 55, 68, 71, 74, 91.

Castanea dentata
Fagaceae
American Chestnut

Chestnut (*Castanea* spp.) contains about 7 to 12 species distributed in North America [4], Europe [1], and Asia [7]. The word *castanea* is the classical Greek and Latin name of chestnut. European chestnut (*Castanea sativa*) was introduced into England by the Romans, probably as food for domestic animals. North American chestnut trees were virtually wiped out by the fungus *Endothia parasitica.* The different species of chestnut hybridize with each other. All species look alike microscopically.

Other Common Names: chestnut, prickly O-heh-yah-bur, sweet chestnut, white chestnut, wormy chestnut.

Distribution: American chestnut's preblight range extended from Maine west to Michigan and south to Mississippi, Alabama and Georgia. The major stands were in southern New England and the Appalachian Mountains. The finest timber came from the Appalachians.

The Tree: American chestnut used to grow to a height of 120 ft (37 m), with a diameter of 7 ft (2.1 m). Its ability to sprout from the cut or dead stump has kept this species in existence, temporarily, although the blight eventually kills the sprouts.

General Wood Characteristics: The narrow sapwood of chestnut is near white, while the heartwood is grayish brown to brown and darkens with age. The wood is coarse, intermediate in strength, light in weight, low in shock resistance, and of average hardness and moderate shrinkage. It can be kiln dried or air seasoned with minimal problems.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green	0.40	55	881
12%	0.43	30	481
Ovendry	0.45	NA	NA

[a] References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.93×10^6 lbf/in^2	6.412 GPa	1.23×10^6 lbf/in^2	8.481 GPa
MOR	5.60×10^3 lbf/in^2	38.612 MPa	8.60×10^3 lbf/in^2	59.297 MPa
$C_{\parallel}$	2.47×10^3 lbf/in^2	17.031 MPa	5.32×10^3 lbf/in^2	36.681 MPa
$C_{\perp}$	0.31×10^3 lbf/in^2	2.137 MPa	0.62×10^3 lbf/in^2	4.275 MPa
WML	7.0 in-lbf/in^3	48.265 kJ/m^3	6.5 in-lbf/in^3	44.818 kJ/m^3
Hardness	420 lbf	1868.16 N	540 lbf	2401.92 N
Shear$_{\parallel}$	0.80×10^3 lbf/in^2	5.516 MPa	1.08×10^3 lbf/in^2	7.446 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	6.7	5.4	2.2
Radial	3.4	2.7	1.1
Volumetric	11.6	9.3	3.9

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-E4	T8-E3	NA	NA	NA

[a]References (6, 86).

Working Properties: Chestnut is easy to work with tools and is easily glued. Because it splits readily, care is required in nailing.

Durability: Rated as very resistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, tannin extract, furniture, caskets, boxes, crates, core stock for plywood, poles, railroad ties, pulpwood, shingles, barrel staves, mine timbers, fuelwood.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74, 81.

Castanopsis chrysophylla Fagaceae Giant Chinkapin

The genus *Castanopsis* contains about 100 species growing in North America [1] and tropical and subtropical Asia [99]. The term *castanopsis* means resembling *Castanea*, a chestnut and related genus, while *chrysophylla* means golden leaf, referring to the golden yellow scales on the underside of leaves.

Other Common Names: chestnut, chinkapin, chinquapin, evergreen chestnut, evergreen chinkapin, giant chinkapin, giant evergreen chinkapin, golden chinkapin, golden chinquapin, goldenleaf chestnut, goldenleaf chinkapin, western chinquapin.

Distribution: Pacific coast region from southwest Washington south to western Oregon, and in coastal ranges and Sierra Nevada to central California.

The Tree: The giant chinkapin attains a height of over 100 ft (30 m) and a diameter of 4 ft (1.2 m). The bark is a dark red–brown, with deep fissures. The trees grow in mountain slopes and ravines between 3,000 (914 m) and 6,000 ft (1,829 m). They occur individually among the coastal redwood forests and in large stands in association with juniper and oaks. Giant chinkapin is a slow-growing species, living to more than 400 years. When the trees flower in late spring, they are covered in white blossoms that emit a strong odor. It is a masting species, producing large crops of nuts in a cyclical manner, after several years of low nut production.

General Wood Characteristics: The sapwood of giant chinkapin is narrow and light brown and is not distinguishable from the heartwood, except the latter can be tinged or striped with pink. It is fine grained, soft and brittle, with no characteristic odor or taste.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.42	61	977
12%	0.46	32	513
Ovendry	0.48	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.02×10^6 lbf/in^2	7.033 GPa	1.24×10^6 lbf/in^2	8.550 GPa
MOR	7.00×10^3 lbf/in^2	48.265 MPa	10.7×10^3 lbf/in^2	73.777 MPa
$C_{\parallel}$	2.03×10^3 lbf/in^2	13.997 MPa	4.15×10^3 lbf/in^2	28.614 MPa
$C_{\perp}$	0.49×10^3 lbf/in^2	3.379 MPa	0.68×10^3 lbf/in^2	4.689 MPa
WML	9.5 in-lbf/in^3	65.503 kJ/m^3	9.5 in-lbf/in^3	65.503 kJ/m^3
Hardness	600 lbf	2668.80 N	730 lbf	3247.04 N
$Shear_{\parallel}$	1.01 lbf/in^2	6.964 MPa	1.26×10^3 lbf/in^2	8.687 MPa

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.4	NA	NA
Radial	4.6	NA	NA
Volumetric	13.2	NA	NA

[a]Reference (59).

Working Properties: Not available at this time.

Durability: Not available at this time.

Preservation: Not available at this time.

Uses: Paneling, tool handles, furniture, novelties, fuel wood.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Catalpa spp.
Bignoniaceae
Catalpa

The genus *Catalpa* is composed of 11 species native to North America [2], West Indies [5], and temperate Asia (China to Tibet) [4]. The name *catalpa* is the Native American (Cherokee) name for this tree.

*Catalpa bignonioides**	beantree, beau-tree, candle-tree, catawba, catawba-tree, cigartree, common catalpa, Indian bean, Indian cigartree, **southern catalpa**
Catalpa longissima	(Jamaica and Haiti) French oak, Haitian oak, Jamaica oak, mast-wood, **yokewood**
*Catalpa speciosa**	candle-tree, catawba, cigartree, hardy catalpa, Indian bean, Indian cigartree, **northern catalpa**, shawnee-wood, western catalpa, western catawba

*commercial species

The following description is for the North American species.

Distribution: Catalpa is native to the central eastern United States, but is naturalized throughout the United States and Canada.

The Tree: Catalpa trees are often planted as street trees and for shade in yards, but most often for their showy flowers. The tree has opposite, simple, entire leaves. The flowers are bisexual and formed in branched clusters. The fruits are large bean-like structures, resembling cigars. Catalpa trees can reach 100 ft (30 m) in height and 3 ft (1 m) in diameter. The bark is thick, with reddish-brown scales.

General Wood Characteristics: The wood is similar for both North American species. The sapwood is narrow and gray, while the heartwood is a grayish brown, tinged with lavender. The wood has a faint aromatic odor and no characteristic taste. It is ring porous, straight grained, light and soft. It can be confused with ash.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.38	41	657
12%	0.41	29	465
Ovendry	0.42	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.84×10^6 lbf/in^2	5.792 GPa	1.21×10^6 lbf/in^2	8.343 GPa
MOR	5.20×10^3 lbf/in^2	35.854 MPa	9.40×10^3 lbf/in^2	64.813 MPa
$C_{\parallel}$	1.45×10^3 lbf/in^2	9.998 MPa	2.74×10^3 lbf/in^2	18.892 MPa
$C_{\perp}$	0.32×10^3 lbf/in^2	2.206 MPa	0.57×10^3 lbf/in^2	3.930 MPa
WML	7.9 in-lbf/in^3	54.471 kJ/m^3	9.6 in-lbf/in^3	66.192 kJ/m^3
Hardness	410 lbf	1823.68 N	550 lbf	2446.40 N
Shear$_{\parallel}$	0.68×10^3 lbf/in^2	4.688 MPa	1.13×10^3 lbf/in^2	7.791 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	4.9	3.9	1.6
Radial	2.5	2.0	0.8
Volumetric	7.3	5.8	2.4

[a]Catalpa dries quickly and is easy to season, provided that the ends of the logs are coated.
[b]References: 0% MC, (59); 6% and 20% MC, (90).

Working Properties: Catalpa works very well with hand and machine tools, although it requires care to sand well.

Durability: Very resistant to heartwood decay when the wood is in contact with the soil.

Preservation: No information available at this time.

Uses: Fence posts and rails, general construction, interior finish, handles, picture frames, cabinetry and fuel wood.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Celtis spp. Ulmaceae Hackberry

The genus *Celtis* is composed of about 75 species native to the United States [7], Mexico and Central America [9], the northern temperate and tropical zones, and south Africa. The name *celtis* is the classical Latin name for a species of lotus.

*Celtis laevigata**	almez americano, American celtis, bagolaro americano, bois inconnu, connu, lowland hackberry, micocoulier a sucre, palo blanco, sockernasslatrad, southern hackberry, **sugarberry**, sugar hackberry, suikernetelboom, Texas sugarberry,
Celtis lindheimeri	**Lindheimer hackberry**, palo blanco
*Celtis occidentalis**	almez occidental, American hackberry, bagolaro occidentale, baralm, bastard elm, beaverwood, bigleaf hackberry, common hackberry, false elm, **hackberry**, hacktree, hoop ash, huck, micocoulier occidental, nettletree, northern hackberry, oneberry, sugarberry, western hackberry, western netelboom, zwepenboom
*Celtis reticulata**	**netleaf hackberry**, palo blanco, sugarberry, thick leaved hackberry, western hackberry
Celtis tenuifolia	dwarf hackberry, **Georgia hackberry**, upland hackberry

*commercial species

Distribution: The United States.

The Tree: Hackberry trees can reach heights of 130 ft (40 m), with a diameter of 4 ft (1.2 m).

General Wood Characteristics: The sapwood of hackberry is pale yellow to grayish or greenish yellow, while the heartwood is a yellowish gray brown to light brown. The wood is straight grained, moderately hard, strong in bending, but weak in compression. It also has high shock resistance, but lacks stiffness; gluing properties are excellent.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.49	50	801
12%	0.53	37	593
Ovendry	0.56	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (50).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.95×10^6 lbf/in^2	6.550 GPa	1.19×10^6 lbf/in^2	8.205 GPa
MOR	6.50×10^3 lbf/in^2	44.818 MPa	11.0×10^3 lbf/in^2	76.535 MPa
$C_{\parallel}$	2.65×10^3 lbf/in^2	18.272 MPa	5.44×10^3 lbf/in^2	37.509 MPa
$C_{\perp}$	0.40×10^3 lbf/in^2	2.758 MPa	0.89×10^3 lbf/in^2	6.137 MPa
WML	14.5 in-lbf/in^3	99.978 kJ/m^3	12.8 in-lbf/in^3	88.256 kJ/m^3
Hardness	700 lbf	3113.60 N	880 lbf	3914.24 N
$Shear_{\parallel}$	1.07×10^3 lbf/in^2	7.377 MPa	1.59×10^3 lbf/in^2	10.963 MPa

[a]Reference (98).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	8.9	7.1	3.0
Radial	4.8	3.8	1.6
Volumetric	13.8	13.5	5.6

[a] References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-C4	T6-C3	T6-C3	T5-C3	T3-B1

[a]References (6, 86).

Working Properties: Hackberry wood planes and turns well. It is intermediate in its ability to hold nails and screws; it resists splitting from screws better than from nails.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Furniture, millwork, sporting and athletic goods, boxes and crates, veneer and plywood.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74, 87.

Conocarpus erectus
Combretaceae
Buttonwood

The genus *Conocarpus* is composed of 2 species native to North America [1] and the shores of tropical America and Africa [1]. The word *conocarpus* means "cone fruit," in reference to the cone-like rounded fruits.

Other Common Names: asokolo, asopolo, botoncahui, botoncillo, botonillo, buttonbush, button mangrove, button-tree, chene guadeloupe, conocarpe droit, estachahuite, Florida button, Florida buttonwood, geli, gray mangrove, grey mangrove, grignon, grijze mangle, grijze mangrove, iztac-cuahuitl, jele, kaba, k'an-chik'-inche, kanche, k'ank-ank-che, k'ank-che, madre de sal, mangel, mangel blancu, mangle, mangle blanco, mangle boton, mangle botoncillo, mangle cenizo, mangle garbancillo, mangle gris, mangle jeli, mangle lloroso, mangle marequita, mangle negro, mangle pinuelo, mangle prieto, mangle roche, mangle torcido, mangle zaragoza, manglier, manglier gris, mangrovia grigia, mangue, mangue branco, mangue de botao, maraquito, n ja, paletuvier, paletuvier gris, pash-ch'uhnul, pataban, saragosa, silver buttonwood, taabche, tabche, witte mangel, witte mangro, wortelboom, x-kanche, xtabche, yana, zaragosa, zaragoza mangrove.

Distribution: Native to the silt shores of coasts and islands of Florida, including the Florida Keys. Also widely distributed on coasts of tropical America from Bermuda and Bahamas through West Indies, including Puerto Rico and Virgin Islands. From Mexico south on the Atlantic coast to Brazil and on the Pacific coast to Ecuador, including the Galapagos Islands and Peru. On coasts of west Africa and in Melanesia and Polynesia.

The Tree: Buttonwood occurs in tidal lagoons and bays of brackish water. It forms dense thickets of shrubby growth, but becomes tree-like when growing alone. Flowers and fruits are produced year round. The tree reaches heights of 60 ft (18 m) and a diameter of 3 ft (1 m). The bark is thick and has broad plates of thin scales which are gray to brown. The bark is rich in tannins.

General Wood Characteristics: The heartwood of buttonwood is olive brown, with a reddish tinge, while the sapwood is lighter. The wood is moderately heavy, hard and strong. It has a high luster, medium texture, with a straight to mottled grain.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green (47%)	0.69	64	1,025
12%	0.71	50	801
Ovendry	0.85	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.19×10^6 lbf/in^2	8.205 GPa	1.58×10^6 lbf/in^2	10.894 GPa
MOR	7.40×10^3 lbf/in^2	51.023 MPa	10.2×10^3 lbf/in^2	70.329 MPa
$C_{\parallel}$	4.10×10^3 lbf/in^2	28.270 MPa	7.85×10^3 lbf/in^2	54.126 MPa
$C_{\perp}$	1.14×10^3 lbf/in^2	7.860 MPa	1.63×10^3 lbf/in^2	11.239 MPa
WML	6.2 in-lbf/in^3	42.749 kJ/m^3	5.9 in-lbf/in^3	40.681 kJ/m^3
Hardness	1,110 lbf	4937.28 N	NA	NA
$Shear_{\parallel}$	1.22×10^3 lbf/in^2	8.412 MPa	NA	NA

[a]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.5	NA	NA
Radial	5.4	NA	NA
Volumetric	14.6	NA	NA

[a] Reference (59).

Working Properties: Buttonwood is not easy to work, but it finishes smoothly.

Durability: Moderately resistant to heartwood decay.

Preservation: No information available at this time.

Uses: Durable construction, fuel, charcoal.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Cornus florida
Cornaceae
Flowering Dogwood

The genus *Cornus* contains about 40 species which grow in the northern temperate regions of the world. The name *cornus* is derived from the Latin name of the type species *Cornus mas* L., Cornelian-cherry of Europe, from the word for horn (*cornu*), referring to the hardness of the wood.

Cornus alternifolia	**alternate leaf dogwood**, blue dogwood, green-osier, pagoda, pagoda cornel, pagoda dogwood, pigeonberry, purple dogwood, umbrella-tree
Cornus drummondii	**roughleaf dogwood**, rough-leaved dogwood
Cornus florida	arrowwood, boxwood, bunchberry, cornel, dogwood (used bark to treat dog's mange), false boxwood, Florida dogwood, **flowering dogwood**, white cornel
Cornus glabrata	brown dogwood, flowering dogwood, mountain dogwood, Pacific dogwood, **smooth dogwood**, western flowering dogwood
Cornus nuttallii	California dogwood, flowering dogwood, mountain dogwood, **Pacific dogwood**, western dogwood, western flowering dogwood
Cornus occidentalis	**western dogwood**
Cornus racemosa	blue-fruit dogwood, **gray dogwood**, stiffcornel, stiffcornel dogwood, stiff dogwood, swamp dogwood
Cornus rugosa	**roundleaf dogwood**
Cornus sessilis	**blackfruit dogwood**, miners dogwood
Cornus stolonifera	American dogwood, California dogwood, creek dogwood, kinnikinnik, red dogwood, **red-osier dogwood**, red-panicled dogwood, redstem dogwood, squawbush, western dogwood
Cornus stricta	bluefruit dogwood, stiffcornel, stiffcornel dogwood, **swamp dogwood**

The following description is for flowering dogwood.

Distribution: North America, from Maine to New York, Ontario, Michigan, Illinois and Missouri south to Kansas, Oklahoma, and Texas east to Florida.

The Tree: Flowering dogwood is well known for its white flower clusters with large white bracts opening in the spring. The fall foliage is bright red. It is a slow-growing tree which attains a height of 40 ft (12 m) and a diameter of 16 inches (40 cm). The bark looks like reddish-brown alligator skin. The tree grows best along streams and in well-drained soils.

General Wood Characteristics: The sapwood of dogwood is wide and creamy in color, while the heartwood is reddish brown to brown, sometimes streaked in white. The wood has a fine, uniform texture with a hard, compact interlocked grain. Strength is similar to that of European Beech, but higher in hardness and shock resistance and slightly lower in stiffness.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.64	64	1,025
12%	0.73	51	817
Ovendry	0.80	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.18×10^6 lbf/in^2	8.136 GPa	1.53×10^6 lbf/in^2	10.549 GPa
MOR	8.80×10^3 lbf/in^2	60.676 MPa	14.9×10^3 lbf/in^2	102.736 MPa
$C_{\parallel}$	3.64×10^3 lbf/in^2	25.098 MPa	7.70×10^3 lbf/in^2	53.092 MPa
$C_{\perp}$	1.03×10^3 lbf/in^2	7.102 MPa	1.92×10^3 lbf/in^2	13.238 MPa
WML	21.0 in-lbf/in^3	144.795 kJ/m^3	19.5 in-lbf/in^3	134.453 kJ/m^3
Hardness	1,410 lbf	6,271.68 N	2,150 lbf	9,563.20 N
$Shear_{\parallel}$	1.52×10^3 lbf/in^2	10.480 MPa	2.26×10^3 lbf/in^2	15.582 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	11.3	9.4	3.9
Radial	7.1	5.9	2.5
Volumetric	19.9	16.6	6.9

[a]Dogwood will check unless dried slowly under controlled conditions. It shows large movement under changing moisture conditions.
[b]References: 0% MC, (59); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-C3	T3-C2	NA	NA	NA

[a]References (6, 86).

Working Properties: Dogwood can be sawn, planed, and turned easily, and it takes a glossy finish.

Durability: Nonresistant to heartwood decay because of the small percentage of heartwood.

Preservation: No information available at this time.

Uses: Weaving shuttles, spool and bobbin heads, small pulleys, skewers, golf club heads, tool handles, charcoal for gunpowder, red dye from bark of roots, medicine from stem bark.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 63, 68, 74.

Diospyros spp.
Ebenaceae
Common Persimmon

The genus *Diospyros* contains about 400 species (including ebony) mostly native to the tropics (Madagascar, Africa and Malaysia), with two native to the United States. The name *diospyros* is derived from the Greek, for the god Zeus or Jupiter and grain, alluding to the edible fruit or "fruit of the gods."

Diospyros kaki	**Oriental persimmon** (Japan) (commercial fruits)
Diospyros texana	black persimmon, chapote, common sweetleaf, Florida laurel, horse sugar, Mexican persimmon, Spanish chapote, sweetleaf, **Texas persimmon**, yellow-wood
*Diospyros virginiana**	bara bara, boawood, butterwood, **common persimmon**, cylil date plum, date plum, eastern persimmon, echtes persimmon, Florida persimmon, plaqueminier, possumwood, seeded plum, simmon, Virginia date palm, winter plum

*commercial species

The following description is for common persimmon.

Distribution: North America, from Connecticut, New York and New Jersey west to Ohio, Illinois, Iowa, Missouri and Kansas, south to Oklahoma and Texas, east to Florida including the Florida Keys.

The Tree: Persimmon trees are slow growing. They produce small white flowers shaped like lanterns or bells. The fruits are eaten by woodland animals and by people (after the first frost or the fruit puckers the lips). The tree attains a height of 80 ft (24 m) and a diameter of 2 ft (0.6 m). The bark develops thick square blocks, like alligator skin. Persimmon grows in disturbed areas and in deciduous woodlands in association with hickory, oak, sycamore, maple, red cedar, tulip poplar and elm. It masts every 2 years.

General Wood Characteristics: The sapwood is white, darkening to a grayish brown, while the small heartwood is dark brown to black (like ebony) and streaked. The wood is uniform in texture, stiff, strong, heavy, hard, and is resilient to pressure. The wood has no characteristic odor or taste. It is semi-ring-porous. Persimmon is sometimes confused with hickory.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.64	63	1,009
12%	0.74	52	833
Ovendry	0.78	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.37×10^6 lbf/in^2	9.446 GPa	2.01×10^6 lbf/in^2	13.859 GPa
MOR	10.0×10^3 lbf/in^2	68.950 MPa	17.7×10^3 lbf/in^2	122.042 MPa
$C_{\parallel}$	4.17×10^3 lbf/in^2	28.752 MPa	9.17×10^3 lbf/in^2	63.227 MPa
$C_{\perp}$	1.11×10^3 lbf/in^2	7.653 MPa	2.46×10^3 lbf/in^2	16.962 MPa
WML	13.0 in-lbf/in^3	89.635 kJ/m^3	15.4 in-lbf/in^3	106.183 kJ/m^3
Hardness	1,280 lbf	5,693.44 N	2,300 lbf	10,230.40 N
$Shear_{\parallel}$	1.47×10^3 lbf/in^2	10.135 MPa	2.16×10^3 lbf/in^2	14.893 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	11.2	9.0	3.7
Radial	7.9	6.3	2.6
Volumetric	19.1	15.3	6.4

[a]Persimmon shrinks considerably and requires great care in seasoning to prevent checking.
[b]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	Golf club heads	Shuttles
Standard	T6-C3	T3-C2	T3-C2	T3-B2

[a]References (6, 86).

Working Properties: Persimmon is hard to work with tools and it does not glue easily.

Durability: Persimmon heartwood is very resistant to decay, but the sapwood is nonresistant.

Preservation: No information available at this time.

Uses: Shuttles, spools, bobbins, billiard cues, parquet floors, turnery, golf club heads, shoe lasts, veneer and handles.

Toxicity: Heartwood may cause dermatitis (105).

Additional Reading: 29, 55, 68, 74.

Fagus grandifolia
Fagaceae
American Beech

Beech (*Fagus* spp.) contains eight species which grow in Asia [4], Europe (*F. sylvatica*), and North America (*F. grandifolia*). The word *fagus* is the classical Latin name, from the Greek word meaning to eat, in reference to the edible beechnuts. All species look alike microscopically.

Other Common Names: beech, carolina beech, gray beech, red beech, ridge beech, stone beech, white beech, winter beech.

Distribution: American beech grows in southeast Canada and in the eastern half of the United States, from Maine to northern Florida, and west from the Atlantic Coast to Wisconsin, Missouri and Texas.

The Tree: The American beech tree grows in large pure stands and intermixed with sugar maple, yellow birch, American basswood, black cherry, eastern hemlock, eastern white pine, red spruce, sweetgum, Southern magnolia, ashes, hickories and oaks. It grows best in deep, rich, moist, well-drained soils. American beech trees reach heights of 120 ft (37 m), with a diameter of almost 4 ft (1.2 m). The bark is thin, smooth, and gray to blue gray.

General Wood Characteristics: The sapwood of American beech is white with a red tinge, while the heartwood is light to dark reddish brown.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.56	54	865
12%	0.64	45	721
Ovendry	0.67	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.38×10^6 lbf/in^2	9.515 GPa	1.72×10^6 lbf/in^2	11.859 GPa
MOR	8.60×10^3 lbf/in^2	59.297 MPa	14.9×10^3 lbf/in^2	102.736 MPa
$C_{\parallel}$	3.55×10^3 lbf/in^2	24.477 MPa	7.30×10^3 lbf/in^2	50.334 MPa
$C_{\perp}$	0.54×10^3 lbf/in^2	3.723 MPa	1.01×10^3 lbf/in^2	6.964 MPa
WML	11.9 in-lbf/in^3	82.051 kJ/m^3	15.1 in-lbf/in^3	104.115 kJ/m^3
Hardness	850 lbf	3,780.80 N	1,300 lbf	5782.40 N
Shear$_{\parallel}$	1.29×10^3 lbf/in^2	8.894 MPa	2.01×10^3 lbf/in^2	13.858 MPa

[a]Reference (98).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	11.9	8.8	3.7
Radial	5.5	4.1	1.7
Volumetric	17.2	13.0	5.4

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-C2	T5-C1	NA	NA	NA
1-in. squares	T8-C3				
2-in. squares	T5-C2				

[a]References (6, 86).

Working Properties: American beech ranks high in holding nails, but it should be prebored. The wood wears well and holds a polish, and it bends readily when steamed. Care is needed in gluing, but the wood finishes well with paint or transparent finishes.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Sapwood and heartwood are permeable when pressure-treated with a compound like creosote. The red heartwood is extremely resistant to penetration.

Uses: Lumber, veneer, charcoal, railroad ties, pulpwood, cooperage, boxes, crates, baskets, pallets, furniture, flooring, sash, doors, trim, paneling, general millwork, woodenware, novelties, handles, brooms and brushes, food containers, turnery, and chemical extracts such as methanol, acetate and wood tar (creosote).

Toxicity: No information available at this time.

Additional Reading: 12, 29, 55, 68, 74.

Fraxinus spp.
Oleaceae
American Ash

Ash (*Fraxinus* spp.) is composed of 40 to 70 species, native to Central and North America [21] and Eurasia [50]. All species look alike microscopically. The name *fraxinus* is the classical Latin name for ash.

The American species are as follows:

*Fraxinus americana**	American white ash, biltmore ash, biltmore white ash, Canadian ash, cane ash, green ash, ground ash, mountain ash, Quebec ash, red ash, smallseed white ash, **white ash**, white river ash, white southern ash
Fraxinus anomala	dwarf ash, **singleleaf ash**
Fraxinus berlandierana	**Berlandier ash**, Mexican ash
Fraxinus caroliniana	**Carolina ash**, Florida ash, pop ash, swamp ash, water ash
Fraxinus cuspidata	flowering ash, **fragrant ash**
Fraxinus dipetala	California flowering ash, California shrub ash, foothill ash, flowering ash, fringe-flowering ash, mountain ash, **two-petal ash**
Fraxinus gooddingii	**Goodding ash**
Fraxinus greggii	dogleg ash, **Gregg ash**, littleleaf ash
*Fraxinus latifolia**	basket ash, **Oregon ash**, water ash, white ash
*Fraxinus nigra**	American black ash, basket ash, **black ash**, brown ash, Canadian ash, hoop ash, splinter ash, swamp ash, water ash
Fraxinus papillosa	**Chihuahua ash**
*Fraxinus pennsylvanica**	bastard ash, black ash, blue ash, brown ash, Canadian ash, darlington ash, gray ash, **green ash**, piss ash, pumpkin ash, red ash, rim ash, river ash, soft ash, swamp ash, water ash, white ash
*Fraxinus profunda**	**pumpkin ash**, red ash
*Fraxinus quadrangulata**	**blue ash**, Virginia ash
Fraxinus texensis	**Texas ash**
Fraxinus velutina	Arizona ash, desert ash, leatherleaf ash, modesto ash, smooth ash, toumey ash, **velvet ash**

* commercial species

Distribution: The north temperate regions of the globe.

The Tree: Ashes are trees or shrubs with large, opposite, pinnately compound leaves. The compound leaves have 2 to 11 leaflets. The flowers can be bisexual or there can be distinct male and female flowers on separate trees. The flowers have no petals and the fruits are dry with a flattened wing. The tree can reach heights of 80 ft (24 m) with straight boles.

General Wood Characteristics: The sapwood of ash is light brown, while the heartwood is brown to grayish brown. White ash and Oregon ash have lighter heartwood than do the other commercial species. The width of the sapwood is 3 to 6 inches (8 to 15 cm). It is ring porous, with the latewood being composed of parenchyma which surrounds and unites the latewood pores in tangential bands. The wood has no characteristic odor or taste.

Weight

Species	MC	SG[a]	Weight[b] lb/ft^3	Weight[b] kg/m^3
Fraxinus americana	Green	0.55	48	769
(white ash)	12%	0.60	42	673
	Ovendry	0.64	NA	NA
Fraxinus latifolia	Green	0.50	46	737
(Oregon ash)	12%	0.55	38	609
	Ovendry	0.58	NA	NA
Fraxinus nigra	Green[b]	0.45	52	833
(black ash)	12%[b]	0.49	34	545
	Ovendry	0.53	NA	NA
Fraxinus pennsylvanica	Green	0.53	49	785
(green ash)	12%	0.56	40	641
	Ovendry	0.61	NA	NA
Fraxinus profunda	Green[b]	0.48	46	737
(pumpkin ash)	12%[b]	0.52	36	577
	Ovendry	0.55	NA	NA
Fraxinus quadrangulata	Green	0.53	46	737
(blue ash)	12%	0.58	40	641
	Ovendry	0.60	NA	NA

[a]Data for green and 12% conditions taken from reference (98); ovendry data from reference (59).
[b]Data from reference (59).

Mechanical properties[a]

Property	Green		Dry	
Fraxinus americana (white ash)[a]				
MOE	1.44×10^6 lbf/in^2	9.928 GPa	1.74×10^6 lbf/in^2	11.997 GPa
MOR	9.60×10^3 lbf/in^2	66.192 MPa	15.0×10^3 lbf/in^2	103.425 MPa
$C_{\|\|}$	3.99×10^3 lbf/in^2	27.511 MPa	7.41×10^3 lbf/in^2	51.092 MPa
$C_{\perp}$	0.67×10^3 lbf/in^2	4.620 MPa	1.16×10^3 lbf/in^2	7.998 MPa
WML	15.7 in-lbf/in^3	108.252 kJ/m^3	16.6 in-lbf/in^3	114.457 kJ/m^3
Hardness	960 lbf	4,270.08 N	1,320 lbf	5,871.36 N
$Shear_{\|\|}$	1.35×10^3 lbf/in^2	9.308 MPa	1.91×10^3 lbf/in^2	13.169 MPa
Fraxinus latifolia (Oregon ash)[a]				
MOE	1.13×10^6 lbf/in^2	7.791 GPa	1.36×10^6 lbf/in^2	9.377 GPa
MOR	7.60×10^3 lbf/in^2	52.402 MPa	12.7×10^3 lbf/in^2	87.567 MPa
$C_{\|\|}$	3.51×10^3 lbf/in^2	24.201 MPa	6.04×10^3 lbf/in^2	41.646 MPa
$C_{\perp}$	0.53×10^3 lbf/in^2	3.654 MPa	1.25×10^3 lbf/in^2	8.619 MPa
WML	12.2 in-lbf/in^3	84.119 kJ/m^3	14.4 in-lbf/in^3	99.288 kJ/m^3
Hardness	790 lbf	3,513.92 N	1,160 lbf	5,159.68 N
$Shear_{\|\|}$	1.19×10^3 lbf/in^2	8.205 MPa	1.79×10^3 lbf/in^2	12.342 MPa
Fraxinus nigra (black ash)[a]				
MOE	1.04×10^6 lbf/in^2	7.171 GPa	1.60×10^6 lbf/in^2	11.032 GPa
MOR	6.00×10^3 lbf/in^2	41.370 MPa	12.6×10^3 lbf/in^2	86.877 MPa
$C_{\|\|}$	2.30×10^3 lbf/in^2	15.859 MPa	5.97×10^3 lbf/in^2	41.163 MPa
$C_{\perp}$	0.35×10^3 lbf/in^2	2.413 MPa	0.76×10^3 lbf/in^2	5.240 MPa
WML	12.1 in-lbf/in^3	83.430 kJ/m^3	14.9 in-lbf/in^3	102.736 kJ/m^3
Hardness	520 lbf	2,312.96 N	850 lbf	3,780.80 N
$Shear_{\|\|}$	0.86×10^3 lbf/in^2	5.929 MPa	1.57×10^3 lbf/in^2	10.825 MPa
Fraxinus pennsylvanica (green ash)[a]				
MOE	1.40×10^6 lbf/in^2	9.653 GPa	1.66×10^6 lbf/in^2	11.446 GPa
MOR	9.50×10^3 lbf/in^2	65.503 MPa	14.1×10^3 lbf/in^2	97.220 MPa
$C_{\|\|}$	4.20×10^3 lbf/in^2	28.959 MPa	7.08×10^3 lbf/in^2	48.817 MPa
$C_{\perp}$	0.73×10^3 lbf/in^2	5.033 MPa	1.31×10^3 lbf/in^2	9.032 MPa
WML	11.8 in-lbf/in^3	81.361 kJ/m^3	13.4 in-lbf/in^3	92.393 kJ/m^3
Hardness	870 lbf	3,869.76 N	1,200 lbf	5,337.60 N
$Shear_{\|\|}$	1.26×10^3 lbf/in^2	8.687 MPa	1.91×10^3 lbf/in^2	13.169 MPa
Fraxinus profunda (pumpkin ash)[b]				
MOE	1.04×10^6 lbf/in^2	7.171 GPa	1.27×10^6 lbf/in^2	8.757 GPa
MOR	7.60×10^3 lbf/in^2	52.402 MPa	11.1×10^3 lbf/in^2	76.535 MPa
$C_{\|\|}$	3.36×10^3 lbf/in^2	23.167 MPa	5.69×10^3 lbf/in^2	39.233 MPa
$C_{\perp}$	0.99×10^3 lbf/in^2	6.826 MPa	1.80×10^3 lbf/in^2	12.411 MPa
WML	9.4 in-lbf/in^3	64.813 kJ/m^3	8.0 in-lbf/in^3	55.160 kJ/m^3
Hardness	750 lbf	3,336.00 N	990 lbf	4,403.52 N
$Shear_{\|\|}$	1.21×10^3 lbf/in^2	8.343 MPa	1.72×10^3 lbf/in^2	11.859 MPa
Fraxinus quadrangulata (blue ash)[c]				
MOE	1.24×10^6 lbf/in^2	8.549 GPa	1.40×10^6 lbf/in^2	9.653 GPa
MOR	9.60×10^3 lbf/in^2	66.192 MPa	13.8×10^3 lbf/in^2	95.151 MPa
$C_{\|\|}$	4.18×10^3 lbf/in^2	28.821 MPa	6.98×10^3 lbf/in^2	48.127 MPa
$C_{\perp}$	0.81×10^3 lbf/in^2	5.585 MPa	1.42×10^3 lbf/in^2	9.791 MPa
WML	14.7 in-lbf/in^3	101.357 kJ/m^3	14.4 in-lbf/in^3	99.288 kJ/m^3
Hardness	1,030 lbf	4581.44 N	2,030 lbf	9029.44 N
$Shear_{\|\|}$	1.54×10^3 lbf/in^2	10.618 MPa	2.03×10^3 lbf/in^2	13.996 MPa

[a]Reference (98). [b]Reference (59). [c]Reference (98) except for hardness, (59).

Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC[a]	6% MC[b]	20% MC[b]
Tangential			
Fraxinus americana (white ash)	7.8	6.2	2.6
Fraxinus latifolia (Oregon ash)	8.1	NA	NA
Fraxinus nigra (black ash)	7.8	6.2	2.6
Fraxinus pennsylvanica (green ash)	7.1	5.7	2.4
Fraxinus profunda (pumpkin ash)	6.3	NA	NA
Fraxinus quadrangulata (blue ash)	6.5	NA	NA
Radial			
Fraxinus americana (white ash)	4.9	3.8	1.6
Fraxinus latifolia (Oregon ash)	4.1	NA	NA
Fraxinus nigra (black ash)	5.0	4.0	1.7
Fraxinus pennsylvanica (green ash)	4.6	3.7	1.5
Fraxinus profunda (pumpkin ash)	3.7	NA	NA
Fraxinus quadrangulata (blue ash)	3.9	NA	NA
Volumetric			
Fraxinus americana (white ash)	13.3	10.7	4.5
Fraxinus latifolia (Oregon ash)	13.2	NA	NA
Fraxinus nigra (black ash)	15.2	12.2	5.1
Fraxinus pennsylvanica (green ash)	12.5	10.0	4.2
Fraxinus profunda (pumpkin ash)	12.0	NA	NA
Fraxinus quadrangulata (blue ash)	11.7	NA	NA

[a]Reference (98).
[b]Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-D4	T5-B3	T5-B3	T3-B2	T3-A1

[a]References (6, 86).

Working Properties: Ash is straight grained, heavy, hard, strong, and stiff; it wears smooth, with high shock resistance. It machines well and is better than average in nail- and screw-holding capacity. It glues moderately well. Black, green, pumpkin and blue ashes have lower specific gravity and lower strength properties, but are still moderately strong, hard, and stiff compared to other native hardwoods. Ashes also split easier, shrink more, are average in workability, and perform more poorly in service compared to other native hardwoods.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Handle stock, baseball bats, unupholstered furniture, flooring, millwork, hand tools, sporting goods, boxes and crates.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74, 89.

Gleditsia triacanthos Leguminosae Honeylocust

The genus *Gleditsia* contains about 14 species native to the warm temperate and tropical regions. There are two species in North America, which hybridize. All species look alike with respect to wood anatomy. The word *gleditsia* is a Latinized name, honoring Johann Gottleib Gleditsch (1714–1786), director of the Berlin Botanic Garden.

Gleditsia triacanthos	common honeylocust, confederate pintree, honey, **honeylocust**, honeyshucks, shucks honeylocust, squeak-bean, sweet-bean, sweetlocust, thornlocust, thorn-tree, thorny acacia, thornylocust, three-thorned locust
Gleditsia aquatica	blacklocust, honeylocust, swamp waterlocust, **waterlocust**

Distribution: The range of honeylocust extends from Pennsylvania west to South Dakota, Nebraska, south to Texas, east to Alabama and Georgia, northeast along the Appalachians to Pennsylvania.

The Tree: Honeylocust trees can reach heights of 80 ft (24 m), with a diameter of 3 ft (1 m).

General Wood Characteristics: The sapwood of honeylocust is yellowish and wide, while the heartwood is light red to reddish brown. The wood has no characteristic odor or taste. It is very heavy and very hard, tough, strong, with a high luster. The texture is moderately coarse, with straight to irregular grain.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.60	61	977
12%	NA	NA	NA
Ovendry	0.67	NA	NA

[a]References: green specific gravity (98), weight (59), ovendry specific gravity (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.29×10^6 lbf/in^2	8.894 GPa	1.63×10^6 lbf/in^2	11.239 GPa
MOR	10.2×10^3 lbf/in^2	70.329 MPa	14.7×10^3 lbf/in^2	101.357 MPa
$C_{\parallel}$	4.42×10^3 lbf/in^2	30.476 MPa	7.50×10^3 lbf/in^2	51.713 MPa
$C_{\perp}$	1.15×10^3 lbf/in^2	7.929 MPa	1.84×10^3 lbf/in^2	12.687 MPa
WML	12.6 in-lbf/in^3	86.877 kJ/m^3	13.3 in-lbf/in^3	91.704 kJ/m^3
Hardness	1,390 lbf	6,182.72 N	1,580 lbf	7,027.84 N
$Shear_{\parallel}$	1.66×10^3 lbf/in^2	11.445 MPa	2.25×10^3 lbf/in^2	15.513 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	6.6	5.3	2.2
Radial	4.2	3.4	1.4
Volumetric	10.8	8.6	3.6

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln Drying Schedule: No information available at this time.

Working Properties: Honeylocust is not easy to work, but it finishes smoothly.

Durability: Rated as moderately resistant to heartwood decay.

Preservation: No information available at this time.

Uses: Fence posts and rails, general construction, furniture, interior trim.

Toxicity: No information available at this time.

Additional Reading: 29, 33, 55, 68, 74.

Gymnocladus dioicus
Leguminosae
Kentucky Coffeetree

The genus *Gymnocladus* is represented by four species native to North America [1] and Asia [3]. The word *gymnocladus* comes from the Greek—naked branch—referring to the few stout twigs, which are conspicuous year round. The word dioicus relates to dioecious, meaning there are male and female trees.

Other Common Names: American coffee bean, American mahogany, chicot, chico du Canada, chicot tree, coffeebean, coffeebean-tree, coffeenut, coffeetree, dead tree, geweihbaum, Kentucky mahogany, mahogany, mahogany-bean, nettle-tree, nicker-tree, stump tree.

Distribution: From central New York and southern Ontario west to southern Michigan, Minnesota and South Dakota south to central Kansas, southern Oklahoma east to Arkansas, Mississippi, Tennessee, Kentucky, Virginia and Pennsylvania.

The Tree: The Kentucky coffeetree is medium size, reaching 100 ft (30 m) tall and 3 ft (1 m) in diameter. The trunk commonly divides into 3 or 4 stems, about 15 ft (4.5 m) from the ground. The tree has deciduous leaves that are bipinnately compound. It produces white to lavender flowers in large clusters (terminal racemes). The tree produces bean-like pods that are hard and woody when mature and contain several seeds surrounded in sweet, greenish pulp. It grows in deep rich soils in bottom lands, in association with sweetgum, tupelo, oaks and hickories. For about 6 months of the year, the tree lies dormant, leading to the name Dead Tree or Stump Tree.

General Wood Characteristics: The wood of Kentucky coffeetree is ring porous, resembling ash, honeylocust or sassafras. Its sapwood is narrow and yellowish white, while the heartwood is light red to reddish brown. The wood has no characteristic odor or taste. It is hard and heavy, with a coarse, straight grain.

Weight[a]

Moisture content	Specific gravity	Weight lb/ft^3	Weight kg/m^3
Green	0.53	NA	NA
12%	0.60	42	673
Ovendry	0.68	NA	NA

[a]Reference (90).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.00×10^6 lbf/in^2	6.895 GPa	1.42×10^6 lbf/in^2	9.791 GPa
MOR	7.32×10^3 lbf/in^2	50.471 MPa	10.5×10^3 lbf/in^2	72.398 MPa
$C_{\parallel}$	3.36×10^3 lbf/in^2	23.167 MPa	6.60×10^3 lbf/in^2	45.507 MPa
$C_{\perp}$	0.87×10^3 lbf/in^2	5.999 MPa	1.47×10^3 lbf/in^2	10.136 MPa
WML	NA	NA	NA	NA
Hardness	1,080 lbf	4,803.84 N	1,390 lbf	6,182.72 N
$Shear_{\parallel}$	1.36×10^3 lbf/in^2	9.377 MPa	1.78×10^3 lbf/in^2	12.273 MPa

[a]Reference (90).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	7.6	5.9	2.4
Radial	4.1	3.3	1.2
Volumetric	11.9	9.6	4.0

[a]Reference (90).

Working Properties: Kentucky coffeetree works without difficulty and finishes to a smooth surface.

Durability: Very resistant to heartwood decay, especially in contact with the soil.

Preservation: No information available at this time.

Uses: Cabinets, railroad ties, fence posts and rails, general construction, railway sleepers, bridge timbers, sills, interior finish, fuel. The seeds were used by the pioneers as a coffee substitute (“coffeetree”).

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Halesia spp.
Styracaceae
Silverbell

The genus *Halesia* is composed of about four species native to the United States [3] and China [1]. The genus *Halesia* was dedicated to Stephen Hales (1677–1761), British clergyman and author of *Vegetable Staticks* (1722).

Halesia carolina	bell-tree, bell olivetree, bellwood, box-elder, **Carolina silverbell**, catbell, Florida silverbell, four-winged halesia, little silverbell, no-name-tree, opossum, opossumwood, mountain silverbell, rattle-box, silverbell-tree, silver-tree, snowdrop-tree, tisswood, wild olivetree
Halesia diptera	cowlicks, silverbell-tree, snowdrop-tree, southern silverbell-tree, **two wing silverbell**
Halesia parviflora	Florida silverbell, **little silverbell**

Distribution: Southeastern United States and China.

The Tree: Silverbells are shrubs or trees with scaly reddish-brown bark. The leaves and small branches are covered with stellate (star-shaped) hairs. The showy white flowers are produced in small, pendulous clusters. They produce dry, winged fruits (drupe). Silverbells can reach a height of 100 ft (30 m), although they normally grow to 40 ft (12 m). The bark is thin, separating into slightly ridged, reddish-brown scales.

General Wood Characteristics: The wood of silverbell is brown, strong, dense and close grained. It has a wide white sapwood and a pale brown heartwood. The wood had medium luster and no odor or taste. The texture is fine and uniform, with a straight grain.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.42	44	705
12%	0.45	32	513
Ovendry	0.48	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.16×10^6 lbf/in^2	7.998 GPa	1.32×10^6 lbf/in^2	9.101 GPa
MOR	6.50×10^3 lbf/in^2	44.818 MPa	8.60×10^3 lbf/in^2	59.297 MPa
$C_{\parallel}$	2.83×10^3 lbf/in^2	19.513 MPa	5.13×10^3 lbf/in^2	35.371 MPa
$C_{\perp}$	0.43×10^3 lbf/in^2	2.965 MPa	0.68×10^3 lbf/in^2	4.689 MPa
WML	8.8 in-lbf/in^3	60.676 kJ/m^3	6.9 in-lbf/in^3	47.576 kJ/m^3
Hardness	470 lbf	2,090.56 N	590 lbf	2,624.32 N
Shear$_{\parallel}$	0.93×10^3 lbf/in^2	6.412 MPa	1.18×10^3 lbf/in^2	8.136 MPa

[a]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	7.6	NA	NA
Radial	3.8	NA	NA
Volumetric	12.6	NA	NA

[a]Reference (59).

Working Properties: Good.

Durability: Resistant to nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Paneling, cabinetwork.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Hamamelis virginiana
Hamamelidaceae
Witch Hazel

The genus *Hamamelis* is composed of six species native to North America [3] and temperate east Asia [3]. The word *hamamelis* is the classical Greek name of *Mesipilus germanica* L., medlar, or perhaps *Sorbus domestica* L., servicetree, words meaning together (in a time sense) and apple, which suggests flowers blooming at the same time.

Other Common Names: common witch hazel, snapping hazel, southern witch hazel, spotted alder, winter bloom.

Distribution: North America, from Nova Scotia, New Brunswick, Maine and Quebec, west to Ontario, Michigan and Minnesota, south to Iowa, Arkansas, Oklahoma and Texas, and east to Florida.

The Tree: Witch hazel is a fall-to-winter flowering tree or shrub. It has a thin, scaly, light-brown bark and small branches that grow in a zigzag manner. The flowers are bisexual with prominent, yellow, ribbon-like petals. The fruits are small, paired and horned. The tree attains heights of 30 ft (9 m) and diameters of 1 ft (0.3 m). Witch hazel grows at forest edges and along streams as an understory species. It grows best in deep, rich soils.

General Wood Characteristics: The sapwood of witch hazel is light brown, with a pinkish hue, while the heartwood is dark brown. The wood has medium luster and no odor or taste. It has medium density, fine texture, and straight grain.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green	0.56	59	945
12%	0.61	43	689
Ovendry	0.71	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.11×10^6 lbf/in^2	7.653 GPa	1.46×10^6 lbf/in^2	10.067 GPa
MOR	8.30×10^3 lbf/in^2	57.229 MPa	15.2×10^3 lbf/in^2	104.804 MPa
$C_{\parallel}$	3.40×10^3 lbf/in^2	23.443 MPa	6.74×10^3 lbf/in^2	46.472 MPa
$C_{\perp}$	0.62×10^3 lbf/in^2	4.275 MPa	1.37×10^3 lbf/in^2	9.446 MPa
WML	19.5 in-lbf/in^3	134.453 kJ/m^3	21.0 in-lbf/in^3	144.795 kJ/m^3
Hardness	980 lbf	4,359.04 N	1,530 lbf	6,805.44 N
Shear$_{\parallel}$	1.12×10^3 lbf/in^2	7.722 MPa	NA	NA

[a]Reference (59).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	NA	NA	NA
Radial	NA	NA	NA
Volumetric	18.8	NA	NA

[a]Reference (59).

Working Properties: Rather easily worked.

Durability: Nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Branches for divining rods, oil from leaves; twigs and bark used for liniments and medicines.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Ilex spp.
Aquifoliaceae
Holly

The genus *Ilex* contains over 350 species native to North America [26], Europe [1], tropical Africa [1], and Australia [1], with the rest in China and Brazil. The word *ilex* is the classical Latin name of *Quercus ilex* L., holly oak, of Europe, which has holly-like leaves.

Ilex ambigua	**Carolina holly**, large-leaf holly, mountain holly, mountain privet, mountain winterberry, myrtle holly, sand holly
Ilex amelanchier	**sarvis holly**, serviceberry holly
Ilex aquifolium	**European holly** (introduced in colonies)
Ilex cassine	Alabama dahoon, cassena-bush, cassena holly, christmasberry, **dahoon**, dahoon holly, Florida holly, hendersonwood, yaupon
Ilex coriacea	bay gallbush, **large gallberry**, sweet gallberry
Ilex decidua	bearberry, curtis possumhaw, deciduous holly, meadow holly, **possumhaw**, privet, swamp holly, winterberry
Ilex krugiana	krug holly, southern holly, **tawnyberry holly**
Ilex laevigata	**smooth winterberry**
Ilex longipes	chapman holly, **Georgia holly**
Ilex montana	mountain holly, **mountain winterberry**
Ilex myrtifolia	dahoon, **myrtle dahoon**, myrtle holly
*Ilex opaca**	**American holly**, christmas holly, evergreen holly, holly, prickly holly, white holly, yule holly
Ilex opaca var. *opaca*	**American holly (typical)**
Ilex opaca var. *arenicola*	**dune holly**, hummock holly, scrub holly
Ilex verticillata	black alder, **common winterberry**, winterberry
Ilex vomitoria	Appalachian tea, bassena, Carolina tea, cassena, cassena-bush, cassine, cassioberry, christmas berry, deerberry, emetic holly, evergreen cassena, evergreen holly, true cassena, **yaupon**, yopon

*commercial species

The following description is for American holly.

Distribution: North America, from Massachusetts, Connecticut and New York, southwest to Pennsylvania, West Virginia, Ohio, Kentucky, Missouri and Oklahoma, south to Texas and east to Florida.

The Tree: Hollies have spiny evergreen leaves and red berries on the female trees. Holly is found in lower areas of deep, rich, moist soils in association with magnolia, oaks, sweet gum, maples, and hackberry. It reaches a height of 50 ft (15 m) with a 2 ft (0.6 m) diameter. The bark is thick and relatively smooth with rough wart-like processes.

General Wood Characteristics: The sapwood of holly is white and the heartwood is an ivory white with a bluish cast or streaks. The wood has no characteristic odor or taste. It is heavy, hard, close-grained and tough, with a low luster like ivory.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.50	57	913
12%	0.57	40	641
Ovendry	0.61	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.90×10^6 lbf/in^2	6.205 GPa	1.11×10^6 lbf/in^2	7.653 GPa
MOR	6.50×10^3 lbf/in^2	44.818 MPa	10.3×10^3 lbf/in^2	71.019 MPa
$C_{\parallel}$	2.64×10^3 lbf/in^2	18.203 MPa	5.54×10^3 lbf/in^2	38.198 MPa
$C_{\perp}$	0.61×10^3 lbf/in^2	4.206 MPa	1.13×10^3 lbf/in^2	7.791 MPa
WML	10.8 in-lbf/in^3	74.466 kJ/m^3	10.7 in-lbf/in^3	73.777 kJ/m^3
Hardness	790 lbf	3,513.92 N	1,020 lbf	4,536.96 N
$Shear_{\parallel}$	1.13×10^3 lbf/in^2	7.791 MPa	1.71×10^3 lbf/in^2	11.790 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	9.9	7.9	3.3
Radial	4.8	3.8	1.6
Volumetric	16.9	13.5	5.6

[a]Holly generally discolors when seasoned slowly. It is best cut in winter and dried quickly. It may warp and cup during kiln drying.
[b]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-D4	T4-C3	NA	NA	NA

[a]References (6, 86).

Working Properties: Holly is difficult to work, but takes a high polish. It glues and screws well, but drilling should be done slowly. The wood takes a stain well and can be ebonized.

Durability: Holly is susceptible to fungal attack.

Preservation: No information available at this time.

Uses: Furniture (inlay), keys for musical instruments (ebonized), scientific instruments, fixtures, brush backs, carvings, scrollwork, engravings, handles, turnery and novelties.

Toxicity: No information available at this time.

Additional Reading: 29, 52, 55, 68, 74.

Juglans cinerea
Juglandaceae
Butternut

The walnut/butternut group (*Juglans* spp.) contains 15 species which grow in South America [6], Eurasia [4] and North America [5]. Of the butternuts, one species grows in the United States, American butternut (*J. cinerea*), and three in the Orient (*J. ailantifolia, J. cathayensis* and *J. mandshurica*). The word *juglans* is the classic Latin name of walnut, meaning nut of Jupiter.

Other Common Names: American white walnut, grey walnut, lemon walnut, oil-beannut, oilnut, walnut, white walnut.

Distribution: Butternut is native to the eastern United States from Tennessee and western North Carolina north to southern Ontario and Quebec. Its distribution is scattered, never growing in pure stands, at the edges of forests or in the open. It is found in association with cherry, basswood, oak, walnut, ash, maple, elm and hemlock.

The Tree: Butternut trees reach heights of 100 ft (30 m), with a 3 ft (1 m) diameter.

General Wood Characteristics: The narrow sapwood of butternut is white to light brown, while the heartwood is chestnut brown with red tinges. The growth rings are distinct, with a marked difference between the size of the earlywood and latewood pores. Butternut is similar to black walnut, but lighter in color and weight. It has no characteristic odor or taste.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.36	46	737
12%	0.38	27	433
Ovendry	0.40	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a,b]

Property	Green		Dry	
MOE	0.97×10^6 lbf/in^2	6.688 GPa	1.18×10^6 lbf/in^2	8.136 GPa
MOR	5.40×10^3 lbf/in^2	37.233 MPa	8.10×10^3 lbf/in^2	55.850 MPa
$C_{\parallel}$	2.42×10^3 lbf/in^2	16.686 MPa	5.11×10^3 lbf/in^2	35.233 MPa
$C_{\perp}$	0.22×10^3 lbf/in^2	1.517 MPa	0.46×10^3 lbf/in^2	3.172 MPa
WML	8.2 in-lbf/in^3	56.539 kJ/m^3	8.2 in-lbf/in^3	56.539 kJ/m^3
Hardness	390 lbf	1734.72 N	490 lbf	2179.52 N
Shear$_{\parallel}$	0.76×10^3 lbf/in^2	5.240 MPa	1.17×10^3 lbf/in^2	8.067 MPa

[a]The wood is lightweight, weak in bending, and weak in end compression. It is soft, but not stiff, and rates high in shock resistance.

[b]Reference (98).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.1	5.1	2.1
Radial	3.6	2.7	1.1
Volumetric	12.5	8.5	3.5

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-E4	T8-E3	NA	NA	NA

[a]References (6, 86).

Working Properties: Buttternut generally has a straight grain, works easily with tools, and takes a rich, lustrous finish.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, furniture, boxes, crates, mill work, veneer.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74, 85.

Juglans nigra
Juglandaceae
Black Walnut

The walnut/butternut group (*Juglans* spp.) contains 15 species which grow in South America [6], Eurasia [4] and North America [6]. The word *juglans* is the classic Latin name of walnut, meaning nut of Jupiter.

North American species of *Juglans*:

Juglans californica	California black walnut, California walnut, claro walnut, **southern California walnut**
Juglans cinerea[a,b]	**butternut**
Juglans hindsii	California black walnut, hinds black walnut, **northern California walnut**
Juglans major	Arizona black walnut, **Arizona walnut**, little walnut, Mexican walnut, western walnut
Juglans microcarpa	Arizona walnut, dwarf walnut, **little walnut**, Mexican walnut, river walnut, Texas black walnut, Texas walnut, western walnut
Juglans nigra[a]	American walnut, American black walnut, **black walnut,** burbank walnut, eastern black walnut, eastern walnut, gunwood, Virginia walnut

[a]commercial species
[b]information available on a separate fact sheet

Distribution: Black walnut is native to the eastern United States, from southern Minnesota east to Pennsylvania, New Jersey, New York; south to South Carolina, Georgia, Florida, Alabama; west to Texas; and north through Oklahoma, Kansas, Nebraska, and South Dakota.

The Tree: Black walnut trees reach heights of 120 ft (37 m), with a diameter of over 3 ft (1 m).

General Wood Characteristics: The sapwood of black walnut is nearly white, while the heartwood is light brown to dark, chocolate brown, often with a purplish cast and darker streaks. The wood is heavy, hard, and stiff and has high shock resistance.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.51	58	929
12%	0.55	38	609
Ovendry	0.56	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.42×10^6 lbf/in^2	9.791 GPa	1.68×10^6 lbf/in^2	11.584 GPa
MOR	9.50×10^3 lbf/in^2	65.503 MPa	14.6×10^3 lbf/in^2	100.667 MPa
$C_{\parallel}$	4.30×10^3 lbf/in^2	29.649 MPa	7.58×10^3 lbf/in^2	52.264 MPa
$C_{\perp}$	0.49×10^3 lbf/in^2	3.379 MPa	1.01×10^3 lbf/in^2	6.964 MPa
WML	14.6 in-lbf/in^3	100.667 kJ/m^3	10.7 in-lbf/in^3	73.777 kJ/m^3
Hardness	900 lbf	4,003.20 N	1,010 lbf	4,492.48 N
$Shear_{\parallel}$	1.22×10^3 lbf/in^2	8.412 MPa	1.37×10^3 lbf/in^2	9.446 MPa

[a]Reference (98).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.8	6.2	2.6
Radial	5.5	4.4	1.8
Volumetric	12.8	10.2	4.3

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-D4	T3-D3	T3-D3	T3-C2	NA

[a]References (6, 86).

Working Properties: Black walnut is straight grained and easily worked with hand tools and by machine. It finishes beautifully and holds paint and stain exceptionally well. It also glues and polishes well.

Durability: Rated as very resistant to heartwood decay—one of the most durable woods, even under conditions favorable to decay.

Preservation: No information available at this time.

Uses: Furniture, fixtures, cabinets, gunstocks, novelties, interior paneling, veneer.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74, 76.

Kalmia latifolia
Ericaceae
Mountain Laurel

The genus *Kalmia* contains about seven species native to North America. Mountain laurel is the only species that attains tree size; the other six are shrubs. The genus *Kalmia* was dedicated by Linnaeus to his student Peter Kalm (1716–1779), a Swedish botanist who traveled and collected in Canada and the eastern United States.

Other Common Names: American briar, American laurel, big leaved ivy, burl laurel, calico bush, calico-flower, calico-tree, ivy, ivy bush, ivy leaf laurel, ivywood, kalmia, lambkill, laurel, laurelwood, mountain, mountain ivy, pale laurel, poison ivy, poison laurel, root laurel, sheep laurel, small laurel, spoonwood, wicky.

Distribution: Southeast Maine west to New York, Ohio and southern Indiana south to western Tennessee, eastern Mississippi and southeast Louisiana east to northern Florida and Georgia.

The Tree: Mountain laurel is a large shrub, occasionally reaching 40 ft (12 m) tall and 2 ft (0.6 m) in diameter in the eastern United States. The leaves, buds, flowers and fruits are poisonous to humans and cattle, but not to indigenous wildlife such as deer. Mountain laurel has leathery, evergreen leaves and very showy flower clusters, making it a favorite plant for ornamental purposes. It prefers acid soils from lowlands to 4,000 ft (1,219 m) elevations. It grows in association with oaks, tulip poplar, beech, sugar maple, white pine and sourwood.

General Wood Characteristics: The wood of mountain laurel is heavy, hard, and strong but rather brittle, with a close, straight grain. It has a light yellow sapwood and a yellow-brown heartwood, spotted with red.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.62	62	993
12%	0.68	48	769
Ovendry	0.74	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.92×10^6 lbf/in^2	6.343 GPa	1.20×10^6 lbf/in^2	8.274 GPa
MOR	8.40×10^3 lbf/in^2	57.918 MPa	11.1×10^3 lbf/in^2	76.535 MPa
$C_{\parallel}$	4.31×10^3 lbf/in^2	29.717 MPa	5.92×10^3 lbf/in^2	40.818 MPa
$C_{\perp}$	1.11×10^3 lbf/in^2	7.653 MPa	1.82×10^3 lbf/in^2	12.549 MPa
WML	12.5 in-lbf/in^3	86.188 kJ/m^3	10.3 in-lbf/in^3	71.019 kJ/m^3
Hardness	1,300 lbf	5,782.40 N	1,790 lbf	7,961.92 N
$Shear_{\parallel}$	1.67×10^3 lbf/in^2	11.514 MPa	NA	NA

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	8.0	NA	NA
Radial	5.6	NA	NA
Volumetric	14.4	NA	NA

[a]Mountain laurel will dry well if debarked and split.
[b]Reference (59).

Working Properties: Works well with carving tools or lathe.

Durability: No information available at this time.

Preservation: No information available at this time.

Uses: Substitute wood for briar pipes, small objects and novelties, tool handles, woodenware, fuel.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Liquidambar styraciflua
Hamamelidaceae
Sweetgum

The genus *Liquidambar* contains three to four species that grow in North and Central America [1] and Asia [2]. All species look alike microscopically. The word *liquidambar* is from the Spanish common name in Mexico (indirectly from Latin liquid and amber), in reference to the fragrant resin.

Other Common Names: alligator-tree, alligatorwood, ambarwood, american mahogany, blisted, delta redgum, figured gum, gum, gumtree, gumwood, hazel, hazel pine, hazelwood, incense-tree, liquidambar, mulberry, opossum-tree, plain redgum, quartered redgum, redgum, sapgum, sapwood hazel pine, satin walnut, satinwood, splint sapgum, splinted sapgum, starleaf gum, sycamore gum, whitegum.

Distribution: Sweetgum occurs naturally in the southeastern United States. Its range extends from New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, Indiana, and Illinois, south to Missouri, Arkansas, Oklahoma and Texas, and east to the Atlantic coast.

The Tree: Sweetgum trees grow to heights of 100 ft (30 m), with diameters of 3 ft (1 m).

General Wood Characteristics: The sapwood of sweetgum is white to light pink, while the heartwood is reddish brown to brown. The grain is interlocked, producing an attractive grain, but causing problems in seasoning. The wood is moderately hard, stiff, and heavy.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.46	50	801
12%	0.52	34	545
Ovendry	0.53	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.20×10^6 lbf/in^2	8.274 GPa	1.64×10^6 lbf/in^2	11.308 GPa
MOR	7.10×10^3 lbf/in^2	48.955 MPa	12.5×10^3 lbf/in^2	86.188 MPa
$C_{\parallel}$	3.04×10^3 lbf/in^2	20.961 MPa	6.32×10^3 lbf/in^2	43.576 MPa
$C_{\perp}$	0.37×10^3 lbf/in^2	2.551 MPa	0.62×10^3 lbf/in^2	4.275 MPa
WML	10.1 in-lbf/in^3	69.640 kJ/m^3	11.9 in-lbf/in^3	82.051 kJ/m^3
Hardness	600 lbf	2,668.80 N	850 lbf	3,780.80 N
Shear$_{\parallel}$	0.99×10^3 lbf/in^2	6.826 MPa	1.60×10^3 lbf/in^2	11.032 MPa

[a]Reference (98).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	10.2	7.9	3.3
Radial	5.3	4.2	1.7
Volumetric	15.8	12.0	5.0

[a]Sweetgum shrinks considerably in drying and does not stay in place well during use. It has a tendency to cup or check when exposed to the weather.
[b]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-C4	T5-C3	T5-C2	T5-B2	NA
1-in. squares	T12-F6				
2-in. squares	T11-D5				

[a]References (6, 86).

Working Properties: Sweetgum is above average in turning, boring, and steam bending. It is intermediate in planing, shaping, bending, splitting and holding nails and screws. It requires pretreatment before gluing.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber (boxes, crates, dimension stock, furniture parts and fixtures), veneer, plywood, slack cooperage, railroad ties, fuel and pulpwood.

Toxicity: No information available at this time.

Additional Reading: 29, 46, 55, 68, 74.

Liriodendron tulipifera Magnoliaceae Yellow Poplar

Yellow poplar (*Liriodendron* spp.) contains two species, the yellow poplar of North America (*L. tulipifera*) and a Chinese species (*L. chinensis*). Both species look alike microscopically. The name *liriodendron* is derived from the Greek lily and tree, because of the showy "lilylike" flowers (the flowers look more like tulips).

Other Common Names: American whitewood, basswood, blue poplar, canary poplar, canary wood, canoewood, cucumbertree, hickory poplar, liriodendron, old wives shirt, poplar, popple, saddle-tree, sap poplar, secoya, southern yellow poplar, tulipia, tulip poplar, tulip-tree, tulipwood, white poplar, whitewood.

Distribution: Most of the eastern United States, from Massachusetts west to Illinois, Arkansas and Louisiana, south to the Gulf Coast and central Florida.

The Tree: Yellow poplar trees reach heights of 160 ft (49 m) with a diameter of 8 ft (2.4 m). It is probably the tallest hardwood tree in the eastern United States.

General Wood Characteristics: Yellow poplar sapwood is white, sometimes with stripes; the heartwood is usually tan, but can range from greenish brown to dark green, purple, black, blue and yellow. The wood is straight grained, uniform in texture and moderate to light weight. Among commercially important hardwoods in the United States, yellow poplar ranks in the lower third of the range of the following properties: specific gravity, bending strength, toughness, impact resistance, work to maximum load, crushing strength, fiber stress at proportional limit, shear strength, tensile strength and side hardness.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.40	38	609
12%	0.42	28	449
Ovendry	0.43	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.22×10^6 lbf/in^2	8.412 GPa	1.58×10^6 lbf/in^2	10.894 GPa
MOR	6.00×10^3 lbf/in^2	41.370 MPa	10.1×10^3 lbf/in^2	69.640 MPa
$C_{\parallel}$	2.66×10^3 lbf/in^2	18.341 MPa	5.54×10^3 lbf/in^2	38.198 MPa
$C_{\perp}$	0.27×10^3 lbf/in^2	1.862 MPa	0.50×10^3 lbf/in^2	3.448 MPa
WML	7.5 in-lbf/in^3	51.713 kJ/m^3	8.8 in-lbf/in^3	60.676 kJ/m^3
Hardness	440 lbf	1957.12 N	540 lbf	2401.92 N
$Shear_{\parallel}$	0.79×10^3 lbf/in^2	5.447 MPa	1.19×10^3 lbf/in^2	8.205 MPa

[a]Reference (98).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	8.2	5.7	2.4
Radial	4.6	3.2	1.3
Volumetric	12.7	9.8	4.1

[a]Yellow poplar wood is intermediate in its tendency to warp, with initial shrinkage being large. It stays in place well after drying. It dries quickly, with minimal loss of quality in all conditions.
[b]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T11-D4	T10-D3	T9-C3	T7-C2	T5-C2

[a]References (6, 86).

Working Properties: Yellow poplar has the reputation of being one of the easiest of all hardwoods to work with hand and machine tools. It works well in planing, turning, gluing and boring. It is average in mortising and nail- and screw-holding abilities, but poor in shaping and sanding. It holds stain and paint well.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, veneer, pulpwood, furniture, plywood, interior finish, dimension stock, gunstocks, musical instruments, toys, novelties, hatblocks, sporting goods, pallets, shipping crates, slack cooperage, particle board.

Toxicity: It may cause allergic reactions or dermatitis (40, 64, 105).

Additional Reading: 29, 55, 68, 74, 100.

Lithocarpus densiflorus Fagaceae Tanoak

Tanoak is a genus with about 100 species native to North America [1] and Asia/Indomalaysia [100]. It is believed to be an evolutionary link between the oaks (*Quercus* spp.) and chestnuts (*Castanea* spp.). The name *lithocarpus* is derived from the Greek, stone and fruit, in allusion to the hard acorns. *Cyclobalanops* spp., *Quercus densiflora and Pasania densiflora* are old scientific names.

Other Common Names: California chestnut oak, chestnut oak, live oak, peach oak, tanbark oak.

Distribution: Southwestern Oregon south to southern California, on the coast and in the Sierra Nevada.

The Tree: The flowers of tanoak resemble chestnut flowers, while the fruits look more like those of oaks (acorns). Tanoak grows mostly in association with redwood, Douglas-fir and California live oak. In close stands the trunks are long and rarely straight, while in the open they are short and thick. The bark is pale brown tinged with red, and can be gray in places. It can be smooth, or broken into wide, square plates by narrow seams. Tanoak is a slow-growing species, resistant to insects, but susceptible to fire injury. The flowers are produced in upright spikes or catkins, with the male flowers on the upper three-fourths of the flower spike and the female flowers (one-several) at the base. The fruits are acorns with fringed cups and thin scales. Tanoak requires moist climates and grows in association with coastal redwood, Port Orford cedar, Douglas-fir, bigleaf maple and box elder.

General Wood Characteristics: The sapwood and heartwood are light to dark red brown. The wood of tanoak is diffuse porous with wide rays.

Weight[a]

Moisture content	Specific gravity	Weight lb/ft^3	Weight kg/m^3
Green	0.58	65	1,041
12%	NA	41	657
Ovendry	0.71	NA	NA

[a]References: specific gravity, green, (98); specific gravity, ovendry, (90); weight, (90).

Mechanical properties[a]

Property	Green[a]		Dry[b]	
MOE	1.55×10^6 lbf/in^2	10.687 GPa	2.16×10^6 lbf/in^2	14.893 GPa
MOR	10.5×10^3 lbf/in^2	72.398 MPa	16.6×10^3 lbf/in^2	114.457 MPa
$C_{\parallel}$	4.65×10^3 lbf/in^2	32.062 MPa	9.20×10^3 lbf/in^2	63.434 MPa
$C_{\perp}$	3.64×10^3 lbf/in^2	25.098 MPa	1.66×10^3 lbf/in^2	11.446 MPa
WML	13.4 in-lbf/in^3	92.393 kJ/m^3	NA	NA kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	1.41×10^3 lbf/in^2	9.722 MPa	1.96×10^3 lbf/in^2	13.514 MPa

[a]Reference (98) except $C_{\perp}$ and $Shear_{\parallel}$ (69).
[b]Reference (69).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	11.7	NA	8.0
Radial	4.9	NA	2.7
Volumetric	17.3	NA	NA

[a]References: 0% MC , (98); 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T3-B1	T3-B1	NA	NA	NA

[a]References (6, 86).

Working Properties: No information available at this time.

Durability: No information available at this time.

Preservation: No information available at this time.

Uses: Flooring, crossties, fuel wood, mine timbers, baseball bats, veneers, pulpwood, furniture. Historically, bark was used for tannin extraction.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 67, 68, 74.

Maclura pomifera
Moraceae
Osage Orange

The genus *Maclura* contains about 12 species native to North America [1], with the rest in tropical America and Africa. The genus *Maclura* is dedicated to William Maclure (1763–1840), an American geologist, while the species epithet *pomifera* means bearing pomes or apples, in allusion to the large, spherical fruits.

Other Common Names: bodare us, bodark, bodeck, bodock, bois d'arc, bowwood, geelhout, hedge, hedge apple, hedge-plant, horse apple, maclura, mock orange, naranjo chino, osage, osage apple-tree, rootwood, wild orange, yellow-wood.

Distribution: Native to Arkansas, Oklahoma and Texas, but since escaped and naturalized throughout the eastern and northwestern United States.

The Tree: Osage orange is a medium-size tree with thorns, which grows in bottom lands. It attains a height of 60 ft (18 m) and a diameter of 3 ft (1 m). The bark has an orange cast and was used in making khaki dye during World War I. Osage orange produces large spherical fruits the size of large grapefruits.

General Wood Characteristics: The sapwood of osage orange is narrow and light yellow, while the heartwood is golden to bright orange, which darkens upon exposure. The heartwood can also contain red streaks. The wood has no characteristic odor or taste. It is very hard, heavy, tough, resilient and takes a high luster. It is ring porous and commonly confused with black locust (*Robinia pseudoacacia*).

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.76	62	993
12%	0.85	53	849
Ovendry	0.84	NA	NA

[a]References: specific gravity, green and ovendry (59); specific gravity, 12%, (90); weight, (90).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.33×10^6 lbf/in^2	9.170 GPa	NA	NA
MOR	13.7×10^3 lbf/in^2	94.462 MPa	NA	NA
$C_{\parallel}$	5.81×10^3 lbf/in^2	40.060 MPa	NA	NA
$C_{\perp}$	2.26×10^3 lbf/in^2	15.583 MPa	NA	NA
WML	37.9×10^3 lbf/in^3	261.321 kJ/m^3	NA	NA
Hardness	2,040 lbf	9073.92 N	NA	NA
$Shear_{\parallel}$	NA	NA	NA	NA

[a]Reference (59).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	NA	NA	NA
Radial	NA	NA	NA
Volumetric	9.2	7.4	3.1

[a]The wood of osage orange seasons well and thereafter maintains dimensional stability well.

[b]Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-A2	T3-A1	NA	NA	NA

[a]References (6, 86).

Working Properties: Osage orange is difficult to work because of its hardness. It holds glue and screws well, but it is difficult to nail.

Durability: Rated as exceptionally resistant to heartwood decay; one of the most durable woods in North America.

Preservation: No information available at this time.

Uses: Fuel wood, fence posts, game calls, smoking pipes, artificial limbs, crutches, insulator pins, wheel rims and hubs of farm wagons, railroad ties, treenails, machinery parts, archery bows (Native Americans), dye from roots, windrows and hedges.

Toxicity: The sap can cause dermatitis (105).

Additional Reading: 11, 29, 55, 68, 74.

Magnolia spp.
Magnoliaceae
Magnolia

Magnolia (*Magnolia* spp.) consists of about 80 species from Asia [50], West Indies [8], Central/South America [10] and North America [8]. Some species separations are possible based on microanatomy. The genus *Magnolia* is dedicated to Pierre Magnol (1638–1715), professor of botany and medicine and director of the botanic garden at Montpellier, France.

*Magnolia acuminata**	black lin, black linn, blue magnolia, cowcumber, cucumber, cucumber magnolia, **cucumbertree**, cucumberwood, elkwood, magnolia, mountain magnolia, pointed-leaved magnolia, yellow cucumbertree, yellow-flower magnolia, yellow lin, yellow linn, yellow poplar, wahoo, wauhoo
Magnolia ashei	**ashe magnolia**, cucumbertree, sandhill magnolia
Magnolia fraseri	cucumber, cucumbertree, earleaf cucumber, earleaf cucumbertree, earleaf umbrella-tree, **Fraser magnolia**, Fraser umbrella, Indian bitters, Indian physic, long-leaf cucumbertree, magnolia, mountain-cucumber, mountain magnolia, mountain-oread, North Carolina bay-tree, umbrella-tree, water-lilly-tree, whahoo
*Magnolia grandiflora**	bat-tree, bull-bay, big-laurel, black lin, cucumberwood, evergreen magnolia, great laurel, large-flower magnolia, laurel, laurel bay, laurel-leaved magnolia, magnolia, mountain magnolia, **southern magnolia**, sweet magnolia
Magnolia macrophylla	big-bloom, **bigleaf magnolia**, cowcumber, cucumber, cucumbertree, elkbark, great-leaved magnolia, large-leaf cucumbertree, large-leaf magnolia, longleaf cucumber, long-leaved magnolia, mountain magnolia, pyramid magnolia, royal-oread, silverleaf, silverleaf magnolia, southern cucumbertree, umbrella-tree, large-leaved umbrella-tree, white cucumbertree
Magnolia pyramidata	mountain magnolia, mountain-oread, **pyramid magnolia**, southern cucumbertree, wood-oread
Magnolia tripetala	cucumber, cucumbertree, elk-browse, elkwood, Japanese magnolia, magnolia, **umbrella magnolia**, umbrella-tree, wahoo
*Magnolia virginiana**	bat-tree, bay, bay-tree, beaver-tree, big laurel, black lin, bullbay, cucumberwood, Indian-bark, laurel magnolia, magnolia, mountain magnolia, small magnolia, southern sweetbay, swampbay, swamp-laurel, swamp magnolia, swamp sassafras, **sweetbay**, sweet magnolia, sweetbay magnolia, Virginia magnolia, white-bay, white-laurel

* commercial species

Distribution: North America.

The Tree: Magnolia trees can reach heights of 80 ft (24 m), with a diameter of 3 ft (1 m).

General Wood Characteristics: The sapwood of magnolia is creamy white, while the heartwood is light to dark brown, often with greenish to purple-black streaks or patches. The wood is even-textured and moderately heavy, fairly hard and straight grained. It resembles yellow poplar (*Liriodendron* spp.). Magnolia is moderately stiff, high in shock resistance, and low in shrinkage. It has no characteristic odor or taste.

Weight

Species	MC	SG[a]	Weight[b] lb/ft^3	Weight[b] kg/m^3
Magnolia acuminata	Green	0.44	49	785
(cucumbertree)	12%	0.48	33	529
	Ovendry	0.52	NA	NA
Magnolia fraseri	Green	0.40[b]	47	753
(Fraser magnolia)	12%	0.44[b]	31	497
	Ovendry	0.48	NA	NA
Magnolia grandiflora	Green[b]	0.46	59	945
(southern magnolia)	12%[b]	0.50	35	561
	Ovendry	0.53	NA	NA

[a]Data for green and 12% conditions taken from reference (98); ovendry data from reference (59).
[b]Data from reference (59).

Mechanical properties

Property	Green		Dry	
Magnolia acuminata (cucumbertree)[a]				
MOE	1.56×10^6 lbf/in^2	10.756 GPa	1.82×10^6 lbf/in^2	12.549 GPa
MOR	7.40×10^3 lbf/in^2	51.023 MPa	12.3×10^3 lbf/in^2	84.809 MPa
$C_{\parallel}$	3.14×10^3 lbf/in^2	21.650 MPa	6.31×10^3 lbf/in^2	43.507 MPa
$C_{\perp}$	0.33×10^3 lbf/in^2	2.275 MPa	0.57×10^3 lbf/in^2	3.930 MPa
WML	10.0 in-lbf/in^3	68.950 kJ/m^3	12.2 in-lbf/in^3	84.119 kJ/m^3
Hardness	520 lbf	2312.96 N	700 lbf	3113.60 N
$Shear_{\parallel}$	0.99×10^3 lbf/in^2	6.826 MPa	1.34×10^3 lbf/in^2	9.239 MPa
Magnolia grandiflora (Southern magnolia)[a]				
MOE	1.11×10^6 lbf/in^2	7.653 GPa	1.40×10^6 lbf/in^2	9.653 GPa
MOR	6.80×10^3 lbf/in^2	46.886 MPa	11.2×10^3 lbf/in^2	77.224 MPa
$C_{\parallel}$	2.70×10^3 lbf/in^2	18.617 MPa	5.46×10^3 lbf/in^2	37.647 MPa
$C_{\perp}$	0.46×10^3 lbf/in^2	3.172 MPa	0.86×10^3 lbf/in^2	5.930 MPa
WML	15.4 in-lbf/in^3	106.183 kJ/m^3	12.8 in-lbf/in^3	88.256 kJ/m^3
Hardness	740 lbf	3,291.52 N	1,020 lbf	4,536.96 N
$Shear_{\parallel}$	1.04×10^3 lbf/in^2	7.171 MPa	1.53×10^3 lbf/in^2	10.549 MPa
Magnolia virginiana (sweetbay)[b]				
MOE	NA	NA	1.64×10^6 lbf/in^2	11.308 GPa
MOR	NA	NA	10.9×10^3 lbf/in^2	75.293 MPa
$C_{\parallel}$	NA	NA	5.68×10^3 lbf/in^2	39.164 MPa
$C_{\perp}$	NA	NA	0.56×10^3 lbf/in^2	3.861 MPa
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	NA	NA	1.68×10^3 lbf/in^2	11.583 MPa

[a]Reference (98).
[b]Reference (90).

Drying and shrinkage

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC[a]	6% MC[b]	20% MC[b]
Tangential			
Magnolia acuminata (cucumbertree)	8.8	7.0	2.9
Magnolia grandiflora (southern magnolia)	6.6	5.3	2.2
Magnolia virginiana (sweetbay)	8.3	NA	NA
Radial			
Magnolia acuminata (cucumbertree)	5.2	4.2	1.7
Magnolia grandiflora (southern magnolia)	5.4	4.3	1.8
Magnolia virginiana (sweetbay)	4.7	NA	NA
Volumetric			
Magnolia acuminata (cucumbertree)	13.6	10.9	4.5
Magnolia grandiflora (southern magnolia)	12.3	9.8	4.1
Magnolia virginiana (sweetbay)	12.9	NA	NA

[a]Reference (98).
[b]Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-D4	T8-D3	NA	NA	NA

[a]References (6, 86) for Magnolia grandiflora (southern magnolia) and Magnolia virginiana (sweetbay).

Working Properties: Magnolia has average nail-holding ability, is readily worked, and glues, paints, and finishes well.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, veneer, furniture (upholstery frames), boxes, interior trim, cabinetry, doors, slats for venetian blinds, plywood.

Toxicity: The bark and leaves can be irritating (64), while the wood has been reported to cause bronchial asthma and rhinitis (40).

Additional Reading: 29, 55, 57, 68, 74.

Magnolia virginiana
Magnoliaceae
Sweetbay

The genus *Magnolia* contains about 80 species native to North America [8], West Indies [8], and Asia [50]. The genus *Magnolia* is dedicated to Pierre Magnol (1638–1715), professor of botany and medicine and director of the botanic garden at Montpellier, France. The name *virginiana* means "of Virginia."

Other Common Names: arbre du castor, bat-tree, bay, bay-tree, beaver tree, big laurel, black lin, bullbay, cucumberwood, evergreen magnolia, Indian bark, laurel magnolia, magnolia, magnolia de virginie, magnolia virginiana, magnolier bleu, magnolier des marais, mountain magnolia, quinquina virginie, small magnolia, Southern magnolia, southern sassafras, southern sweetbay, swampbay, swamp laurel, swamp magnolia, swamp sassafras, sweet bay, sweetbay magnolia, sweet magnolia, Virginia magnolia, virginische magnolia, whitebay, white laurel.

Distribution: North America, along the coastal plain from Long Island, New Jersey, and Pennsylvania, south to Florida, west to Texas, and north to Arkansas and Tennessee. Also occurs in eastern Massachusetts.

The Tree: Sweetbay grows in wet, sandy soil along streams, bottom lands and swamps. It is deciduous and shrubby in the northern parts of its range, but evergreen in the south. Sweetbay is slow-growing and flowers in spring. It grows in association with redbay, maples, holly and loblolly bay. It reaches heights of 80 ft (24 m), with a diameter of 1.5 ft (0.5 m). The gray to gray-brown bark is thin, smooth, and irregularly furrowed as a result of plates. The bark is also aromatic.

General Wood Characteristics: The wood is soft and pale brown, with a brown, aromatic heartwood, and is straight grained.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.42	NA	NA
12%	NA	29	465
Ovendry	0.48	NA	NA

[a]Reference (90).

Mechanical properties[a]

Property	Green		Dry	
MOE	NA	NA	1.64×10^6 lbf/in^2	11.308 GPa
MOR	NA	NA	10.92×10^3 lbf/in^2	75.293 MPa
$C_{\parallel}$	NA	NA	5.68×10^3 lbf/in^2	39.164 MPa
$C_{\perp}$	NA	NA	0.56×10^3 lbf/in^2	3.861 MPa
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	NA	NA	1.68×10^3 lbf/in^2	11.583 MPa

[a]Reference (90).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.3	NA	NA
Radial	4.7	NA	NA
Volumetric	12.9	NA	NA

[a]Reference (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-D4	T8-D3	NA	NA	NA

[a]References (6, 86).

Working Properties: It is easily worked and finishes well.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, veneer, furniture, boxes and containers.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Malus sylvestris
Rosaceae
Apple

Apple (*Malus* spp.) consists of 30+ species that occur on both sides of the Atlantic in northern temperate zones. Its wood can be confused with pear (*Pyrus* spp.) and other "fruitwoods" in the rose family (Rosaceae). *Malus* is the classical Latin name for apple. Apple hybridizes with North American crab apples.

Malus angustifolia	American crab apple, buncombe crab apple, crab apple, crabtree, narrowleaf crab, narrowleaf crab apple, southern crab, **southern crab apple**, wild crab, wild crab apple
Malus coronaria	Alabama crab, Allegheny crab, American crab, American crab apple, Biltmore crab apple, Buncombe crab, crab, crab apple, Dawson crab, Dunbar crab, fragrant crab, garland tree, lanceleaf crab apple, Missouri crab, **sweet crab apple**, sweet-scented crab, sweet wild crab, wild crab, wild sweet crab
Malus fusca	crab apple, Oregon crab, **Oregon crab apple**, Pacific crab apple, western crab apple, wild crab apple
Malus ioensis	Bechel crab, crab apple, Iowa crab, Iowa crab apple, prairie crab, **prairie crab apple**, wild crab, wild crab apple
Malus sylvestris	**apple**, common apple, wild apple.

Distribution: Apple is a cultivated fruit tree, persistent, escaped and naturalized locally across southern Canada, in eastern continental United States, and from Washington south to California. Native to Europe and west Asia. Apple grows wild in the southern part of Great Britain and Scandinavia and is found throughout Europe and southwestern Asia. It is planted in most temperate climates

The Tree:. The tree rarely reaches 30 ft (9 m), with a small crooked bole to 1 ft (0.3 m) in diameter.

General Wood Characteristics: Apple wood has a reddish gray heartwood and light reddish sapwood (12 to 30 rings of sapwood). When steamed, the wood becomes reddish brown to dark red-brown. The wood of wild apple trees is said to be better than that of cultivated varieties, which is also true of pear trees.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.61	55	881
12%	0.67	47	753
Ovendry	0.74	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.05×10^6 lbf/in^2	7.239 GPa	1.27×10^6 lbf/in^2	8.757 GPa
MOR	7.40×10^3 lbf/in^2	51.023 MPa	12.8×10^3 lbf/in^2	88.256 MPa
$C_{\parallel}$	3.00×10^3 lbf/in^2	20.685 MPa	6.03×10^3 lbf/in^2	41.577 MPa
$C_{\perp}$	0.85×10^3 lbf/in^2	5.861 MPa	1.30×10^3 lbf/in^2	8.964 MPa
WML	15.7 in-lbf/in^3	108.252 kJ/m^3	23.0 in-lbf/in^3	158.585 kJ/m^3
Hardness	1,090 lbf	4,848.32 N	1,730 lbf	7,695.04 N
$Shear_{\parallel}$	1.64×10^3 lbf/in^2	11.307 MPa	1.74×10^3 lbf/in^2	11.997 MPa

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	10.1	NA	NA
Radial	5.6	NA	NA
Volumetric	17.6	NA	NA

[a]Reference (59).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-C3	T3-C2	NA	NA	NA

[a]References (6, 86).

Working Properties: The wood, which is very difficult to split, is hard and difficult to work, but is easily stained and polished. The timber converts cleanly but is moderately hard to saw. A clean finish is produced normally, but a reduction of the cutting angle to 20° is an advantage to planing.

Durability: When exposed, apple wood is nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Apple is used in furniture, turnings, mallet heads, skittle balls, umbrella handles, machines and toys, cog wheels, fruit presses, shuttles, wood screws, plane blocks, book-binder screws, boat knees, canes and walking sticks, drawing instruments, pianos and tool handles.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Nyssa spp. Nyssaceae Tupelo

Tupelo contains about five species native to the United States [3] and eastern Asia [2]. The word *nyssa* is the name of a water nymph, so-called because the type species, *Nyssa aquatica* L., water tupelo, grows in water.

Nyssa aquatica	bay-poplar, bastard cottonwood, big tupelo, bowl gum, chickasawatchie whitewood, cotton-gum, gray gum, gum cottonwood, hazel pine, hickory poplar, ladle gum, large tupelo, olivetree, pawpaw gum, rootwood tupelo, sap gum, sour gum, swamp gum, swamp poplar, swamp tupelo, trade tupelo, tupelo, tupelo gum, water gum, **water tupelo**, white gum, wild olivetree, yellow gum
Nyssa ogeche	bee tupelo, gopher plum, limetree, ogeechee lime, lone tupelo, ogeeche gum, ogeechee plum, **ogeechee tupelo**, sour tupelo, sour tupelo gum, tupelo, white tupelo, white tupelo gum, wild limetree
Nyssa sylvatica	blackgum, **black tupelo**, bowl gum, gum, pepperidge, plain black gum, quartered black gum, sour gum, stinkwood, swamp blackgum, swamp tupelo, tupelo, tupelo gum, yellow gum, yellow gumtree, wild pear-tree
Nyssa sylvatica var. *biflora*	**blackgum**, swamp blackgum, bouw gum, lowland black gum, lowland gum, sour gum, southern gum, swamp black gum, swamp tupelo, tupelo gum, water gum

Distribution: The eastern to southeastern United States.

The Tree: Tupelo trees reach heights of 100 ft (30 m), with a diameter of over 3 ft (1 m).

General Wood Characteristics: The sapwood of tupelo is a light gray-brown, while the heartwood is darker. The wood has interlocked grain, with a natural tendency to warp when dried, especially when flatsawn. It shows a characteristic figure when quartersawn. It has no characteristic odor or taste.

Weight

			Weight[b]	
Species	MC	SG[a]	lb/ft^3	kg/m^3
Nyssa aquatica	Green	0.46	NA	NA
(water tupelo)	12%	0.50	NA	NA
	Ovendry	NA	NA	NA
Nyssa sylvatica	Green	0.46	45	721
(black tupelo)	12%	0.50	35	561
	Ovendry	0.55	NA	NA

[a]Data for green and 12% conditions taken from reference (98); ovendry data from reference (59).
[b]Data from reference (59).

Mechanical properties[a]

Property	Green		Dry	
Nyssa aquatica (water tupelo)				
MOE	1.05×10^6 lbf/in^2	7.239 GPa	1.26×10^6 lbf/in^2	8.688 GPa
MOR	7.30×10^3 lbf/in^2	50.334 MPa	9.60×10^3 lbf/in^2	66.192 MPa
$C_{\parallel}$	3.37×10^3 lbf/in^2	23.236 MPa	5.92×10^3 lbf/in^2	40.818 MPa
$C_{\perp}$	0.48×10^3 lbf/in^2	3.310 MPa	0.87×10^3 lbf/in^2	5.999 MPa
WML	8.30 in-lbf/in^3	57.229 kJ/m^3	6.90 in-lbf/in^3	47.576 kJ/m^3
Hardness	710 lbf	3,158.08 N	880 lbf	3,914.24 N
Shear$_{\parallel}$	1.19×10^3 lbf/in^2	8.205 MPa	1.59×10^3 lbf/in^2	10.963 MPa
Nyssa sylvatica (black tupelo)				
MOE	1.03×10^6 lbf/in^2	7.102 GPa	1.20×10^6 lbf/in^2	8.274 GPa
MOR	7.00×10^3 lbf/in^2	48.265 MPa	9.60×10^3 lbf/in^2	66.192 MPa
$C_{\parallel}$	3.04×10^3 lbf/in^2	20.961 MPa	5.52×10^3 lbf/in^2	38.060 MPa
$C_{\perp}$	0.48×10^3 lbf/in^2	3.310 MPa	0.93×10^3 lbf/in^2	6.412 MPa
WML	8.00 in-lbf/in^3	55.160 kJ/m^3	6.20 in-lbf/in^3	42.749 kJ/m^3
Hardness	640 lbf	2,846.72 N	810 lbf	3,602.88 N
Shear$_{\parallel}$	1.10×10^3 lbf/in^2	7.584 MPa	1.34×10^3 lbf/in^2	9.239 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential			
Nyssa aquatica (water tupelo)	7.6	6.1	2.5
Nyssa sylvatica (black tupelo)	8.7	6.2	2.6
Radial			
Nyssa aquatica (water tupelo)	4.2	3.4	1.4
Nyssa sylvatica (black tupelo))	5.1	3.5	1.5
Volumetric			
Nyssa aquatica (water tupelo)	12.5	10.0	4.2
Nyssa sylvatica (black tupelo))	14.4	11.1	4.6

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Nyssa sylvatica (black tupelo)	T12-E5	T11-D3	T11-D3	T9-C2	T7-C2
Nyssa sylvatica var. biflora (blackgum)	T10-E3	T8-D2	NA	NA	NA

[a]References (6, 86).

Working Properties: It is moderately strong, but difficult to glue.

Durability: Tupelo lacks any natural durability.

Preservation: Tupelo is permeable.

Uses: Furniture, shipping containers, millwork, veneer, plywood, crossties, bridge ties and crossing planks.

Toxicity: No information available at this time.

Additional Reading: 21, 29, 55, 68, 74.

Ostrya spp.
Betulaceae
Hophornbeam

The genus *Ostrya* is composed of about eight species native to Mexico [1], Eurasia [1], eastern Asia/Japan [3], the United States, and Canada [3]. The name *ostrya* is Latinized from the Greek *ostrua*, a tree with very hard wood and most likely the European Hornbeam (*Carpinus betulus*).

Ostrya carpinifolia	**European hophornbeam**
Ostrya chisosensis	Big Bend hophornbeam, **Chisos hophornbeam**
Ostrya knowltonii	ironwood, **Knowlton hophornbeam**, western hophornbeam, wolf hophornbeam
*Ostrya virginiana**	American hophornbeam, deerwood, **eastern hophornbeam**, hardhack, hornbeam, ironwood, leverwood, Ostria

* commercially important

The following description is for eastern hophornbeam.

Distribution: North America, from Nova Scotia to Maine, Quebec, Ontario, Michigan, Minnesota, Manitoba and North Dakota, south to South Dakota, Nebraska, Kansas, Oklahoma, Texas and Mexico, east to Florida.

The Tree: Hophornbeams are small deciduous trees with scaly rough bark. The leaves are double-toothed and of alternate arrangement. The male flowers are borne on upright catkins, while the female flowers and fruits are grouped in clusters, resembling hops. Hophornbeams reach heights of 60 ft (18 m) and 2 ft (0.6 m) in diameter. The tree prefers upland soils in hilly country.

General Wood Characteristics: The sapwood of hophornbeam is wide and whitish, while the heartwood is light brown with red streaks. The wood has no characteristic odor or taste. It is very heavy and hard, and is sometimes confused with birch.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.63	60	961
12%	0.70	49	785
Ovendry	0.76	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.15×10^6 lbf/in^2	7.929 GPa	1.70×10^6 lbf/in^2	11.722 GPa
MOR	8.50×10^3 lbf/in^2	58.608 MPa	14.1×10^3 lbf/in^2	97.220 MPa
$C_{\parallel}$	3.57×10^3 lbf/in^2	24.615 MPa	7.76×10^3 lbf/in^{22}	53.505 MPa
$C_{\perp}$	0.73×10^3 lbf/in^2	5.033 MPa	1.50×10^3 lbf/in^2	10.343 MPa
WML	13.3 in-lbf/in^3	91.704 kJ/m^3	14.0 in-lbf/in^3	96.530 kJ/m^3
Hardness	1,170 lbf	5204.16 N	1,860 lbf	8273.28 N
$Shear_{\parallel}$	1.37×10^3 lbf/in^2	9.446 MPa	1.79×10^3 lbf/in^2	12.342 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	9.6	8.0	3.3
Radial	8.2	6.8	2.8
Volumetric	18.6	15.5	6.5

[a]Seasoning is difficult, as a result of the high density, which lengthens the drying period.

[b]References: 0% MC (59), 6% and 20% MC (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-B3	T3-B1	NA	NA	NA

[a]References (6, 86).

Working Properties: Very difficult to work.

Durability: Not available at this time.

Preservation: Not available at this time.

Uses: Furniture, axles, handles, levers, mallets, splitting wedges, canes, wooden wares, novelties, fuel wood.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Oxydendrum arboreum Ericaceae Sourwood

The genus *Oxydendrum* contains only one species native to North America. The word *oxydendrum* comes from the Greek, meaning sour and tree, from the acid taste of the leaves.

Other Common Names: arrowwood, elk tree, lily-of-the-valley tree, sorrel gum, sorrel tree, sour gum, titi, titi tree.

Distribution: From Pennsylvania to Ohio and Indiana, south to Kentucky, Tennessee, Mississippi and Louisiana, east to Florida, Georgia, Virginia and Maryland.

The Tree: Sourwood is a medium-size tree which grows at altitudes up to 3,500 ft (1,067 m) in well-drained gravelly soils. It grows scattered among oaks, sweetgum, hickories and pines. It produces white flowers which are bell-shaped like lily-of-the-valley flowers and capsule-shaped fruits. Sourwood attains a height of 60 ft (18 m) and a diameter of 2 ft (0.6 m).

General Wood Characteristics: The sapwood of sourwood is wide and yellowish brown to light pink-brown, while the heartwood is brown tinged with red, dulling with age. The wood has no characteristic odor or taste and is heavy and hard. It is diffuse porous.

Weight[a]

Moisture content	Specific gravity	Weight	
		lb/ft^3	kg/m^3
Green	0.50	53	849
12%	0.55	38	609
Ovendry	0.59	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.32×10^6 lbf/in^2	9.101 GPa	1.54×10^6 lbf/in^2	10.618 GPa
MOR	7.70×10^3 lbf/in^2	53.092 MPa	11.6×10^3 lbf/in^2	79.982 MPa
$C_{\parallel}$	3.25×10^3 lbf/in^2	22.409 MPa	6.19×10^3 lbf/in^2	42.680 MPa
$C_{\perp}$	0.68×10^3 lbf/in^2	4.689 MPa	1.08×10^3 lbf/in^2	7.447 MPa
WML	9.8 in-lbf/in^3	67.571 kJ/m^3	10.9 in-lbf/in^3	75.156 kJ/m^3
Hardness	730 lbf	3247.04 N	940 lbf	4181.12 N
$Shear_{\parallel}$	1.16×10^3 lbf/in^2	7.998 MPa	1.50×10^3 lbf/in^2	10.342 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.9	NA	NA
Radial	6.3	NA	NA
Volumetric	15.2	NA	NA

[a]Sourwood is difficult to season.
[b]Reference (59).

Working Properties: Sourwood is difficult to work.

Durability: No information available at this time.

Preservation: No information available at this time.

Uses: Paneling, bearings of machinery, sled runners, fuel wood and tool handles.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 68, 74.

Platanus occidentalis
Platanaceae
Sycamore

Sycamore (*Platanus* spp.), also known as buttonwood or plane, is composed of five to nine species which grow in Eurasia [2] and North America [8]. All species look alike microscopically. The common name "sycamore" is used in England to designate a species in the hard maple group (*Acer pseudoplatanus*), whereas plane or planetree is used to name the *Platanus* that grows there. The word *platanus* is the classical Latin and Greek name of *Platanus orientalis* L., oriental planetree, from the Greek word for broad, referring to the leaves.

Platanus occidentalis	American plane, American planetree, American sycamore, Buttonball, buttonball-tree, buttonwood, California button, California sycamore, cotonier, lacewood, oriental planetree, oriental sycamore, plane, planetree, quartered sycamore, **sycamore**, water beech
Platanus racemosa	aliso, buttonball, buttonball-tree, buttonwood, California planetree, **California sycamore**, planetree, sycamore, western sycamore
Platanus wrightii	alamo, Arizona planetree, **Arizona sycamore**, sycamore

Distribution: The eastern United States, from the Canadian border to the Gulf of Mexico and from the Atlantic coast west to the Great Plains.

The Tree: Sycamore trees reach heights of 120 ft (37 m), with a diameter of 3 ft (1 m).

General Wood Characteristics: The sapwood of sycamore is white to light yellow, while the heartwood is light to dark brown. The wood is classified as moderate in weight, hardness, stiffness, shock resistance, strength in bending, endwise compression and nail-holding ability. It has a close texture, glues well, and resists splitting due to interlocked grain. Sycamore is odorless, stain-free, and tasteless.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.46	52	833
12%	0.49	34	545
Ovendry	0.54	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.06×10^6 lbf/in^2	7.308 GPa	1.42×10^6 lbf/in^2	9.791 GPa
MOR	6.50×10^3 lbf/in^2	44.818 MPa	10.0×10^3 lbf/in^2	68.950 MPa
$C_{\parallel}$	2.92×10^3 lbf/in^2	20.133 MPa	5.38×10^3 lbf/in^2	37.095 MPa
$C_{\perp}$	0.36×10^3 lbf/in^2	2.482 MPa	0.70×10^3 lbf/in^2	4.827 MPa
WML	7.50 in-lbf/in^3	51.713 kJ/m^3	8.50 in-lbf/in^3	58.608 kJ/m^3
Hardness	610 lbf	2713.28 N	770 lbf	3424.96 N
$Shear_{\parallel}$	1.00×10^3 lbf/in^2	6.895 MPa	1.47×10^3 lbf/in^2	10.135 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.4	6.1	2.5
Radial	5.0	4.1	1.7
Volumetric	14.1	11.4	4.7

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-D2	T3-D1	T3-D1	T3-C1	T3-B1

[a]References (6, 86).

Working Properties: Sycamore has a close texture, glues well, and resists splitting because of its interlocked grain. It holds its shape well after steaming and machines well, but requires high speed cutter heads to prevent chipping.

Durability: Rated as nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Furniture (especially drawer sides), containers, millwork, flooring, veneer, pallets, boxes, plywood, pulp wood, paper, particleboard.

Toxicity: No information available at this time.

Additional Reading: 29, 55, 61, 68, 74.

Populus spp.
Salicaceae
Aspen
Populus grandidentata (Bigtooth Aspen)
Populus tremuloides (Quaking Aspen)

Aspen (the genus *Populus*) is composed of 35 species which contain the cottonwoods and poplars. Species in this group are native to Eurasia/north Africa [25], Central America [2] and North America [8]. All species look alike microscopically. The word *populus* is the classical Latin name for the poplar tree.

Other Common Names

Populus grandidentata	American aspen, aspen, **bigtooth aspen**, Canadian poplar, large poplar, largetooth aspen, large-toothed poplar, poplar, white poplar
Populus tremuloides	American aspen, American poplar, aspen, aspen poplar, golden aspen, golden trembling aspen, leaf aspen, mountain aspen, poplar, popple, quaking asp, **quaking aspen**, quiver-leaf, trembling aspen, trembling poplar, Vancouver aspen, white poplar

Distribution: Quaking aspen ranges from Alaska through Canada and into the northeastern and western United States. In North America, it occurs as far south as central Mexico at elevations where moisture is adequate and summers are sufficiently cool. The more restricted range of bigtooth aspen includes southern Canada and the northern United States, from the Atlantic coast west to the prairie.

The Tree: Aspens can reproduce sexually, yielding seeds, or asexually, producing suckers (clones) from their root system. In some cases, a stand could then be composed of only one individual, genetically, and could be many years old and cover 100 acres (40 hectares) or more. Most aspen stands are a mosaic of several clones.

Aspen can reach heights of 120 ft (48 m), with a diameter of 4 ft (1.6 m). Aspen trunks can be quite cylindrical, with little taper and few limbs for most of their length. They also can be very crooked or contorted, due to genetic variability. The bark of the two species can be quite variable in color and degree of furrowing. The leaves of aspen can vary from nearly round to ovate, with small to large teeth. Aspen trees are dioecious, that is, they occur as either male or female trees.

General Wood Characteristics: The sapwood of aspen is white, blending into the light brown heartwood. The wood of aspen has a uniform texture; is straight grained, light and soft; and has good dimensional stability and low to moderate shrinkage.

Weight

			Weight[b]	
Species	MC	SG[a]	lb/ft^3	kg/m^3
Populus	Green	0.36	43	689
grandidentata	12%	0.39	27	433
(bigtooth aspen)	Ovendry	0.41	NA	NA
Populus tremuloides	Green	0.35	43	689
(quaking aspen)	12%	0.38	26	417
	Ovendry	0.40	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59).
[b]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
Populus grandidentata (bigtooth aspen)[b]				
MOE	1.12×10^6 lbf/in^2	7.722 GPa	1.43×10^6 lbf/in^2	9.860 GPa
MOR	5.40×10^3 lbf/in^2	37.233 MPa	9.10×10^3 lbf/in^2	62.745 MPa
$C_{\parallel}$	2.50×10^3 lbf/in^2	17.238 MPa	5.30×10^3 lbf/in^2	36.544 MPa
$C_{\perp}$	0.21×10^3 lbf/in^2	1.448 MPa	0.45×10^3 lbf/in^2	3.103 MPa
WML	5.70 in-lbf/in^3	39.302 kJ/m^3	7.70 in-lbf/in^3	53.092 kJ/m^3
Hardness	370 lbf	1645.76 N	420 lbf	1868.16 N
$Shear_{\parallel}$	0.73×10^3 lbf/in^2	5.033 MPa	1.08×10^3 lbf/in^2	7.446 MPa
Populus tremuloides (quaking aspen)[c]				
MOE	0.86×10^6 lbf/in^2	5.929 GPa	1.18×10^6 lbf/in^2	8.136 GPa
MOR	5.10×10^3 lbf/in^2	35.165 MPa	8.40×10^3 lbf/in^2	57.918 MPa
$C_{\parallel}$	2.14×10^3 lbf/in^2	14.755 MPa	4.25×10^3 lbf/in^2	29.304 MPa
$C_{\perp}$	0.18×10^3 lbf/in^2	1.241 MPa	0.37×10^3 lbf/in^2	2.551 MPa
WML	6.40 in-lbf/in^3	44.128 kJ/m^3	7.60 in-lbf/in^3	52.402 kJ/m^3
Hardness	300 lbf	1334.40 N	350 lbf	1556.80 N
$Shear_{\parallel}$	0.66×10^3 lbf/in^2	4.551 MPa	0.85×10^3 lbf/in^2	5.861 MPa

[a]Relatively low strength, moderate stiffness and shock resistance.
[b]Reference (98) except for hardness (59).
[c]Reference (98).

Drying and shrinkage[a,b]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential			
Populus grandidentata (bigtooth aspen)	7.9	6.3	2.6
Populus tremuloides (quaking aspen)	6.7	5.4	2.2
Radial			
Populus grandidentata (bigtooth aspen)	3.3	2.6	1.1
Populus tremuloides (quaking aspen)	3.5	2.8	1.2
Volumetric			
Populus grandidentata (bigtooth aspen)	11.8	9.4	3.9
Populus tremuloides (quaking aspen)	11.5	9.2	3.8

[a]Water soaked material can develop “wetwood” from bacteria, causing a collapse in the zone between sapwood and heartwood during drying.
[b]References: 0% MC, (98); 6% and 20% MC (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Normal wood	T12-E7	T10-E6	T8-E5	T8-E5	T7-C4
Wet streak or collapse prone	Table 109	Table 110	NA	NA	NA

[a]References (6, 86).

Working Properties: Aspen does not split when nailed, machines easily with a slightly fuzzy surface, and turns, bores and sands well. It holds nails poorly to fairly well, but glues, prints, and holds paint well. It is easily pulped by all commercial processes.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Extremely resistant.

Uses: Pulp for books, newsprint and fine printing papers. Fiberboard, wafer board, sheathing, decking, decorative applications, boxes, crates, pallets, furniture parts, lumber core, veneer, match sticks, tongue depressors, paneling, excelsior.

Toxicity: Sawdust may cause dermatitis (40, 64, 105).

Additional Reading: 29, 55, 68, 70, 74.

Populus spp. Salicaceae Cottonwood

Cottonwood (the genus *Populus*) is composed of 35 species which contain the aspens and poplars. Species in this group are native to Eurasia/north Africa [25], Central America [2] and North America [8]. All species look alike microscopically. The word *populus* is the classical Latin name for the poplar tree.

Populus angustifolia	balsam, bitter cottonwood, black cottonwood, lanceleaf cottonwood, mountain cottonwood, **narrowleaf cottonwood**, narrow leaved poplar, Rydberg cottonwood, smoothbark cottonwood, willow cottonwood, willowleaf cottonwood
Populus balsamifera	balm, balm of Gilead, balm of Gilead poplar, balm cottonwood, balsam, balsam cottonwood, **balsam poplar**, bam, black balsam poplar, black cottonwood, black poplar, California poplar, Canadian balsam poplar, Canadian poplar, cottonwax, hackmatack, hairy balm of Gilead, heartleaf balsam poplar, northern black cottonwood, Ontario poplar, tacamahac, tacamahac poplar, toughbark poplar, western balsam poplar
*Populus deltoides**	aspen cottonwood, big cottonwood, Carolina poplar, cotton tree, **eastern cottonwood**, eastern poplar, fremont cottonwood, great plains cottonwood, Missourian poplar, necklace poplar, northern fremont cottonwood, palmer cottonwood, **plains cottonwood**, Rio Grande cottonwood, river cottonwood, river poplar, southern cottonwood, Tennessee poplar, Texas cottonwood, valley cottonwood, Vermont poplar, Virginia poplar, water poplar, western cottonwood, whitewood, wislizenus cottonwood, yellow cottonwood
Populus fremontii	Arizona cottonwood, **Fremont cottonwood**, Fremont poplar, meseta cottonwood, valley cottonwood, wislizenus cottonwood
Populus heterophylla	bigleaf cottonwood, black cottonwood, cotton gum, cotton tree, cottonwood, downy cottonwood, downy poplar, river cottonwood, **swamp cottonwood**, swamp poplar
*Populus trichocarpa**	balsam cottonwood, **black cottonwood**, California poplar, cottonwood, western balsam poplar

*commercial species

Distribution: Most of North America, with *Populus deltoides* in the eastern to midwest United States and *Populus trichocarpa* in the western United States.

The Tree: Cottonwood trees can reach heights of 190 ft (77 m), with a diameter of 6 ft (2.4 m).

General Wood Characteristics: The sapwood of cottonwood is white, while the heartwood is light brown to brown. The wood is weak in bending and compression, soft and low in shock resistance. It has a sour odor when wet, but no characteristic odor or taste when dry. Tension wood is frequently present, causing a fuzzy surface when cut.

Weight

			Weight[b]	
Species	MC	SG[a]	lb/ft^3	kg/m^3
Populus balsamifera	Green	0.31	40	641
(balsam poplar)	12%	0.34	23	368
	Ovendry	0.35	NA	NA
Populus deltoides	Green	0.37	49	785
(eastern	12%	0.40	28	449
cottonwood)	Ovendry	0.43	NA	NA
Populus trichocarpa	Green	0.31	46	737
(black cottonwood)	12%	0.35	24	384
	Ovendry	0.37	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59).
[b]Reference (59).

Mechanical properties

Property	Green		Dry	
Populus balsamifera (balsam poplar)[a]				
MOE	0.75×10^6 lbf/in^2	5.171 GPA	1.10×10^6 lbf/in^2	7.585 GPa
MOR	3.90×10^3 lbf/in^2	26.891 MPa	6.80×10^3 lbf/in^2	46.886 MPa
$C_{\|\|}$	1.69×10^3 lbf/in^2	11.653 MPa	4.02×10^3 lbf/in^2	27.718 MPa
$C_{\perp}$	0.14×10^3 lbf/in^2	0.965 MPa	0.30×10^3 lbf/in^2	2.069 MPa
WML	4.2 in-lbf/in^3	28.959 kJ/m^3	5.0 in-lbf/in^3	34.475 kJ/m^3
Hardness	230 lbf	1023.04 N	300 lbf	1334.40 N
$Shear_{\|\|}$	0.50×10^3 lbf/in^2	3.447 MPa	0.79×10^3 lbf/in^2	5.447 MPa
Populus deltoides (eastern cottonwood)[b]				
MOE	1.01×10^6 lbf/in^2	6.964 GPa	1.37×10^6 lbf/in^2	9.446 GPa
MOR	5.30×10^3 lbf/in^2	36.544 MPa	8.50×10^3 lbf/in^2	58.608 MPa
$C_{\|\|}$	2.28×10^3 lbf/in^2	15.721 MPa	4.91×10^3 lbf/in^2	33.854 MPa
$C_{\perp}$	0.20×10^3 lbf/in^2	1.379 MPa	0.38×10^3 lbf/in^2	2.620 MPa
WML	7.3 in-lbf/in^3	50.334 kJ/m^3	7.4 in-lbf/in^3	51.023 kJ/m^3
Hardness	340 lbf	1512.32 N	430 lbf	1912.64 N
$Shear_{\|\|}$	0.68×10^3 lbf/in^2	4.688 MPa	0.93×10^3 lbf/in^2	6.412 MPa
Populus trichocarpa (black cottonwood)[b]				
MOE	1.08×10^6 lbf/in^2	7.446 GPa	1.27×10^6 lbf/in^2	8.757 GPa
MOR	4.90×10^3 lbf/in^2	33.786 MPa	8.50×10^3 lbf/in^2	58.608 MPa
$C_{\|\|}$	2.20×10^3 lbf/in^2	15.169 MPa	4.50×10^3 lbf/in^2	31.028 MPa
$C_{\perp}$	0.16×10^3 lbf/in^2	1.103 MPa	0.30×10^3 lbf/in^2	2.069 MPa
WML	5.0 in-lbf/in^3	34.475 kJ/m^3	6.7 in-lbf/in^3	46.197 kJ/m^3
Hardness	250 lbf	1112.00 N	350 lbf	1556.80 N
$Shear_{\|\|}$	0.61×10^3 lbf/in^2	4.206 MPa	1.04×10^3 lbf/in^2	7.171 MPa

[a]Reference (98) except for hardness (59).
[b]Reference (98).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential			
Populus balsamifera (balsam poplar)	7.1	NA	NA
Populus deltoides (eastern cottonwood	9.2	7.4	3.1
Populus trichocarpa (black cottonwood)	8.6	6.9	2.9
Radial			
Populus balsamifera (balsam poplar)	3.0	2.9	1.2
Populus deltoides (eastern cottonwood	3.9	3.1	1.3
Populus trichocarpa (black cottonwood)	3.6	2.9	1.2
Volumetric			
Populus balsamifera (balsam poplar)	10.5	NA	NA
Populus deltoides (eastern cottonwood	13.9	11.3	4.7
Populus trichocarpa (black cottonwood)	12.4	9.9	4.1

[a]References: 0% MC, (98); 6% and 20% MC (90).

Kiln drying schedule[a,b]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Normal wood	T10-F5	T8-F4	T6-E3	T5-D2	NA
Wet streaks	T8-D5	T6-C4	T4-D3	T3-D2	NA

[a]Schedule for Populus balsamifera (balsam poplar), P. deltoides (eastern cottonwood), P. heterophylla (swamp cottonwood), P. sargentii (plains cottonwood) and P. trichocarpa (black cottonwood).

[b]References (6, 86).

Working Properties: Cottonwood glues well, has low nail-holding ability, does not split easily, and holds paint well.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, veneer, plywood short bolts, pulpwood, boxes, crates, food containers, interior furniture parts, agricultural implements, wooden ware, cutting boards.

Toxicity: Sawdust may cause dermatitis (40, 64, 105).

Additional Reading: 29, 49, 55, 68, 74.

Prosopis spp. Leguminosae Mesquite

Mesquite (the genus *Prosopis*) is represented by about 45 species of trees and shrubs native to North America, Central/South America and Africa/Asia. The word *prosopis* is an ancient Greek plant name, used by Dioscorides apparently for burdock. Only trees are included in the following list.

North American species

Prosopis glandulosa	algaroba, bilayati kikar, common mesquite, cuji, honey locust, **honey mesquite**, honey-pod, ibapiguazu, inesquirte, ironwood, mesquite, screwbean, Torrey mesquite, wawahi, western honey mesquite
Prosopis pubescens	mescrew, screwbean, **screwbean mesquite**, screw-pod mesquite, scrub mesquite, tornillo
Prosopis velutina	mesquite, **velvet mesquite**

South/Central American species

Prosopis abbreviata	algarrobillo espinoso
Prosopis alba	acacia de catarina, algaroba, algaroba blanca, algarobo, algarroba, algarrobe blanco, algarrobo, algarrobo bianco, **algarrobo blanco**, algarrobo impanta, algarrobo panta, aroma, barbasco, bate caixa, bayahonda, carbon, chachaca, cuji yaque, ibope-para, igope, igope-para, ironwood, jacaranda, manca-caballa, mesquite, nacasol, screwbean, tintatico, visna, vit algarroba, white algaroba
Prosopis affinis	algarobilla, algarobillo, algarrobilla, algarrobo nandubay, algarrobo negro, calden, espinillo, espinillo nandubay, ibope-moroti, **nandubay**
Prosopis articulata	mesquit, mesquite, mesquite amargo

Prosopis caldenia	**calden**
Prosopis calingastana	cusqui
Prosopis chilensis	algaroba chilena. algaroba du chili, algarroba, algarrobo, algarrobo blanco, algarrobo cileno, algarrobo de chile, algarrobo panta, arbol blanco, chilean algaroba, chileens algaroba, cupesi, dicidivi, divi-divi, mesquite, nacascal, nacascol, nacascolote, nasascalote, tcako, trupillo
Prosopis cineraria	jambu, kandi, shami
Prosopis ferox	churqui, churqui blanco, churqui jujeno, quiscataco
Prosopis flexulosa	algarroba, algarrobo, algarrobo amarillo, algarrobo dulce, algarrobo negro, arbol negro, lamar, lamaro, panta negro
Prosopis hassleri	algarrobo, algarrobo del chaco, algarrobo paraguayo
Prosopis juliflora	acacia de catarina, algaroba, algarobo, algarroba, algarrobo, algarrobo Colorado, algarrobo del brasil, aroma, aroma americana, aromo, barbasco, baron, bate caixa, bavahonda, bayahonda, bayahonde, bayarone, biia, cambron, carbon, cashaw, catzimec, chachaca, chucata, cuida, cuji, cuji amarillo, cuji carora, cuji negro, cuji yaque, espino ruco, ganda babool, gandasein, guatapana, guisache, haas, honey locust, huupa, inda-a, indjoe, indju, ironwood, jacaranda, ju'upa, jupala, katzimelk, kuigi, maiz criollo, maje, manca caballo, manca-caballa, mareno, me-equite, mesquit-tree, mesquite, mesquito, mezquite, mezquite amarillo, mezquite blanco, mezquite chino, mezquite Colorado, mimisquicuabitl, mimisquitl, misquitl, mizquitl, nacascol, nacasol, prosopis de mexique, qui, t'hai, tai, taj, tepemezquite, tintatico, toji, trupillo, tsirisicua, ttahi, tziritsequa, tziritzecua, uejoue, upala, utuh, visna, wawabi, yaga-bu, yaque, yaque blanco, yaque negro
Prosopis kuntzei	barba de tigre, caranda, **itin**, jacaranda, lanza-lanza, palo mataco, yacaranda, yacaranda itin
Prosopis laevigata	algarrobo, mesquite, mezquite, thako
Prosopis nandubay	algarrobillo, espinillenhout, espinillo, nandubay
Prosopis nigra	acacia de catarina, agarrobo morado, algaroba, algaroba negra, algaroba negro, algaroba noir, algarobo, algarroba, algarroba dulce, **algarroba negro**, algarrobi negro, algarrobo, algarrobo amarillo, algarrobo negro, algeroba negra, arbol negro, aroma, barbasco, bate caixa, bayahonda, black algaroba, carbon, chachaca, cuji yaque, ibope-hu, ibope-saiyu, igope-guazu, ironwood, jacaranda, manca-caballa, mesquite, mezquite, nacasol, screwbean, tintatico, visna, yura-tacu, zwarte algaroba
Prosopis pallida	algaroba, algarroba, algarroba paiva, algarrobo, algarrobo americano, carobier, huarango, kiawe, mesquite
Prosopis palmeri	palo de hierro, palo fierro
Prosopis panta	algarobilla, algarrobo, algarrobo panta, cama tala, cama tale, panta
Prosopis pugionata	algarrobo, algarrobo de las salinas, alpataco
Prosopis rubiflora	espinillo
Prosopis ruscifolia	algarrobo blanco, ibope-moroti, olkha, pao de espinho, quilin, **vinal**, visnal, yuncumarim
Prosopis tamarugo	tamarugo
Prosopis tamaruya	tamarugo
Prosopis torquata	lata, quenti, schinqui, tintitaco, tusca
Prosopis vinalillo	algarrobo blanco, algarrobo santiagueno, quilin, vinalillo

African/Asian species

Prosopis africana	abusurug, akaba, akaka, guele, ir, kaki, kiriya, kpanena, palo, pangi, pau carvao, stenkoltra, zingili
Prosopis cineraria	ghaf, ihand, jambu, jand, jandi, jhand, shumi
Prosopis pallida	algarroba, bayahonda, kiawe, mesquite

The Tree:

Prosopis alba reaches heights of 60 ft (24 m), with diameters of 5 ft (2 m) (94).

Prosopis affinis reaches heights of 65 ft (26 m), with diameters of 2 ft (0.6 m) (94).

Prosopis glandulosa reaches heights of 40 ft (16 m), with diameters of 10 inches (25 cm) to 4 ft (1.2 m) (74).

Prosopis juliflora reaches heights of 40 ft (16 m), with a diameter of 4 ft (1.2 m). It is a deciduous tree with a short, twisted bole, which is cultivated as an ornamental and used for reforestation and conservation in dry areas. It is moderately fast-growing (4).

Prosopis kuntze is a low tree, 35 ft (11 m) tall and 2 ft (0.6 m) in diameter, with large, sharp spines. It is devoid of leaves for most of the year (74, 94).

Prosopis nanduba rarely reaches heights of 20 ft (6 m) (74).

Prosopis nigra reaches heights of 33 to 52 ft (10 to 16 m), with a diameter of 1.3 to 4 ft (0.4 to 1.2 m) and a clear bole of 10 ft (3 m) (94, 96).

Prosopis ruscifolia reaches heights of 50 ft (15 m), with diameters of 1.5 ft (0.5 m) (94).

General Wood Characteristics:

Prosopis alba: The sapwood is light yellow, while the heartwood is reddish brown changing to dark brown. The wood has a pronounced stripe, with spiral to interlocked grain (94).

Prosopis affinis: The sapwood is yellow, while the heartwood is a reddish brown, changing to dark brown upon exposure to the air. The wood has a medium texture, with spiral to interlocked grain (94).

Prosopis caldenia: The sapwood is yellow-ochre; the heartwood is reddish brown, turning chestnut brown after cut. The wood has pronounced stripes, with a medium texture and wavy, interlocked grain (94).

Prosopis glandulosa: The sapwood is a lemon yellow, while the heartwood is a deep reddish brown. The wood is dense, close grained, very hard and heavy, but somewhat brittle. It is exceedingly resistant to heartwood decay, with a thin sapwood. It contains high concentrations of tannins (94).

Prosopis juliflora: The sapwood is narrow and pale yellow, while the heartwood is yellowish brown to dark brown. The wood has a slight luster, straight to wavy grain, and medium to coarse texture. It has a fragrant odor when freshly cut. It is hard, heavy, tough and strong (4).

Prosopis kuntzei: The sapwood is light yellow, while the heartwood is chestnut brown with patches of dark violet. The heartwood darkens upon exposure. The wood has a fine texture and straight to wavy to interlocked grain. This species is probably the densest wood of the genus (74, 94).

Prosopis nigra: The sapwood is yellow-ochre, while the sapwood is chestnut brown, darkening upon exposure, and sometimes has a wavy stripe. The texture is average, with slanted, interlocked grain. The wood is resistant to heartwood decay and is heavy (94, 96).

Prosopis ruscifolia: The sapwood is light yellow; the heartwood ranges from yellow-brown to reddish brown, with dark stripes, and darkens upon exposure. The wood has coarse to medium texture, with wavy to interlocked grain (94).

Weight[a]

Species	SG	Weight	
		lb/ft^3	kg/m^3
Prosopis alba	0.75–0.85[b]	NA	NA
Prosopis affinis	0.93–1.05[b]	NA	NA
Prosopis caldenia	0.65–0.75[b]	NA	NA
Prosopis chilensis	0.80–0.92[c]	50–58[c]	801–929
Prosopis glandulosa	0.819[d]	NA	NA
Prosopis juliflora	0.944[b]	50.5–56[e]	809–897
Prosopis kuntzei	1.20–1.35[b]	NA	NA
Prosopis nigra	0.85[b]	NA	NA
	0.80[f]	NA	NA
Prosopis ruscifolia	0.70–0.85[b]	NA	NA

[a]Moisture content equals 12%.
[b]Reference (94).
[c]Reference (74).
[d]Reference (103).
[e]Reference (4).
[f]Reference (96).

Mechanical properties

Property	Green		Dry	
Prosopis affinis				
MOE	NA	NA	$1.42^a \times 10^6$ lbf/in^2	9.791 GPa
MOR	NA	NA	$6.43^a \times 10^3$ lbf/in^2	44.335 MPa
$C_{\|\|}$	NA	NA	NA	NA
$C_{\perp}$	$7.04^a \times 10^3$ lbf/in^2	48.541 MPa	NA	NA
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	NA	NA	NA	NA
Prosopis alba				
MOE	NA	NA	$0.882^a \times 10^6$ lbf/in^2	6.081 GPa
MOR	NA	NA	$9.15^a \times 10^3$ lbf/in^2	63.089 MPa
$C_{\|\|}$	NA	NA	$8.51^a \times 10^3$ lbf/in^2	58.676 MPa
$C_{\perp}$	NA	NA	$4.55^a \times 10^3$ lbf/in^2	31.372 MPa
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	NA	NA	NA	NA
Prosopis caldenia				
MOE	NA	NA	NA	NA
MOR	NA	NA	$4.82^a \times 10^3$ lbf/in^2	33.234 MPa
$C_{\|\|}$	NA	NA	$4.65^a \times 10^3$ lbf/in^2	32.062 MPa
$C_{\perp}$	NA	NA	NA	NA
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	NA	NA	NA	NA

Mechanical properties—con.

Property	Green		Dry	
Prosopis juliflora				
MOE	$1.80^{b} \times 10^{6}$ lbf/in^2	12.411 GPa	$2.06^{b} \times 10^{6}$ lbf/in^2 1.33^{a}	14.204 Gpa 9.170
MOR	$10.6^{b} \times 10^{3}$ lbf/in^2	73.087 MPa	$16.5^{b} \times 10^{3}$ lbf/in^2 12.3^{a}	113.768 Mpa 84.809
$C_{\|\|}$	$5.30^{b} \times 10^{3}$ lbf/in^2	36.544 MPa	$9.00^{b} \times 10^{3}$ lbf/in^2 9.12^{a}	62.055 Mpa 62.882
$C_{\perp}$	NA	NA	NA	NA
WML	NA	NA	NA	NA
Hardness	NA	NA	2940^{a} lbf	13077.12 N
$Shear_{\|\|}$	$1.32^{b} \times 10^{3}$ lbf/in^2	9.101 MPa	$2.18^{b} \times 10^{3}$ lbf/in^2	15.031 MPa
Prosopis kuntzei				
MOE	NA	NA	$2.52^{a} \times 10^{3}$ lbf/in^2	17.375 GPa
MOR	NA	NA	$22.3^{a} \times 10^{3}$ lbf/in^2	153.759 MPa
$C_{\|\|}$	NA	NA	$12.7^{a} \times 10^{3}$ lbf/in^2	87.567 MPa
$C_{\perp}$	NA	NA	NA	NA
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	NA	NA	NA	NA
Prosopis nigra				
MOE	NA	NA	$0.853^{a} \times 10^{6}$ lbf/in^2 1.38^{c}	5.881 Gpa 9.515
MOR	NA	NA	$9.02^{a} \times 10^{3}$ lbf/in^2 13.4^{c}	62.193 Mpa 92.393
$C_{\|\|}$	NA	NA	$8.28^{a} \times 10^{3}$ lbf/in^2 8.70^{c}	57.091 Mpa 59.987
$C_{\perp}$	NA	NA	$4.41^{a} \times 10^{3}$ lbf/in^2	30.407 MPa
WML	NA	NA	NA	NA
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	NA	NA	$1.99^{a} \times 10^{3}$ lbf/in^2	13.721 MPa

[a]Reference (94).
[b]Reference (4).
[c]Reference (96).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	12% MC	20% MC
Tangential			
Prosopis alba	3.1[b]	2.8[c]	0.7[b]
Prosopis glandulosa	3.2[d]	1.4[d]	0.144[d]
Prosopis juliflora	8.1[e]	7.1[e]	NA
Prosopis kuntzei	NA	5.3[c]	NA
Prosopis nigra	NA	2.5[c]	NA
Prosopis nigra	NA	3.0[f]	NA

Drying and shrinkage—con.

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Radial			
Prosopis alba	2.2[b]	2.1[c]	0.2[b]
Prosopis glandulosa	1.6[d]	0.72[d]	0.09[d]
Prosopis juliflora	>5.1[e]	>4.1[e]	NA
Prosopis kuntzei	NA	4.3[c]	NA
Prosopis nigra	NA	1.9[c]	NA
Prosopis nigra	NA	2.1[f]	NA
Volumetric			
Prosopis alba	NA	8.2[c]	NA
Prosopis glandulosa	4.8[d]	2.12[d]	0.23[d]
Prosopis kuntzei	NA	11.0[c]	NA
Prosopis nigra	NA	6.6[c]	NA
Prosopis nigra	NA	6.8[f]	NA

[a]Prosopis juliflora: This species tends to produce small checks during air drying, but it is very stable (4). Prosopis nigra: Rated as very stable (96).
[b]Reference (95).
[c]Reference (94).
[d]Reference (103).
[e]Reference (4).
[f]Reference (96).

Kiln Drying Schedule: No information available at this time.

Working Properties:

Prosopis juliflora works easily with most tools and finishes smoothly, but it does not take a high polish. Preboring is necessary for nailing (4).

Durability: Mesquite is rated as very resistant to heartwood decay (98).

Prosopis juliflora is classed as resistant to very resistant to heartwood decay. It is susceptible to Lyctus beetles, termites and pinhole bores. (4)

Prosopis nigra is resistant to heartwood decay in damp and open air conditions (96).

Preservation:

Prosopis nigra is slightly permeable with reduced absorption. Immersion or surface treatments are good if parts are sapwood, although puncturing will work somewhat (96).

Uses:

Prosopis chilensis: Fuel, posts, stakes (74).

Prosopis glandulosa: Buildings, cabinetry, posts, charcoal, fuel, railway crossties, paving blocks (74).

Prosopis juliflora: Charcoal, firewood, buildings, cabinetry, and posts; pods are good for fodder (4).

Prosopis nandubay: Posts (74).

Prosopis nigra: Flooring, cooperage, firewood, charcoal, posts, boats, carriages, turnery, furniture, frames for doors and windows (96).

Toxicity: Dermatitis has been reported for *Prosopis juliflora*, *P. africana* and *P. glandulosa*, possibly due to an alkaloid, prospinine (40, 64, 105).

Additional Reading: 10, 29, 55, 74.

Prunus serotina
Rosaceae
Black Cherry

Prunus is a genus of 120 to 400 species that contain fruitwoods like cherry, plum and almond. The species are native to North America, Asia, Europe and the Mediterranean region. All species look alike microscopically. The word *prunus* is the classical Latin name for the cherry tree.

Other Common Names: American cherry, black wild cherry, cabinet cherry, chisos wild cherry, Edwards Plateau cherry, escarpment cherry, gila chokecherry, mountain black cherry, rum cherry, southwest choke cherry, southwestern chokecherry, wild black cherry, wild cherry, whisky cherry

Distribution: Cherry is found in the eastern half of the United States, from the plains to the Atlantic Ocean and from the Great Lakes to the Gulf of Mexico. It also occurs in high elevations in Mexico.

The Tree: The tree reaches a height of 100 ft (30 m), with a diameter of 4 to 5 ft (1.2 to 1.5 m). It is shrubby under poor growth conditions and at the northern limit of its range. It does best on the rich, moist soil of the Appalachians.

General Wood Characteristics: The sapwood is light yellow, while the heartwood is brownish with a greenish tinge, darkening upon exposure to a deep reddish brown with a golden luster. The wood has a mild, aromatic scent, but no characteristic taste. It is of medium density, firm, and strong, with a fine, uniform texture. The grain is generally straight.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.47	45	721
12%	0.50	35	561
Ovendry	0.53	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.31×10^6 lbf/in^2	9.032 GPa	1.49×10^6 lbf/in^2	10.274 GPa
MOR	8.00×10^3 lbf/in^2	55.160 MPa	12.3×10^3 lbf/in^2	84.809 MPa
$C_{\parallel}$	3.54×10^3 lbf/in^2	24.408 MPa	7.11×10^3 lbf/in^2	49.023 MPa
$C_{\perp}$	0.36×10^3 lbf/in^2	2.482 MPa	0.69×10^3 lbf/in^2	4.758 MPa
WML	12.8 in-lbf/in^3	88.256 kJ/m^3	11.4 in-lbf/in^3	78.603 kJ/m^3
Hardness	660 lbf	2935.68 N	950 lbf	4225.60 N
$Shear_{\parallel}$	1.13×10^3 lbf/in^2	7.791 MPa	1.70×10^3 lbf/in^2	11.721 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential	7.1	5.7	2.4
Radial	3.7	3.0	1.2
Volumetric	11.5	9.2	3.8

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Black cherry	T8-B4	T5-B3	T5-B2	T3-B2	T3-A1
Bitter cherry (P. emarginata)	T5-B2	T3-A1	NA	NA	NA

[a]References (6, 86).

Working Properties: Cherry is easy to work, finishes smoothly, and is dimensionally stable. It is easily machined. It can be sawn cleanly, turned well, and planed excellently with standard cutting angles. Screw-holding ability is good, as is gluing, except where gum streaks are present.

Durability: Rated as very resistant to heartwood decay.

Preservation: No information available at this time.

Uses: Fine furniture, printing and engraving blocks, patterns, professional and scientific instruments, piano actions, handles, wooden ware, toys, and specialty items.

Toxicity: No information available at this time.

Additional Reading: 29, 34, 59, 68, 74.

Quercus spp. Fagaceae Oak

Worldwide, the oaks (*Quercus* spp.) consist of 275 to 500 species that can be separated into three groups based on their microanatomy: the live or evergreen oak group, the red oak group *(Erythrobalanus),* and the white oak group *(Leucobalanus).* Species within each group look alike microscopically. The word *quercus* is the classical Latin name of oaks, said to be derived from Celtic fine and tree.

The commercial North American species are as follows:

Red Oak Group (*Erythrobalanus*)

Quercus coccinea	bastard oak, black oak, buck oak, red oak, **scarlet oak**, Spanish oak, spotted oak
Quercus falcata	American red oak, bottomland red oak, **cherrybark oak**, Elliott oak, red oak, Spanish oak, **southern red oak**, swamp red oak, swamp spanish oak, turkeyfoot oak, water oak
Quercus kelloggii	black oak, **California black oak**, Kellogg oak, mountain black oak
Quercus laurifolia	Darlington oak, diamond-leaf oak, **laurel oak**, laurel-leaf oak, swamp laurel oak, water oak, obtusa oak
Quercus nigra	American red oak, blackjack, pin oak, possum oak, punk oak, red oak, spotted oak, **water oak**
Quercus nuttallii	**nuttall oak**, pin oak, red oak, red river oak, striped oak
Quercus palustris	**pin oak**, red oak, Spanish oak, Spanish swamp oak, Spanish water oak, swamp oak, swamp Spanish oak, water oak
Quercus phellos	black oak, laurel oak, peach oak, pin oak, red oak, swamp willow oak, water oak, **willow oak**, willow swamp oak
Quercus rubra	American red oak, black oak, buck oak, Canadian red oak, common red oak, gray oak, eastern red oak, leopard oak, Maine red oak, mountain red oak, **northern red oak**, red oak, Spanish oak, spotted oak, southern red oak, swamp red oak, water oak, West Virginia soft red oak
Quercus shumardii	American red oak, Schneck oak, Schneck red oak, **shumard oak**, Shumard red oak, southern red oak, spotted bark, spotted oak, swamp red oak, Texas oak, Texas red oak
Quercus velutina	American red oak, blackjack, **black oak**, dyer oak, jack oak, quercitron, quercitron oak, redbush, red oak, smoothbark oak, spotted oak, tanbark oak, yellowbark, yellow oak, yellowbark oak

White Oak Group (*Leucobalanus*)

Quercus alba	American white oak, Arizona oak, Arizona white oak, forked-leaf white oak, Louisiana white oak, mantua oak, ridge white oak, stave oak, true white oak, West Virginia soft white oak, **white oak**
Quercus bicolor	blue oak, cherry oak, curly swamp oak, swamp oak, **swamp white oak**, white oak
Quercus garryana	Brewer oak, Garry oak, Oregon oak, **Oregon white oak**, Pacific post oak, Pacific white oak, post oak, prairie oak, shin oak, western oak, western white oak, white oak
Quercus lyrata	American white oak, **overcup oak**, swamp post oak, swamp white oak, water white oak
Quercus macrocarpa	blue oak, **bur oak**, burr oak, mossycup oak, mossy-overcup oak, overcup oak, scrub oak, white oak, white mossycup oak, white overcup oak
Quercus michauxii	American white oak, basket oak, cow oak, swamp oak, **swamp chestnut oak**
Quercus muehlenbergii	chestnut oak, **chinkapin oak**, chinquapin oak, dwarf chestnut oak, dwarf chinkapin, pin oak, rock oak, rock chestnut oak, running white oak, scrub oak, shrub oak, white oak, yellow oak, yellow chestnut oak

Quercus prinus	American white oak, basket oak, **chestnut oak**, chestnut rock oak, chestnut swamp oak, cow oak, mountain oak, rock oak, rock chestnut, rock chestnut oak, swamp oak, tanbark oak, white oak, white chestnut oak
Quercus stellata	American post oak, barren white oak, bastard oak, bastard white oak, box oak, box white oak, brash oak, Delta post oak, Durand oak, iron oak, pin oak **post oak**, ridge oak, rough oak, rough white oak, southern oak, turkey oak, white box oak, white oak
Live Oak Group	
Quercus virginiana	dwarf live oak, encino, **live oak**, rolfs oak, scrub live oak, Virginia live oak, Virginia oak

Distribution: Widely distributed throughout the United States.

The Tree: Oaks can reach a height of 125 ft (38 m), with large diameters.

General Wood Characteristics: The sapwood of oak is white to very light brown, while the heartwood is light to dark brown in the white oak group and reddish brown in the red oak group. Oak wood has a course texture; it is heavy, straight-grained, hard, tough, very stiff, and strong. Fast-grown oak, with wide rings, is stronger and heavier than slow-grown oak.

Weight[a]

			Weight	
Species	MC	SG	lb/ft^3	kg/m^3
Red Oak Group				
Quercus coccinea	Green	0.60	62	993
(scarlet oak)	12%	0.67	47	753
	Ovendry	0.71	NA	NA
Quercus falcata	Green	0.52	62	993
(southern red oak)	12%	0.59	41	657
	Ovendry	0.62	NA	NA
Quercus falcata var. pagodifolia	Green	0.61	68	1,089
(cherrybark oak)	12%	0.68	47	753
	Ovendry	0.71	NA	NA
Quercus laurifolia	Green	0.56	65	1,041
(laurel oak)	12%	0.63	44	705
	Ovendry	0.70	NA	NA
Quercus nigra	Green	0.56	63	1,009
(water oak)	12%	0.63	44	705
	Ovendry	0.68	NA	NA
Quercus palustris	Green	0.58	63	1,009
(pin oak)	12%	0.63	44	705
	Ovendry	0.68	NA	NA
Quercus phellos	Green	0.56	67	1073
(willow oak)	12%	0.69	48	769
	Ovendry	0.69	NA	NA
Quercus rubra	Green	0.56	63	1,009
(northern red oak)	12%	0.63	44	705
	Ovendry	0.66	NA	NA
Quercus velutina	Green	0.56	62	993
(black oak)	12%	0.61	43	689
	Ovendry	0.67	NA	NA

Weight—con.

Species	MC	SG	Weight lb/ft^3	Weight kg/m^3
White Oak Group				
Quercus alba	Green	0.60	62	993
(white oak)	12%	0.68	48	769
	Ovendry	0.71	NA	NA
Quercus bicolor	Green	0.64	69	1,105
(swamp white oak)	12%	0.72	50	801
	Ovendry	0.79	NA	NA
Quercus garryana	Green	0.64	69	1,105
(Oregon white oak)	12%	0.72	50	801
	Ovendry	0.75	NA	NA
Quercus lyrata	Green	0.57	NA	NA
(overcup oak)	12%	0.63	NA	NA
	Ovendry	NA	NA	NA
Quercus macrocarpa	Green	0.58	62	993
(bur oak)	12%	0.64	45	721
	Ovendry	0.67	NA	NA
Quercus michauxii	Green	0.60	65	1,041
(swamp chestnut oak)	12%	0.67	47	753
	Ovendry	0.76	NA	NA
Quercus prinus	Green	0.57	61	977
(chestnut oak)	12%	0.66	46	737
	Ovendry	0.67	NA	NA
Quercus stellata	Green	0.60	63	1,009
(post oak)	12%	0.67	47	753
	Ovendry	0.74	NA	NA
Live Oak Group				
Quercus virginiana	Green	0.80	76	1,218
(live oak)	12%	0.88	62	993
	Ovendry	0.98	NA	NA

[a]References: specific gravity, green and 12%, (98), except for Q. garryana (59); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
Red Oak Group				
Quercus coccinea (scarlet oak)				
MOE	1.48×10^6 lbf/in^2	10.204 GPa	1.91×10^6 lbf/in^2	13.169 GPa
MOR	10.4×10^3 lbf/in^2	71.708 MPa	17.4×10^3 lbf/in^2	119.973 MPa
$C_{\parallel}$	4.09×10^3 lbf/in^2	28.201 MPa	8.33×10^3 lbf/in^2	57.435 MPa
$C_{\perp}$	0.83×10^3 lbf/in^2	5.723 MPa	1.12×10^3 lbf/in^2	7.722 MPa
WML	15.0 in-lbf/in^3	103.425 kJ/m^3	20.5 in-lbf/in^3	141.348 kJ/m^3
Hardness	1,200 lbf	5,337.60 N	1,400 lbf	6,227.20 N
$Shear_{\parallel}$	1.41×10^3 lbf/in^2	9.722 MPa	1.89×10^3 lbf/in^2	13.031 MPa
Quercus falcata (southern red oak)				
MOE	1.14×10^6 lbf/in^2	7.860 GPa	1.49×10^6 lbf/in^2	10.274 GPa
MOR	6.90×10^3 lbf/in^2	47.576 MPa	10.9×10^3 lbf/in^2	75.156 MPa
$C_{\parallel}$	3.03×10^3 lbf/in^2	20.892 MPa	6.09×10^3 lbf/in^2	41.991 MPa
$C_{\perp}$	0.55×10^3 lbf/in^2	3.792 MPa	0.87×10^3 lbf/in^2	5.999 MPa
WML	8.0 in-lbf/in^3	55.160 kJ/m^3	9.4 in-lbf/in^3	64.813 kJ/m^3
Hardness	860 lbf	3,825.28 N	1,060 lbf	4,714.88 N
$Shear_{\parallel}$	0.93×10^3 lbf/in^2	6.412 MPa	1.39×10^3 lbf/in^2	9.584 MPa
Quercus falcata var. pagodifolia (cherrybark oak)				
MOE	1.79×10^6 lbf/in^2	12.342 GPa	2.28×10^6 lbf/in^2	15.721 GPa
MOR	10.8×10^3 lbf/in^2	74.466 MPa	18.1×10^3 lbf/in^2	124.800 MPa
$C_{\parallel}$	4.62×10^3 lbf/in^2	31.855 MPa	8.74×10^3 lbf/in^2	60.262 MPa
$C_{\perp}$	0.76×10^3 lbf/in^2	5.240 MPa	1.25×10^3 lbf/in^2	8.619 MPa
WML	14.7 in-lbf/in^3	101.357 kJ/m^3	18.3 in-lbf/in^3	126.179 kJ/m^3
Hardness	1,240 lbf	5,515.52 N	1,480 lbf	6,583.04 N
$Shear_{\parallel}$	1.32×10^3 lbf/in^2	9.101 MPa	2.00×10^3 lbf/in^2	13.790 MPa
Quercus laurifolia (laurel oak)				
MOE	1.39×10^6 lbf/in^2	9.584 GPa	1.69×10^6 lbf/in^2	11.653 GPa
MOR	7.90×10^3 lbf/in^2	54.471 MPa	12.6×10^3 lbf/in^2	86.877 MPa
$C_{\parallel}$	3.17×10^3 lbf/in^2	21.857 MPa	6.98×10^3 lbf/in^2	48.127 MPa
$C_{\perp}$	0.57×10^3 lbf/in^2	3.930 MPa	1.06×10^3 lbf/in^2	7.309 MPa
WML	11.2 in-lbf/in^3	77.224 kJ/m^3	11.8 in-lbf/in^3	81.361 kJ/m^3
Hardness	1,000 lbf	4,448.00 N	1,210 lbf	5,382.08 N
$Shear_{\parallel}$	1.18×10^3 lbf/in^2	8.136 MPa	1.83×10^3 lbf/in^2	12.617 MPa
Quercus nigra (water oak)				
MOE	1.55×10^6 lbf/in^2	10.687 GPa	2.02×10^6 lbf/in^2	13.928 GPa
MOR	8.90×10^3 lbf/in^2	61.366 MPa	15.4×10^3 lbf/in^2	106.183 MPa
$C_{\parallel}$	3.74×10^3 lbf/in^2	25.787 MPa	6.77×10^3 lbf/in^2	46.679 MPa
$C_{\perp}$	0.62×10^3 lbf/in^2	4.275 MPa	1.02×10^3 lbf/in^2	7.033 MPa
WML	11.1 in-lbf/in^3	76.535 kJ/m^3	21.5 in-lbf/in^3	148.243 kJ/m^3
Hardness	1,010 lbf	4,492.48 N	1,190 lbf	5,293.12 N
$Shear_{\parallel}$	1.24×10^6 lbf/in^2	8.549 MPa	2.02×10^3 lbf/in^2	13.927 MPa
Quercus palustris (pin oak)				
MOE	1.32×10^6 lbf/in^2	9.101 GPa	1.73×10^6 lbf/in^2	11.928 GPa
MOR	8.30×10^3 lbf/in^2	57.229 MPa	14.0×10^3 lbf/in^2	96.530 MPa
$C_{\parallel}$	3.68×10^3 lbf/in^2	25.374 MPa	6.82×10^3 lbf/in^2	47.024 MPa
$C_{\perp}$	0.72×10^3 lbf/in^2	4.964 MPa	1.02×10^3 lbf/in^2	7.033 MPa
WML	14.0 in-lbf/in^3	96.530 kJ/m^3	14.8 in-lbf/in^3	102.046 kJ/m^3
Hardness	1,070 lbf	4,759.36 N	1,510 lbf	6,716.48 N
$Shear_{\parallel}$	1.29×10^3 lbf/in^2	8.894 MPa	2.08×10^3 lbf/in^2	14.341 MPa

Mechanical properties—con.

Property	Green		Dry	
Quercus phellos (willow oak)				
MOE	1.29×10^6 lbf/in^2	8.894 GPa	1.90×10^6 lbf/in^2	13.101 GPa
MOR	7.40×10^3 lbf/in^2	51.023 MPa	14.5×10^3 lbf/in^2	99.978 MPa
$C_{\parallel}$	3.00×10^3 lbf/in^2	20.685 MPa	7.04×10^3 lbf/in^2	48.541 MPa
$C_{\perp}$	0.61×10^3 lbf/in^2	4.206 MPa	1.13×10^3 lbf/in^2	7.791 MPa
WML	8.8 in-lbf/in^3	60.676 kJ/m^3	14.6 in-lbf/in^3	100.667 kJ/m^3
Hardness	980 lbf	4,359.04 N	1,460 lbf	6,494.08 N
$Shear_{\parallel}$	1.18×10^3 lbf/in^2	8.136 MPa	1.65×10^3 lbf/in^2	11.376 MPa
Quercus rubra (northern red oak)				
MOE	1.35×10^6 lbf/in^2	9.308 GPa	1.82×10^6 lbf/in^2	12.549 GPa
MOR	8.30×10^3 lbf/in^2	57.229 MPa	14.3×10^3 lbf/in^2	98.599 MPa
$C_{\parallel}$	3.44×10^3 lbf/in^2	23.719 MPa	6.76×10^3 lbf/in^2	46.610 MPa
$C_{\perp}$	0.61×10^3 lbf/in^2	4.206 MPa	1.01×10^3 lbf/in^2	6.964 MPa
WML	13.2 in-lbf/in^3	91.014 kJ/m^3	14.5 in-lbf/in^3	99.978 kJ/m^3
Hardness	1,000 lbf	4,448.00 N	1,290 lbf	5,737.92 N
$Shear_{\parallel}$	1.21×10^3 lbf/in^2	8.343 MPa	1.78×10^3 lbf/in^2	12.273 MPa
Quercus velutina (black oak)				
MOE	1.18×10^6 lbf/in^2	8.136 GPa	1.64×10^6 lbf/in^2	11.308 GPa
MOR	8.20×10^3 lbf/in^2	56.539 MPa	13.9×10^3 lbf/in^2	95.841 MPa
$C_{\parallel}$	3.47×10^3 lbf/in^2	23.926 MPa	6.52×10^3 lbf/in^2	44.955 MPa
$C_{\perp}$	0.71×10^3 lbf/in^2	4.895 MPa	0.93×10^3 lbf/in^2	6.412 MPa
WML	12.2 in-lbf/in^3	84.119 kJ/m^3	13.7 in-lbf/in^3	94.462 kJ/m^3
Hardness	1,060 lbf	4,714.88 N	1,210 lbf	5,382.08 N
$Shear_{\parallel}$	1.20×10^3 lbf/in^2	8.274 MPa	1.91×10^3 lbf/in^2	13.169 MPa
White Oak Group (*Leucobalanus*)				
Quercus alba (white oak)				
MOE	1.25×10^6 lbf/in^2	8.618 GPa	1.78×10^6 lbf/in^2	12.273 GPa
MOR	8.30×10^3 lbf/in^2	57.229 MPa	15.2×10^3 lbf/in^2	104.804 MPa
$C_{\parallel}$	3.56×10^3 lbf/in^2	24.546 MPa	7.44×10^3 lbf/in^2	51.299 MPa
$C_{\perp}$	0.67×10^3 lbf/in^2	4.620 MPa	1.07×10^3 lbf/in^2	7.378 MPa
WML	11.6 in-lbf/in^3	79.982 kJ/m^3	14.8 in-lbf/in^3	102.046 kJ/m^3
Hardness	1,060 lbf	4,714.88 N	1,360 lbf	6,049.28 N
$Shear_{\parallel}$	1.25×10^3 lbf/in^2	8.618 MPa	2.00×10^3 lbf/in^2	13.790 MPa
Quercus bicolor (swamp white oak)				
MOE	1.59×10^6 lbf/in^2	10.963 GPa	2.05×10^6 lbf/in^2	14.135 GPa
MOR	9.90×10^3 lbf/in^2	68.261 MPa	17.7×10^3 lbf/in^2	122.042 MPa
$C_{\parallel}$	4.36×10^3 lbf/in^2	30.062 MPa	8.60×10^3 lbf/in^2	59.297 MPa
$C_{\perp}$	0.76×10^3 lbf/in^2	5.240 MPa	1.19×10^3 lbf/in^2	8.205 MPa
WML	14.5 in-lbf/in^3	99.978 kJ/m^3	19.2 in-lbf/in^3	132.384 kJ/m^3
Hardness	1,160 lbf	5,159.68 N	1,620 lbf	7,205.76 N
$Shear_{\parallel}$	1.30×10^3 lbf/in^2	8.963 MPa	2.00×10^3 lbf/in^2	13.790 MPa
Quercus lyrata (overcup oak)				
MOE	1.15×10^6 lbf/in^2	7.929 GPa	1.42×10^6 lbf/in^2	9.791 GPa
MOR	8.00×10^3 lbf/in^2	55.160 MPa	12.6×10^3 lbf/in^2	86.877 MPa
$C_{\parallel}$	3.37×10^3 lbf/in^2	23.236 MPa	6.20×10^3 lbf/in^2	42.749 MPa
$C_{\perp}$	0.54×10^3 lbf/in^2	3.723 MPa	0.81×10^3 lbf/in^2	5.585 MPa
WML	12.6 in-lbf/in^3	86.877 kJ/m^3	15.7 in-lbf/in^3	108.252 kJ/m^3
Hardness	960 lbf	4,270.08 N	1,190 lbf	5,293.12 N
$Shear_{\parallel}$	1.32×10^3 lbf/in^2	9.101 MPa	2.00×10^3 lbf/in^2	13.790 MPa

Mechanical properties—con.

Property	Green		Dry	
Quercus macrocarpa (bur oak)				
MOE	0.88×10^6 lbf/in^2	6.067 GPa	1.03×10^6 lbf/in^2	7.102 GPa
MOR	7.20×10^3 lbf/in^2	49.644 MPa	10.3×10^3 lbf/in^2	71.019 MPa
$C_{\|\|}$	3.29×10^3 lbf/in^2	22.685 MPa	6.06×10^3 lbf/in^2	41.784 MPa
$C_{\perp}$	0.68×10^3 lbf/in^2	4.689 MPa	1.20×10^3 lbf/in^2	8.274 MPa
WML	10.7 in-lbf/in^3	73.777 kJ/m^3	9.8 in-lbf/in^3	67.571 kJ/m^3
Hardness	1,110 lbf	4,937.28 N	1,370 lbf	6,093.76 N
$Shear_{\|\|}$	1.35×10^3 lbf/in^2	9.308 MPa	1.82×10^3 lbf/in^2	12.548 MPa
Quercus michauxii (swamp chestnut oak)				
MOE	1.35×10^6 lbf/in^2	9.308 GPa	1.77×10^6 lbf/in^2	12.204 GPa
MOR	8.50×10^3 lbf/in^2	58.608 MPa	13.9×10^3 lbf/in^2	95.841 MPa
$C_{\|\|}$	3.54×10^3 lbf/in^2	24.408 MPa	7.27×10^3 lbf/in^2	50.127 MPa
$C_{\perp}$	0.57×10^3 lbf/in^2	3.930 MPa	1.11×10^3 lbf/in^2	7.653 MPa
WML	12.8 in-lbf/in^3	88.256 kJ/m^3	12.0 in-lbf/in^3	82.740 kJ/m^3
Hardness	1,110 lbf	4,937.28 N	1,240 lbf	5,515.52 N
$Shear_{\|\|}$	1.26×10^3 lbf/in^2	8.687 MPa	1.99×10^3 lbf/in^2	13.721 MPa
Quercus prinus (chestnut oak)				
MOE	1.37×10^6 lbf/in^2	9.446 GPa	1.59×10^6 lbf/in^2	10.963 GPa
MOR	8.00×10^3 lbf/in^2	55.160 MPa	13.3×10^3 lbf/in^2	91.704 MPa
$C_{\|\|}$	3.52×10^3 lbf/in^2	24.270 MPa	6.83×10^3 lbf/in^2	47.093 MPa
$C_{\perp}$	0.53×10^3 lbf/in^2	3.654 MPa	0.84×10^3 lbf/in^2	5.792 MPa
WML	9.4 in-lbf/in^3	64.813 kJ/m^3	11.0 in-lbf/in^3	75.845 kJ/m^3
Hardness	890 lbf	3,958.72 N	1,130 lbf	5,026.24 N
$Shear_{\|\|}$	1.21×10^3 lbf/in^2	8.343 MPa	1.49×10^3 lbf/in^2	10.273 MPa
Quercus stellata (post oak)				
MOE	1.09×10^6 lbf/in^2	7.515 GPa	1.51×10^6 lbf/in^2	10.411 GPa
MOR	8.10×10^3 lbf/in^2	55.850 MPa	13.2×10^3 lbf/in^2	91.014 MPa
$C_{\|\|}$	3.48×10^3 lbf/in^2	23.995 MPa	6.60×10^3 lbf/in^2	45.507 MPa
$C_{\perp}$	0.86×10^3 lbf/in^2	5.930 MPa	1.43×10^3 lbf/in^2	9.860 MPa
WML	11.0 in-lbf/in^3	75.845 kJ/m^3	13.2 in-lbf/in^3	91.014 kJ/m^3
Hardness	1,130 lbf	5,026.24 N	1,360 lbf	6,049.28 N
$Shear_{\|\|}$	1.28×10^3 lbf/in^2	8.825 MPa	1.84×10^3 lbf/in^2	12.686 MPa
Live Oak Group				
Quercus virginiana (live oak)				
MOE	1.58×10^6 lbf/in^2	10.894 GPa	1.98×10^6 lbf/in^2	13.652 GPa
MOR	11.9×10^3 lbf/in^2	82.051 MPa	18.4×10^3 lbf/in^2	126.868 MPa
$C_{\|\|}$	5.43×10^3 lbf/in^2	37.440 MPa	8.90×10^3 lbf/in^2	61.366 MPa
$C_{\perp}$	2.04×10^3 lbf/in^2	14.066 MPa	2.84×10^3 lbf/in^2	19.582 MPa
WML	12.3 in-lbf/in^3	84.809 kJ/m^3	18.9 in-lbf/in^3	130.316 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\|\|}$	2.21×10^3 lbf/in^2	15.237 MPa	2.66×10^3 lbf/in^2	18.340 Mpa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential			
Red Oak Group			
Quercus coccinea (scarlet oak)	10.8	7.8	3.2
Quercus falcata (southern red oak)	11.3	NA	NA
Quercus falcata var. pagodifolia (cherrybark oak)	10.6	NA	NA
Quercus laurifolia (laurel oak)	9.9	NA	NA
Quercus nigra (water oak)	9.8	7.4	3.1
Quercus palustris (pin oak)	9.5	7.6	3.2
Quercus phellos (willow oak)	9.6	NA	NA
Quercus rubra (northern red oak)	8.6	6.6	2.7
Quercus velutina (black oak)	11.1	7.8	3.2
White Oak Group			
Quercus alba (white oak)	10.5	7.2	3.0
Quercus bicolor (swamp white oak)	NA	NA	NA
Quercus lyrata (overcup oak)	12.7	NA	NA
Quercus macrocarpa (bur oak)	8.8	7.0	2.9
Quercus michauxii (swamp chestnut oak)	10.8	8.6	3.6
Quercus prinus (chestnut oak)	10.8	7.8	3.2
Quercus stellata (post oak)	9.8	7.8	3.3
Live Oak Group			
Quercus virginiana (live oak)	9.5	7.6	3.2
Radial			
Red Oak Group			
Quercus coccinea (scarlet oak)	4.4	3.7	1.5
Quercus falcata (southern red oak)	4.7	NA	NA
Quercus falcata var. pagodifolia (cherrybark oak)	5.5[b]	NA	NA
Quercus laurifolia (laurel oak)	4.0	NA	NA
Quercus nigra (water oak)	4.4	3.4	1.4
Quercus palustris (pin oak)	4.3	3.4	1.4
Quercus phellos (willow oak)	5.0	NA	NA
Quercus rubra (northern red oak)	4.0	3.2	1.3
Quercus velutina (black oak)	4.4	3.6	1.5
White Oak Group			
Quercus alba (white oak)	5.6	4.2	1.8
Quercus bicolor (swamp white oak)	NA	NA	NA
Quercus lyrata (overcup oak)	5.3	NA	NA
Quercus macrocarpa (bur oak)	4.4	3.5	1.5
Quercus michauxii (swamp chestnut oak)	5.2	4.2	1.7
Quercus prinus (chestnut oak)	5.3	4.4	1.8
Quercus stellata (post oak)	5.4	4.3	1.8
Live Oak Group			
Quercus virginiana (live oak)	6.6	5.3	2.2

Drying and shrinkage—con.

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Volumetric			
Red Oak Group			
Quercus coccinea (scarlet oak)	14.7	11.0	4.6
Quercus falcata (southern red oak)	16.1	NA	NA
Quercus falcata var. pagodifolia (cherrybark oak)	16.1	NA	NA
Quercus laurifolia (laurel oak)	19.0	NA	NA
Quercus nigra (water oak)	16.1	13.1	5.5
Quercus palustris (pin oak)	14.5	11.6	4.8
Quercus phellos (willow oak)	18.9	NA	NA
Quercus rubra (northern red oak)	13.7	10.8	4.5
Quercus velutina (black oak)	15.1	11.4	4.7
White Oak Group			
Quercus alba (white oak)	16.3	12.6	5.3
Quercus bicolor (swamp white oak)	NA	NA	NA
Quercus lyrata (overcup oak)	16.0	NA	NA
Quercus macrocarpa (bur oak)	12.7	10.2	4.2
Quercus michauxii (swamp chestnut oak)	16.4	13.1	5.5
Quercus prinus (chestnut oak)	16.4	13.4	5.6
Quercus stellata (post oak)	16.2	13.0	5.4
Live Oak Group			
Quercus virginiana (live oak)	14.7	11.8	4.9

[a]References: 0% MC, (98); 6% and 20%, (90).
[b]Reference (90).

Kiln drying schedule[a]

Species	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Western oaks[b]	T3-B1	T3-B1	NA	NA	NA
Upland red oaks[c]	T4-D2	T3-D1	T3-C1	T3-C1	NA
Lowland red oaks[d]	T2-C1	Table 113	NA	NA	NA
Upland white oaks[e]	T4-C2	T3-C1	T3-B1	T3-B1	NA
Lowland white oaks[f]	T2-C1	Table 113	NA	NA	NA

[a]References (6, 86).
[b]California black, Oregon white, canyon live.
[c]Black, blackjack, cherrybark, northern pin, northern red, scarlet, Schumard, southern red, turkey, water.
[d]Cherrybark, laurel, nuttall, pin, Shumard, water, willow.
[e]Blue, bur, chestnut, chinkapin, Emory, Gambel, Mexican blue, post, white.
[f]Bur, live, overcup, swamp chestnut, swamp white, white.

Working Properties: Oak wood has good working properties. It machines and glues well and holds fasteners extremely well. It tends to split when nailed, unless predrilled. Oak finishes well, but shrinks considerably.

Durability: The oaks are rated with respect to resistance to heartwood decay as follows (98):

Very resistant	bur oak, chestnut oak, Gambel oak, Oregon oak, post oak and white oak
Moderately resistant	swamp chestnut oak
Slightly to nonresistant	black oak and red oak

Preservation: The heartwood of the white oak group is resistant to impregnation with preservatives, whereas that of the red oak group is more easily penetrated.

Uses: Ships, railroad crossties, timber bridges, tannin dyes, fuel wood, hardwood dimensions and flooring, furniture, veneer, plywood, barrels, kegs and casks (white oak group), truck and trailer beds, mining timbers, containers, pallets, caskets, boxes, paneling.

Toxicity: May cause allergic bronchial asthma, rhinitis, and dermatitis (40, 64, 105).

Additional Reading: 29, 55, 68, 74, 78.

Rhamnus spp. Rhamnaceae Buckthorn

The genus *Rhamnus* contains more than 100 species native to North America [5]; species are also located in the north temperate regions, South America, and South Africa. Many nonnative species have been naturalized in the United States. The name *rhamnus* is an ancient Greek name.

Rhamnus betulifolia	**birchleaf buckthorn**
Rhamnus californica	**California buckthorn**, California coffeeberry, coast coffeeberry, coffeeberry, pigeonberry, Sierra coffeeberry
Rhamnus caroliniana	alder buckthorn, birch bog, brittlewood, buckthorn-tree, **Carolina buckthorn**, elbow-brush, Indian cherry, pale-cat-wood, polecat-tree, polecatwood, stinkberry, stink cherry, stinkwood, tree buckthorn, yellow buckthorn, yellowwood
Rhamnus crocea	California redberry, coffeeberry, evergreen buckthorn, great redberry buckthorn, **hollyleaf buckthorn**, island buckthorn, island redberry buckthorn, redberry, redberry buckthorn
*Rhamnus purshiana**	bayberry, bearberry, bearwood, bitterbark, bitterboom, bittertrad, buckthorn cascara, California coffee, cascara, **cascara buckthorn**, cascara sagrada, chitam, chittam, chittern, chittim, coffeeberry, coffeebush, coffeetree, Oregon bearwood, pigeonberry, shittimwood, wahoo, western coffee, wild cherry, wild coffee, wild coffeebush, yellow-wood

*Commercial American species

The following description is for cascara buckthorn.

Distribution: The Pacific Coast region from British Columbia (including Vancouver Island), south to Washington, Oregon and northern California in coastal ranges, and Sierra Nevada. Also in the Rocky Mountain region of British Columbia, Washington, Idaho, and Montana.

The Tree: Cascara buckthorn grows in bottom lands, but it can be found along fence rows and roadsides. The tree grows scattered among Douglas-fir, maples, western redcedar and hemlock. The tree grows to a height of 40 ft (12 m), with a diameter of 1.5 ft (0.5 m). The bark is thin and smooth, developing brown to gray scales.

General Wood Characteristics: The sapwood of cascara buckthorn is yellowish white, while the heartwood is similar but with a red tinge. The wood is without characteristic odor or taste; it is hard and heavy.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.50	50	801
12%	0.52	36	577
Ovendry	0.55	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.63×10^6 lbf/in^2	4.344 GPa	0.96×10^6 lbf/in^2	6.619 GPa
MOR	6.30×10^3 lbf/in^2	43.439 MPa	8.70×10^3 lbf/in^2	59.987 MPa
$C_{\parallel}$	3.27×10^3 lbf/in^2	22.547 MPa	6.08×10^3 lbf/in^2	41.922 MPa
$C_{\perp}$	0.67×10^3 lbf/in^2	4.620 MPa	1.31×10^3 lbf/in^2	9.032 MPa
WML	13.4 in-lbf/in^3	92.393 kJ/m^3	7.8 in-lbf/in^3	53.781 kJ/m^3
Hardness	730 lbf	3,247.04 N	1,040 lbf	4,625.92 N
Shear$_{\parallel}$	1.15×10^3 lbf/in^2	7.929 MPa	1.61×10^3 lbf/in^2	11.101 MPa

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	4.6	NA	NA
Radial	3.2	NA	NA
Volumetric	7.6	NA	NA

[a]Reference (59.

Working Properties: Not available at this time.

Durability: Not available at this time.

Preservation: Not available at this time.

Uses: Posts, turnery, furniture parts, novelties. Bark and wood extract used for laxative.

Toxicity: Bark and fruits are poisonous; sap causes dermatitis (54, 64).

Additional Reading: 29, 55, 68, 74.

Rhus spp.
Anacardiaceae
Sumac

Sumac contains 100 to 150 species that grow in Eurasia/Africa [100], Central America [5] and North America [54]. All species look alike microscopically and are fluorescent under long-wave ultraviolet light. One species, *R. vernicifera,* is used for Oriental lacquer. The word *rhus* is from the classical Greek and Latin name of the type species, Sicilian sumac, *Rhus coriara* L.

Rhus choriophylla	**Mearns sumac**, New Mexico evergreen sumac, tough leaf sumac
Rhus copallina	black sumac, common sumac, dwarf sumac, flame leaf sumac, mountain sumac, mountain dwarf sumach, mountain wing-rib sumach, **shining sumac**, smooth sumac, southern sumac, upland sumac, varnish sumac whiteflower dwarf sumach, winged sumac, wing rib sumac
Rhus copallina var. *copallina*	black sumac, common sumac, dwarf sumac, flame leaf sumac, mountain sumac, mountain dwarf sumach, mountain wing-rib sumach, **shining sumac (typical)**, smooth sumac, southern sumac, upland sumac, varnish sumac, whiteflower dwarf sumach, winged sumac, wing rib sumac
Rhus glabra	common sumac, red sumac, Rocky Mountain sumac, scarlet sumac, **smooth sumac**, smooth sumach
Rhus integrifolia	California mahogany, California sumac, California sumach, lemonadeberry, **lemonade sumac**, lemonade sumach, lentisco, mahogany, mahogany sumac, mahogany sumach, sourberry, sourwood, western sumach
Rhus kearneyi	**Kearney sumac**
Rhus lanceolata	dwarf sumac, dwarf sumach, lanceleaf dwarf sumach, prairie dwarf sumach, prairie flame leaf sumac, prairie shining sumac, **prairie sumac**, Texan sumac
Rhus laurina	**laurel sumac**, laurel sumach
Rhus microphylla	desert sumac, flame leaf sumac, **littleleaf sumac**, scrub sumac, small leaf dwarf sumac, small-leaf sumac, winged sumac, wing rib sumac
Rhus ovata	bush laurel, chaparral sumac, mountain laurel, sugarbush, **sugar sumac**
Rhus typhina	American sumac, hairy sumac, hairy sumach, **staghorn sumac**, staghorn sumach, velvet sumac, velvet sumach, vinegar tree, Virginia sumach
Rhus virens	**evergreen sumac**, lentisco, tobacco sumac

The following description is for *Rhus typhina*.

Distribution: North America, from Quebec to Maine, southern Ontario, northern Michigan, Wisconsin, and Minnesota; south to northeastern Iowa, Illinois, Indiana, northern Kentucky, West Virginia, and Maryland. In the mountains to Virginia, North Carolina, northern Georgia and central Tennessee.

The Tree: Staghorn sumac is the largest of the native sumacs. It is classed as a large shrub reaching 40 ft (12 m) high and 1 ft (0.3 m) wide at base. Sumacs are fast-growing, short-lived plants important to wildlife for cover. The fruits are produced in large amounts and are eaten by many species of birds and mammals. The leaves are also eaten by mammals. Sumacs can be shrubs, vines and trees with alternate pinnately compound leaves, which may be evergreen or deciduous. Shoot buds are covered with hairs. The flowers are yellowish green and are produced in small clusters. The flower spikes turn into velvety bunches (staghorns) in the fall, with the fruits berry-like, small, and round or oval, with a pit and seed. The leaves turn to red, purple and yellow in the fall. Tannins can be obtained from bark and leaves.

General Wood Characteristics: The wood of sumac is ring porous to semi-ring porous, with a whitish gray sapwood with yellow or green streaks. The heartwood is olive-green to greenish yellow to russet brown with dark streaks. The wood is fluorescent under ultraviolet radiation. It is light weight, soft, and brittle, with a high luster.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.45	41	657
12%	0.47	33	529
Ovendry	NA	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.81×10^6 lbf/in^2	5.585 GPa	1.19×10^6 lbf/in^2	8.205 GPa
MOR	5.80×10^3 lbf/in^2	39.991 MPa	10.2×10^3 lbf/in^2	70.329 MPa
$C_{\parallel}$	2.68×10^3 lbf/in^2	18.479 MPa	5.94×10^3 lbf/in^2	40.956 MPa
$C_{\perp}$	0.48×10^3 lbf/in^2	3.310 MPa	1.01×10^3 lbf/in^2	6.964 MPa
WML	10.8 in-lbf/in^3	74.466 kJ/m^3	8.4 in-lbf/in^3	57.918 kJ/m^3
Hardness	590 lbf	2,624.32 N	680 lbf	3,024.64 N
Shear$_{\parallel}$	NA	NA	NA	NA

[a]Reference (59).

Drying and Shrinkage: Sumac is easily air-dried without cracks or checks. The fresh-cut wood exudes a sticky fluid at the cambium (junction between bark and wood), which dries after seasoning.

Working Properties: Sumac wood is easily worked with sharp tools. It frays on turning.

Durability: No information available at this time.

Preservation: No information available at this time.

Uses: Novelties, carving, turnery.

Toxicity: Sap and wood cause dermatitis (40, 54, 64, 105).

Additional Reading: 29, 55, 68, 74.

Robinia pseudoacacia
Leguminosae
Black Locust

Robinia is a genus of about 10 species native to eastern North America and Mexico. The genus *Robinia* is dedicated to Jean Robin (1550-1629) and his son Vespasian Robin (1579-1662), herbalists to kings of France and first to cultivate locust in Europe.

Robinia kelseyi	**Kelsey locust**
Robinia neomexicana	locust, Mexican locust, New Mexican locust, New Mexican robinia, **New Mexico locust**, southwestern locust, thorny locust, western locust
*Robinia pseudoacacia**	acacia, bastard locust, black laurel, **black locust**, common locust, common robinia, false acacia, false black locust, green locust, honey locust, locust, peaflower locust, post locust, red locust, robinia, shipmast locust, white locust, white honey-flower, yellow locust
Robinia viscosa	black locust, clammy-bark locust, **clammy locust**, false acacia, honey locust, red locust, red-flowering locust, rose acacia, rose-flowering locust

* commercial species

Distribution: Black locust is native to the Appalachian Mountains from Pennsylvania to northern Georgia and Alabama and to the Ozark Mountains of southern Missouri, Arkansas and eastern Oklahoma. Also in southern Illinois and Indiana. Black locust has been extensively naturalized in the United States and Canada.

The Tree: Black locust reaches a height of 100 ft (30 m), with a diameter of 3 ft (1 m).

General Wood Characteristics: The sapwood of black locust is a creamy white, while the heartwood varies from a greenish yellow to dark brown. The wood turns a reddish brown when exposed to the air. The wood is often confused with osage orange (*Maclura pomifera*). It has a high density and decay resistance. It shows slight shrinkage and stays in place well. Black locust is very strong in bending and is one of the hardest woods in America. Its shock resistance is almost that of hickory (*Carya* spp.).

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.66	58	929
12%	0.69	48	769
Ovendry	0.71	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.85×10^6 lbf/in^2	12.755 GPa	2.05×10^6 lbf/in^2	14.135 GPa
MOR	13.8×10^3 lbf/in^2	95.151 MPa	19.4×10^3 lbf/in^2	133.763 MPa
$C_{\parallel}$	6.80×10^3 lbf/in^2	46.886 MPa	10.2×10^3 lbf/in^2	70.329 MPa
$C_{\perp}$	1.16×10^3 lbf/in^2	7.998 MPa	1.83×10^3 lbf/in^2	12.618 MPa
WML	15.4 in-lbf/in^3	106.183 kJ/m^3	18.4 in-lbf/in^3	126.868 kJ/m^3
Hardness	1,570 lbf	6,983.36 N	1,700 lbf	7,561.60 N
$Shear_{\parallel}$	1.76×10^3 lbf/in^2	12.135 MPa	2.48×10^3 lbf/in^2	17.099 MPa

[a]Reference (98).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.2	5.8	2.4
Radial	4.6	3.7	1.5
Volumetric	10.2	8.2	3.4

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-A3	T3-A1	NA	NA	NA

[a]References (6, 86).

Working Properties: Black locust is difficult to work with hand tools, but it turns well on a lathe and nails well. It has no distinctive odor or taste.

Durability: Rated as exceptionally resistant to heartwood decay.

Preservation: No information available at this time.

Uses: Fencing, insulator pins, furniture, mine timbers, treenails for ships. The trees are used in strip mine reclamation because of their ability to survive the acid conditions and for their nitrogen-fixing roots.

Toxicity: There are reports of dermatitis from the wood (4, 9, 17).

Additional Reading: 20, 29, 41, 55, 60, 68, 74, 82, 104.

Salix nigra
Salicaceae
Black Willow

Willow (*Salix* spp.) is composed of 170 to 400 species native to Eurasia [60], South America [1], Central America [19] and North America [87]. All species look alike microscopically. The word *salix* is the classical Latin name for willow.

Other Common Names: Dudley willow, Goodding willow, southeastern black willow, swamp walnut, swamp willow, tall black willow, western black willow, willow.

Distribution: Throughout the eastern United States, from the Atlantic coast west to Minnesota, Iowa, Nebraska, Kansas, Oklahoma and Texas.

The Tree: Black willow trees reach a height of 140 ft (43 m), with a diameter of 4 ft (1.2 m).

General Wood Characteristics: The sapwood of black willow is light tan, while the heartwood is pale reddish brown to grayish brown. The wood has no characteristic odor or taste. It is soft, but does not splinter when dented; uniform in texture; and weak in bending and crushing.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.36	50	801
12%	0.39	26	417
Ovendry	0.41	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry, (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.79×10^6 lbf/in^2	5.45 GPa	1.01×10^6 lbf/in^2	6.96 GPa
MOR	4.8×10^3 lbf/in^2	33.1 MPa	7.8×10^3 lbf/in^2	53.8 MPa
$C_{\parallel}$	2.04×10^3 lbf/in^2	14.1 MPa	4.10×10^3 lbf/in^2	28.3 MPa
$C_{\perp}$	0.18×10^3 lbf/in^2	1.24 MPa	0.43×10^3 lbf/in^2	2.96 MPa
WML	11.0 in-lb/in^3	75.8 kJ/m^3	8.80 in-lb/in^3	60.7 kJ/m^3
Hardness	NA	NA	NA	NA
$Shear_{\parallel}$	0.68×10^3 lbf/in^2	4.69 MPa	1.25×10^3 lbf/in^2	8.62 MPa

[a]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.7	6.5	2.7
Radial	3.3	2.1	0.9
Volumetric	13.9	11.5	4.8

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T10-F4	T8-F3	NA	NA	NA

[a]References (6, 86).

Working Properties: Black willow is classed as one of the most difficult woods to machine. It glues very well and readily accepts finishes. It rates moderately high in shock resistance and low in nail-holding ability, but it does not split readily because of its interlocked grain.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Factory lumber, veneer, box lumber, pulpwood, furniture, paneling, interior trim, cabinetry, artificial limbs, fiber board, slack cooperage, excelsior, novelties, toys, wooden shoes, polo balls and carvings.

Toxicity: No information available at this time.

Additional Reading: 29, 53, 55, 68, 74.

Sambucus spp. Caprifoliaceae Elder

The genus *Sambucus* is composed of about 30 species, native to North America, Asia, Europe, northern Africa, the West Indies and the Andean region of South America. Elder trees are naturalized in other areas of the world. The word *sambucus* is the classical Latin name, believed to be from the Greek name of a stringed musical instrument made of this wood.

Sambucus callicarpa	California tree elder, coast red elder, **Pacific red elder,** redberry elder, red elderberry
Sambucus canadensis	**American elder,** blackberry elder, common elder, common elderberry
Sambucus canadensis var. *canadensis*	**American elder (typical)**
Sambucus canadensis var. *laciniata*	**Florida elder**, Florida elderberry, Gulf elder, southern elder
Sambucus cerulea	blueberry elder, **blue elder**, blue elderberry, New Mexico elder
Sambucus mexicana	Arizona elder, desert elderberry, **Mexican elder**, mountain elder, New Mexico elder, saúco, tapiro
Sambucus velutina	**velvet elder**, velvetleaf elder

Distribution: North America

The Tree: Elder trees are woody plants (trees to shrubs) with large, opposite leaves, which may be evergreen or deciduous and are pinnately compound. The trees produce clusters of small white to pink flowers in flat-topped clusters (like Queen Anne's lace), which later develop into berry-like fruits. Elders can attain a height of 50 ft (15 m), with a diameter of 1 ft (0.3 m). The bark is thick, with irregular ridges or scales, and dark brown to reddish brown.

The following description is for blue elder.

General Wood Characteristics: The sapwood of elder is white, while the heartwood is a yellowish brown. The wood has a low luster and no odor or taste. It is light weight, brittle, and of medium texture.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.46	65	1,041
12%	0.52	36	577
Ovendry	0.57	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.90×10^6 lbf/in^2	6.205 GPa	1.03×10^6 lbf/in^2	7.102 GPa
MOR	6.60×10^3 lbf/in^2	45.507 MPa	9.20×10^3 lbf/in^2	63.434 MPa
$C_{\parallel}$	3.04×10^3 lbf/in^2	20.961 MPa	5.09×10^3 lbf/in^2	35.096 MPa
$C_{\perp}$	0.52×10^3 lbf/in^2	3.585 MPa	0.76×10^3 lbf/in^2	5.240 MPa
WML	8.8 in-lbf/in^3	60.676 kJ/m^3	9.9 in-lbf/in^3	68.261 kJ/m^3
Hardness	720 lbf	3202.56 N	840 lbf	3736.32 N
$Shear_{\parallel}$	1.09×10^3 lbf/in^2	7.515 MPa	NA	NA

[a]Reference (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	9.0	NA	NA
Radial	4.4	NA	NA
Volumetric	15.6	NA	NA

[a]Reference (59).

Working Properties: Elder is easy to work and finishes smoothly.

Durability: Nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Twigs with pith removed were used for "spiles," the pipes used for getting maple sap to the bucket. Turnery.

Toxicity: The whole plant is poisonous (54).

Additional Reading: 29, 55, 68, 74.

Sassafras albidum
Lauraceae
Sassafras

Sassafras is a genus composed of three species native to North America [1], China [1] and Taiwan [1]. The name *sassafras* is a Native American name used by the Spanish and French in Florida in the middle of the 16th century. In 1577, the use of sassafras by Native Americans was reported and in 1587, Sir Walter Raleigh brought it back to England from the Virginia Colony. In the early 17th century (1602–1603), several ships were dispatched from England to the colonies to collect sassafras roots; the colonists used the wood to build forts. These forays were known as the Great Sassafras Hunts.

Other Common Names: ague-tree, black ash, cinnamon wood, common sassafras, file-gumbo, gumbo-file, red sassafras, sasafras, sassafac, sassafrac, **sassafras**, sassafrasso, saxifrax, saxifrax tree, smelling-stick, wah-en-nah-kas, white sassafras.

Distribution: Sassafras is native to North America from Maine through Ontario, Michigan, Iowa, and Kansas, to Florida and Texas.

The Tree: The tree can reach a height of 90 ft (27 m) and a diameter of 5 ft (1.5 m). The leaves vary in shape from simple (entire) to mitten-shape to tri-lobed on the same tree. Sassafras produces greenish-yellow flowers in the spring and bright red, yellow, and orange foliage in the fall. It has thick, dark red-brown bark that is deeply furrowed. Trees are either male or female, although the flowers may appear perfect. The fruits are olive-shaped to spherical, with a dark skin and thin flesh. Sassafras is a pioneer species, the first to invade abandoned fields. It spreads asexually by root runners, forming small groves of the tree. Sassafras grows alongside persimmon, oak, sweetgum, dogwood, ironwood and pawpaw.

General Wood Characteristics: Sassafras heartwood is pale brown to orange brown, resembling ash or chestnut; the sapwood is a narrow yellowish-white. The wood is coarse-grained, straight, brittle and soft, with a spicy aromatic odor. Sassafras is a ring-porous species.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.42	44	705
12%	0.46	31	497
Ovendry	0.47	NA	NA

[a]References: specific gravity, green and 12%, (98); specific gravity, ovendry (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.91×10^6 lbf/in^2	6.274 GPa	1.12×10^6 lbf/in^2	7.722 GPa
MOR	6.00×10^3 lbf/in^2	41.370 MPa	9.00×10^3 lbf/in^2	62.055 MPa
$C_{\parallel}$	2.73×10^3 lbf/in^2	18.823 MPa	4.76×10^3 lbf/in^2	32.820 MPa
$C_{\perp}$	0.37×10^3 lbf/in^2	2.551 MPa	0.85×10^3 lbf/in^2	5.861 MPa
WML	7.1 in-lbf/in^3	48.955 kJ/m^3	8.7 in-lbf/in^3	59.987 kJ/m^3
Hardness	520 lbf	2,312.96 N	630 lbf	2,802.24 N
$Shear_{\parallel}$	0.95×10^3 lbf/in^2	6.550 MPa	1.24×10^3 lbf/in^2	8.549 MPa

[a]Reference (98) except hardness (59).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	6.2	5.0	2.1
Radial	4.0	3.2	1.3
Volumetric	10.3	8.2	3.4

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T8-D4	NA	NA	NA	NA

[a]References (6, 86).

Working Properties: Sassafras is easily worked and takes a finish well. It glues well and holds screws better than nails.

Durability: Sassafras is very resistant to heartwood decay in exposed, damp conditions, making it good for fence posts and the sills of houses.

Preservation: No information available at this time.

Uses: Lumber, furniture, posts, fence rails and posts, kindling, boxes, cooperage (slack), general millwork, small boats, oil from root bark, colonial dye (orange) from bark.

Toxicity: No information available at this time.

Additional Reading: 13, 29, 55, 68, 74.

Tilia americana
Tiliaceae
American Basswood

Basswood (*Tilia* spp.), also known as lime in England and Europe, consists of 30 to 35 species native to Eurasia [30] and North America [4]. All species look alike microscopically. A favorite wood for carvings, such as those by Grinling Gibbons (England, 1670-1710). The word *tilia* is the classical Latin name, probably from the Greek *ptilon*, wing, referring to the winglike bract of flower clusters.

*Tilia americana**	**American basswood**, American limetree, American linden, American whitewood, Amerikaanse linde, Amerikanische linde, Amerikansk lind, bass-tree, basswood, bee-tree, black limetree, gray linden, lein, limetree, linden, linn, linn-tree, spoonwood, svart-lind, tiglio americano, tiglo americano, tilleul americain, tilleul noir, tilo americano, white linn, whitewood, wickup, yellow basswood
*Tilia caroliniana**	Amerikaanse linde, Amerikansk lind, basswood, **Carolina basswood**, Carolina linde, Carolina linden, downy basswood, Florida basswood, Florida linden, linden, southern basswood, tiglio Americano, tilleul Americain, tilleul de Caroline, tilo Americano, tilo de Carolina
*Tilia heterophylla**	American lime, Amerikaanse linde, Amerikansk lind, basswood, bee-tree, beetree linden, Tiglio Americano, Tilleul Americain, Tilo Americano, Tuleul Americain, **white basswood**

* commercial species

Distribution: The natural range of American basswood is from southwestern New Brunswick to central Quebec, Ontario and southeast Manitoba, south to eastern North Dakota and northeastern Oklahoma to northern Arkansas and Tennessee, east to North Carolina, and north to Pennsylvania and New Jersey.

The Tree: American basswood grows to co-dominance in association with sugar maple and red oak/white ash forests, while it is a minor component in other forest types. It can grow to an elevation of 5,000 ft (1524 m) in the Appalachians. The tree can reach a height of 120 ft (37 m), with a diameter of almost 5 ft (1.5 m). Basswood may grow to be more than 140 years old. The trees have straight trunks, with most of the bole limb-free, and narrow, short crowns. The trees grow as a cluster of stems, developed from stump sprouts. The bark is initially dark green and shiny, developing to a grayish color with deep furrows.

General Wood Characteristics: The sapwood of basswood is white to cream, while the heartwood is pale to reddish brown, with darker streaks. When dry, the wood has no characteristic odor or taste. The wood is soft and light, with a fine, even texture.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.32	42	673
12%	0.37	26	417
Ovendry	0.40	NA	NA

[a]References: specific gravity green and 12% (98); specific gravity, ovendry (59); weight (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	1.04×10^6 lbf/in^2	7.171 GPa	1.46×10^6 lbf/in^2	10.067 GPa
MOR	5.00×10^3 lbf/in^2	34.475 MPa	8.70×10^3 lbf/in^2	59.987 MPa
$C_{\parallel}$	2.22×10^3 lbf/in^2	15.307 MPa	4.73×10^3 lbf/in^2	32.613 MPa
$C_{\perp}$	0.17×10^3 lbf/in^2	1.172 MPa	0.37×10^3 lbf/in^2	2.551 MPa
WML	5.3 in-lbf/in^3	36.544 kJ/m^3	7.2 in-lbf/in^3	49.644 kJ/m^3
Hardness	250 lbf	1,112.00 N	410 lbf	1,823.68 N
$Shear_{\parallel}$	0.60×10^3 lbf/in^2	4.137 MPa	0.99×10^3 lbf/in^2	6.826 MPa

[a]Reference (98).

Drying and shrinkage[a]

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	9.3	7.4	3.1
Radial	6.6	5.3	2.2
Volumetric	15.8	12.6	5.3

[a]References: 0% MC, (98); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T12-E7	T10-E6	NA	NA	NA
Lighter color	T9-E7	T7-E6	NA	NA	NA

[a]References (6, 86).

Working Properties: American basswood works easily with tools, making it a premier carving wood. It is poor in holding nails and in bending, but moderate in gluing and good for holding paint or printing inks.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: No information available at this time.

Uses: Lumber, veneer, plywood, carvings, pulp, decoys, fiber products, furniture stock, caskets, mobile homes, shade rollers, signs, toys, sporting goods, wooden ware, and novelties.

Toxicity: No information available at this time.

Additional Reading: 29, 47, 55, 68, 74.

Ulmus spp.
Ulmaceae
Elm

Elm (*Ulmus* spp.) contains about 45 species native to Asia [11], Europe and the Mediterranean [6], South and Central America [7] and North America [7]. All species look alike microscopically. The word *ulmus* is the classical Latin name.

Soft Elms

Ulmus americana	**American elm**, American soft elm, American weeping elm, American white elm, Florida elm, gray elm, gray hard elm, rock elm, springwood, soft elm, swamp elm, water elm, white elm
Ulmus rubra	gray elm, Indian elm, it slips ooo-hoosk-ah, moose elm, red elm, red wooded elm, rock elm, **slippery elm**, soft elm, sweet elm

Hard Elms

Ulmus alata	cork elm, mountain elm, red elm, southern elm, wahoo, wahoo elm, water elm, whahoo, **winged elm**, witch elm
Ulmus crassifolia	American red elm, basket elm, **cedar elm**, red elm, rock elm, small leaved elm, southern rock elm, Texas elm, water elm
Ulmus serotina	Red elm, **September elm**
Ulmus thomasii	Canadian rock elm, cliff elm, cork elm, corkbark elm, corky elm, corky barked elm, hickory elm, northern cork elm, northern corkbark elm, **rock elm**, swamp elm, Thomas elm, wahoo, white elm, white corky elm

Distribution: The eastern to midwest United States.

The Tree: Elm trees can reach a height of 100 ft (30 m), with a diameter of 3 ft (1 m). They may be infected with the Dutch elm disease, caused by a fungus (*Ceratocystis ulmi*), especially in shade trees.

General Wood Characteristics: The sapwood of elm is nearly white, while the heartwood is light brown to brown with a reddish tinge. The wood has no characteristic odor or taste.

Weight

Species	MC	SG	Weight lb/ft^3	Weight kg/m^3
Ulmus alata	Green	0.60	60	960
(winged elm)[a]	12%	0.66	42	673
	Ovendry	0.73	NA	NA
Ulmus americana	Green	0.46	54	865
(American elm)[b]	12%	0.50	35	561
	Ovendry	0.55	NA	NA
Ulmus crassifolia	Green	0.59	59	945
(cedar elm)[a]	12%	0.64	41	657
	Ovendry	0.70	NA	NA
Ulmus rubra	Green	0.48	56	897
(slippery elm)[b]	12%	0.53	37	593
	Ovendry	0.57	NA	NA
Ulmus thomasii	Green	0.57	53	849
(rock elm)[b]	12%	0.63	44	705
	Ovendry	0.66	NA	NA

[a]Reference (90).
[b]References: specific gravity, green and 12%, (98); specific gravity, ovendry (59); weight, (59).

Mechanical properties[a]

Property	Green		Dry	
Ulmus alata (winged elm)[a]				
MOE	1.21×10^6 lbf/in^2	8.343 GPa	1.65×10^6 lbf/in^2	11.377 GPa
MOR	9.20×10^3 lbf/in^2	63.434 MPa	14.8×10^3 lbf/in^2	102.046 MPa
$C_{\|\|}$	3.70×10^3 lbf/in^2	25.512 MPa	6.78×10^3 lbf/in^2	46.748 MPa
$C_{\perp}$	0.63×10^3 lbf/in^2	4.344 MPa	1.02×10^3 lbf/in^2	7.033 MPa
WML	21.7 in-lbf/in^3	149.622 kJ/m^3	23.1 in-lbf/in^3	159.275 kJ/m^3
Hardness	1,1140lbf	5,070.72 N	1,540 lbf	6,849.92 N
$Shear_{\|\|}$	1.30×10^3 lbf/in^2	8.963 MPa	2.37×10^3 lbf/in^2	16.341 MPa
Ulmus Americana (American elm)[b]				
MOE	1.11×10^6 lbf/in^2	7.653 GPa	1.34×10^6 lbf/in^2	9.239 GPa
MOR	7.20×10^3 lbf/in^2	49.644 MPa	11.8×10^3 lbf/in^2	81.361 MPa
$C_{\|\|}$	2.91×10^3 lbf/in^2	20.064 MPa	5.52×10^3 lbf/in^2	38.060 MPa
$C_{\perp}$	0.36×10^3 lbf/in^2	2.482 MPa	0.69×10^3 lbf/in^2	4.758 MPa
WML	11.8 in-lbf/in^3	81.361 kJ/m^3	13.0 in-lbf/in^3	89.635 kJ/m^3
Hardness	620 lbf	2,757.76 N	830 lbf	3,691.84 N
$Shear_{\|\|}$	1.00×10^3 lbf/in^2	6.895 MPa	1.51×10^3 lbf/in^2	10.411 MPa
Ulmus crassifolia (cedar elm)[a]				
MOE	1.17×10^6 lbf/in^2	8.067 GPa	1.48×10^6 lbf/in^2	10.205 GPa
MOR	9.20×10^3 lbf/in^2	63.434 MPa	13.5×10^3 lbf/in^2	93.083 MPa
$C_{\|\|}$	3.37×10^3 lbf/in^2	23.236 MPa	6.02×10^3 lbf/in^2	41.508 MPa
$C_{\perp}$	0.60×10^3 lbf/in^2	4.137 MPa	0.95×10^3 lbf/in^2	6.550 MPa
WML	20.0 in-lbf/in^3	137.900 kJ/m^3	18.6 in-lbf/in^3	128.247 kJ/m^3
Hardness	1,100 lbf	4,892.80 N	1,320 lbf	5,871.36 N
$Shear_{\|\|}$	1.32×10^3 lbf/in^2	9.101 MPa	2.24×10^3 lbf/in^2	15.444 MPa
Ulmus rubra (slippery elm)[b]				
MOE	1.23×10^6 lbf/in^2	8.481 GPa	1.49×10^6 lbf/in^2	10.274 GPa
MOR	8.00×10^3 lbf/in^2	55.160 MPa	13.0×10^3 lbf/in^2	89.635 MPa
$C_{\|\|}$	3.32×10^3 lbf/in^2	22.891 MPa	6.36×10^3 lbf/in^2	43.852 MPa
$C_{\perp}$	0.42×10^3 lbf/in^2	2.896 MPa	0.82×10^3 lbf/in^2	5.654 MPa
WML	15.4 in-lbf/in^3	106.183 kJ/m^3	16.9 in-lbf/in^3	116.526 kJ/m^3
Hardness	660 lbf	2,935.68 N	860 lbf	3,825.28 N
$Shear_{\|\|}$	1.11×10^3 lbf/in^2	7.653 MPa	1.63×10^3 lbf/in^2	11.238 MPa
Ulmus thomasii (rock elm)[b]				
MOE	1.19×10^6 lbf/in^2	8.205 GPa	1.54×10^6 lbf/in^2	10.618 GPa
MOR	9.50×10^3 lbf/in^2	65.503 MPa	14.8×10^3 lbf/in^2	102.046 MPa
$C_{\|\|}$	3.78×10^3 lbf/in^2	26.063 MPa	7.05×10^3 lbf/in^2	48.610 MPa
$C_{\perp}$	0.61×10^3 lbf/in^2	4.206 MPa	1.23×10^3 lbf/in^2	8.481 MPa
WML	19.8 in-lbf/in^3	136.521 kJ/m^3	19.2 in-lbf/in^3	132.384 kJ/m^3
Hardness	940 lbf	4,181.12 N	1,320 lbf	5,871.36 N
$Shear_{\|\|}$	1.27×10^3 lbf/in^2	8.756 MPa	1.92×10^3 lbf/in^2	13.238 MPa

[a]Reference (90).
[b]Reference (98).

Drying and shrinkage[a]

Type of shrinkage	Percentage of shrinkage (green to final moisture content) 0% MC	6% MC	20% MC
Tangential			
Ulmus alata (winged elm)	11.6	NA	NA
Ulmus americana (American elm)	9.5	7.6	3.2
Ulmus crassifolia (cedar elm)	10.2	NA	NA
Ulmus rubra (slippery elm)	8.9	7.1	3.0
Ulmus thomasii (rock elm)	8.1	6.5	2.7
Radial			
Ulmus alata (winged elm)	5.3	NA	NA
Ulmus americana (American elm)	4.2	3.4	1.4
Ulmus crassifolia (cedar elm)	4.7	NA	NA
Ulmus rubra (slippery elm)	4.9	3.9	1.6
Ulmus thomasii (rock elm)	4.8	3.8	1.6
Volumetric			
Ulmus alata (winged elm)	17.7	NA	NA
Ulmus americana (American elm)	14.6	11.7	4.9
Ulmus crassifolia (cedar elm)	15.4	NA	NA
Ulmus rubra (slippery elm)	13.8	11.0	4.6
Ulmus thomasii (rock elm)	14.9	11.3	4.7

[a]References: 0% MC, (98); 6% and 20%, (90).

Kiln drying schedule[a]

Species	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-B3	T3-B2	T3-B2	T3-B1	T3-A1

[a]References (6, 86).

Working Properties: Elm is moderately heavy, hard and stiff, with excellent bending and shock resistance. It is difficult to split because of its interlocked grain.

Durability: Rated as slightly or nonresistant to heartwood decay.

Preservation: Slippery elm is classed as permeable to preservatives, and rock elm, resistant.

Uses: Boxes, baskets, crates, cheese boxes, slack cooperage, furniture, caskets, hockey sticks, veneer, pulp and paper manufacture.

Toxicity: No information available at this time.

Additional Reading: 16, 29, 55, 68, 74.

Umbellularia californica
Lauraceae
California Laurel

Umbellularia californica is the only species in this genus. Its name is derived from the Latin *umbellula*, a small umbel, describing the flower cluster (inflorescence).

Other Common Names: acacia, acacia burl, balm-of-heaven, bay, bay laurel, bay tree, black laurel, black myrtle, cajeput, cajeput-tree, California bay, California bay tree, **California laurel**, California olive, California sassafras, Californian olive, laurel, mountain hemlock, mountain laurel, myrtle, myrtle tree, myrtly, Oregon mirt, Oregon myrtle, oreodaphne, Pacific myrtle, peppermintwood, pepperwood, spice tree, white laurel, white myrtle, yellow laurel, yellow myrtle.

Distribution: Pacific coast region of southwest Oregon, south mostly in coastal ranges to southern California; in the Sierra Nevada to central California.

The Tree: The tree grows to 80 ft (24 m) in height and 3 ft (1 m) in diameter. California laurel grows at elevations from sea level to over 6,000 ft (1,828 m). It is tolerant of various soil types and conditions. California laurel grows in many habitats, from flatlands to mountain slopes; the best conditions are alluvial deposits from streams and rivers. It grows in association with coastal redwood, sequoia, Port Orford cedar and Douglas-fir. The trees are slow-growing and have multiple trunks in poorer soils. The leaves are used by spice companies as "bay" leaves. The leaves are evergreen and glossy, while the flowers are small and yellowish green. The tree produces spherical purplish fruits. This species is planted as an ornamental shrub in warmer climates of the south and west. The small twigs are pale green, turning reddish brown over time. The bark is a dark red-brown and sometimes an inch (25 mm) thick.

General Wood Characteristics: The sapwood of California laurel is thick and whitish to light brown, while the heartwood is light brown to grayish brown to an olive color, with dark streaks. The wood has a strong, spicy odor. It darkens when soaked in water.

Weight[a]

		Weight	
Moisture content	Specific gravity	lb/ft^3	kg/m^3
Green	0.51	54	865
12%	0.55	39	625
Ovendry	0.59	NA	NA

[a]Reference (59).

Mechanical properties[a]

Property	Green		Dry	
MOE	0.72×10^6 lbf/in^2	4.964 GPa	0.94×10^6 lbf/in^2	6.481 GPa
MOR	6.6×10^3 lbf/in^2	45.507 MPa	8.0×10^3 lbf/in^2	55.160 MPa
$C_{\parallel}$	3.02×10^3 lbf/in^2	20.823 MPa	5.64×10^3 lbf/in^2	38.888 MPa
$C_{\perp}$	0.80×10^3 lbf/in^2	5.516 MPa	1.40×10^3 lbf/in^2	9.653 MPa
WML	16.8 in-lbf/in^3	115.836 kJ/m^3	8.2 in-lbf/in^3	56.539 kJ/m^3
Hardness	1,000 lbf	4,448.00 N	1,270 lbf	5,648.96 N
$Shear_{\parallel}$	1.27×10^3 lbf/in^2	8.756 MPa	1.86×10^3 lbf/in^2	12.824 MPa

[a]Reference (59).

Drying and shrinkage[a,b]

Type of shrinkage	Percentage of shrinkage (green to final moisture content)		
	0% MC	6% MC	20% MC
Tangential	8.1	6.8	2.8
Radial	2.8	2.3	1.0
Volumetric	11.9	9.9	4.1

[a]Difficult to season while bringing out the best colors. Should be submerged when green, with very slow, controlled drying.
[b]References: 0% MC, (59); 6% and 20% MC, (90).

Kiln drying schedule[a]

Condition	4/4, 5/4, 6/4 stock	8/4 stock	10/4 stock	12/4 stock	16/4 stock
Standard	T6-A4	T5-A3	NA	NA	NA

[a]References (6, 86).

Working Properties: California laurel is easily worked and takes a high polish.

Durability: The heartwood is very resistant to decay.

Preservation: No information available at this time.

Uses: Veneer (burls for cabinetry), novelties, candlesticks, bowls, plates, woodenware, turnery, furniture squares, cabinetwork, interior trim. Used under the keel to launch ships.

Toxicity: Can be an irritant (64, 105).

Additional Reading: 29, 55, 68, 74.

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Glossary

Airdried—The dried condition of lumber, usually 12 to 20 percent moisture content, reached by exposing the wood for a sufficient period to the prevailing atmospheric conditions.

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 springwood and summerwood.

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.

Birds-eye—Small localized areas in wood with the fibers indented and otherwise contorted to form few to many small circular or elliptical figures remotely resembling birds'eyes on the tangential surface. Common in sugar maple and used for decorative purposes; rare in other hardwood species.

Board— (1) Yard lumber that is less than 2 inches (50 mm) thick and 2 or more inches wide. (2) A term usually applied to 1-inch- (25.4-mm-) thick lumber of all widths and lengths.

Broad-leaved trees— (*See* Hardwoods.)

Cambium—The one-cell-thick 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 anatom*y, a general term for the minute units of wood structure having distinct cell walls and cell cavities. Includes wood fibers, vessel segments, 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.

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).

Clear wood—Wood without knots.

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.

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, ringshaked, 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; from insect or fungus attack; and from 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 in terms of moisture content.

Diffuse-porous wood—A hardwood in which the pores tend to be uniform in size and distribution throughout each annual ring or to decrease in size slightly and gradually toward the outer border of the ring.

Discoloration—*Syn*: Stain. Change in the color of lumber resulting from fungal and chemical stains, weathering, or heat treatment.

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.

Earlywood—*Syn*: Springwood. Wood formed during the early period of annual growth; usually less dense and mechanically weaker than wood formed later.

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.

Fiber, wood—A comparatively long, narrow, tapering hardwood cell closed at both ends.

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 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 of 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.

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.

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 just as cut from freshly felled trees. (2) In accordance with the American Softwood Lumber Standard, lumber above 19 percent 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, one of the botanical groups of trees that have 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, lower strength, higher 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 depending 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 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 inches (50 mm) thick and 2 or more inches wide.

Lumber, dimension—Lumber from 2 inches (50 mm) up to 5 inches (127 mm) thick and 2 or more inches wide. Includes joists, rafters, studs, planks, and small timbers.

Lumber, timbers—Lumber ≥5 inches (≥127 mm) in the smallest dimension. Includes beams, stringers, posts, caps, sills, girders, and purlins.

Lumen—In wood anatomy, the cell cavity.

Mineral streak—An olive to greenish-black or brown discoloration of undetermined cause in hardwoods, particularly hard maples; commonly associated with bird pecks and other injuries; occurs in streaks usually containing accumulations of mineral matter.

Moisture content, wood—Weight of water contained in the wood, expressed as a percentage of the weight of the ovendry wood. Moisture content classes:

Airdried—Wood having an average moisture content of 25 percent or lower, with no material over 30 percent.

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 airdried—Wood with an average moisture content between 25 and 45 percent, with no material over 50 percent.

Shipping dry—Lumber partially dried to prevent stain or mold in brief periods of transit, preferably with the outer 1/8-inch (3-mm) dried.

Mold—A fungus growth on lumber at or near the surface and, therefore, 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 from 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.

Ovendry—The 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 further 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.

Pore—The cross section of a specialized hardwood cell known as a vessel. *See* Vessels.

Porous woods—Another name for hardwoods, which frequently have vessels or pores large enough to be seen readily without magnification.

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.

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.

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-porous wood—Wood in which the pores of the earlywood (springwood) are distinctly larger than those of the latewood (summerwood) and form a well-defined zone or growth ring.

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.

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.

Softwood—Generally, one of the botanical groups of trees that, in most cases, have needlelike to scalelike leaves; the conifers. Also, the wood produced by such trees. (The term has no reference to the actual hardness of the wood.)

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 higher than the variety.

Specific gravity—The ratio of the ovendry 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 ovendry weight.

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.

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.

Stress—Force per unit of area.

Summerwood—*See* Latewood.

Swelling—Increase in the dimensions of wood caused by increased moisture content. Swelling occurs tangentially, radially, and, to a less 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 is sawn tangentially.

Tension wood—A type of wood found in leaning trees of some hardwood species, characterized by the presence of fibers technically known as “gelatinous” and by excessive longitudinal shrinkage. Tension wood fibers tend to “pull out” on sawn and planed surfaces, giving so-called fuzzy grain. Tension wood causes crook and bow and may collapse. Because of slower than normal drying, tension wood zones may remain wet when the surrounding wood is dry.

Texture—A term often used interchangeably with grain; sometimes used to combine the concepts of density and degree of contrast between springwood and summerwood. In

this publication, texture refers to the finer structure of the wood (*see* Grain) rather than the annual rings.

Tyloses—Masses of cells appearing somewhat like froth in the pores of some hardwoods, notably white oak and black locust. In hardwoods, tyloses are formed when walls of living cells surrounding vessels extend into the vessels. They are sometimes formed in softwoods in a similar manner by the extension of cell walls into axial tracheids.

Vessels—Wood cells in hardwoods of comparatively large diameter that have open ends and are set one above the other so as to form continuous tubes. The openings of the vessels on the surface of a piece of wood are usually referred to as pores.

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.

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, 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 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.

Properties and units of measurement

Term	Definition
4/4	nominal 1-inch (standard 25.4-mm) thickness
5/4	nominal 1-1/4-inch (standard 32-mm) thickness
6/4	nominal 1-1/2-inch (standard 38-mm) thickness
8/4	nominal 2-inch (standard 51-mm) thickness
10/4	nominal 2-1/2-inch (standard 64-mm) thickness
12/4	nominal 3-inch (standard 76-mm) thickness
16/4	nominal 4-inch (standard 102-mm) thickness
$C_{\parallel}$	compression parallel to grain, maximum crushing strength
$C_{\perp}$	compression perpendicular to grain, stress at proportional limit
Dry	12 percent moisture content
GPa	gigapascal ($\times 10^9$ Pa)
Hardness	side hardness
kJ	kilojoule ($\times 10^3$ J)
lbf	pound-force
m	meter
MC	moisture content
MOE	modulus of elasticity
MOR	modulus of rupture
MPa	megapascal ($\times 10^6$ Pa)
N	newton
NA	information not available
Pa	pascal
$Shear_{\parallel}$	shear parallel to grain, maximum shearing strength
SG	specific gravity
WML	work to maximum load

Appendix—Trade Name Index

American ash	*Fraxinus* spp.
American basswood	*Tilia americana*
American beech	*Fagus grandifolia*
American birch	*Betula* spp.
American chestnut	*Castanea dentata*
American hornbeam	*Carpinus caroliniana*
Apple	*Malus sylvestris*
Aspen	*Populus* spp.
Black cherry	*Prunus serotina*
Black locust	*Robinia pseudoacacia*
Black mangrove	*Avicennia* spp.
Black walnut	*Juglans nigra*
Black willow	*Salix nigra*
Boxelder	*Acer negundo*
Butternut	*Juglans cinerea*
Buttonwood	*Conocarpus erectus*
Buckthorn	*Rhamnus* spp.
California laurel	*Umbellularia californica*
Catalpa	*Catalpa* spp.
Common persimmon	*Diospyros* spp.
Cottonwood	*Populus* spp.
Elder	*Sambucus* spp.
Elm	*Ulmus* spp.
Flowering dogwood	*Cornus florida*
Giant chinkapin	*Castanopsis chrysophylla*
Hackberry	*Celtis* spp.
Hickory	*Carya* spp.
Holly	*Ilex* spp.
Honeylocust	*Gleditsia triacanthos*
Hophornbeam	*Ostrya* spp.
Kentucky coffeetree	*Gymnocladus dioicus*
Madrone	*Arbutus* spp.
Magnolia	*Magnolia* spp.
Maple	*Acer* spp.
Mesquite	*Prosopis* spp.
Mountain laurel	*Kalmia latifolia*
Oak	*Quercus* spp.
Osage orange	*Maclura pomifera*
Red alder	*Alnus rubra*
Sassafras	*Sassafras albidum*
Serviceberry	*Amelanchier* spp.
Silverbell	*Halesia* spp.
Sourwood	*Oxydendrum arboreum*
Sumac	*Rhus* spp.
Sweetbay	*Magnolia virginiana*
Sweetgum	*Liquidambar styraciflua*
Sycamore	*Acer pseudoplatanus*
Sycamore	*Platanus occidentalis*
Tanoak	*Lithocarpus densiflorus*
Tree-of-heaven	*Ailanthus altissima*
Tupelo	*Nyssa* spp.
Witch hazel	*Hamamelis virginiana*
Yellow buckeye	*Aesculus octandra*
Yellow poplar	*Liriodendron tulipifera*