Selected Characteristics of Colorado Woods

Wood species	Paint-holding characteristic: Oil based paint	Paint-holding characteristic: Latex paint	Weathering: Resistance to cupping	Heartwood: Decay resistance	Heartwood: Ease of treating	Heartwood: Color of heartwood	Ease of machining	Resistance to splitting in nailing and screwing	Nail and screw holding ability	Ease of bonding
Aspen	2	3	3	1	3	Pale brown	3	4	2	4
Douglas-fir	1	3	3	2	1	Pale red	3	3	4	3
Engelmann Spruce	2	3	3	1	2	White	3	4	2	4
Limber Pine				1						
Lodgepole Pine				1	2	Pale yellow	3	3	2	3
Pinon Pine				1	4					
Ponderosa Pine	2	3	3	1	4	Cream	4	4	2	4
Plains Cottonwood	2	3	1	1	3	White	1	4	2	2
Subalpine Fir	2	4	3	1	1	Pale tan	2	4	2	4
White Fir	2	4	3	1	2	White	2	4	3	4

Excellent 4 Very Good 3 Good 2 Fair 1

COLORADO WOOD UTILIZATION AND MARKETING ASSISTANCE CENTER

The Colorado Wood Utilization and Marketing Assistance Center is a collaborative between Colorado State University, the Colorado State Forest Service, and the US Forest Service. Its mission is to contribute to the improvement and maintenance of healthy forests conditions in Colorado through extension and outreach in the areas of wood science, forest products and business assistance. It was designed to help communities and businesses utilize the wood products made available from fuel reduction and forest restoration thinning activities in Colorado.

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Physical and Mechanical Properties (continued)

maximum crushing strength; compression perpendicular to grain is fiber stress at proportional limit; shear is maximum shearing strength; tension is maximum tensile strength; and side hardness is hardness measured when load is perpendicular to grain.

Most code requirements for wood interior finish materials are expressed in terms of flame spread index numbers. These values are determined in a standard fire test which evaluates the surface burning characteristics of a material. Different maximum flame spread indices are permitted depending upon building occupancy, location of the material in the building, and the presence of sprinklers.

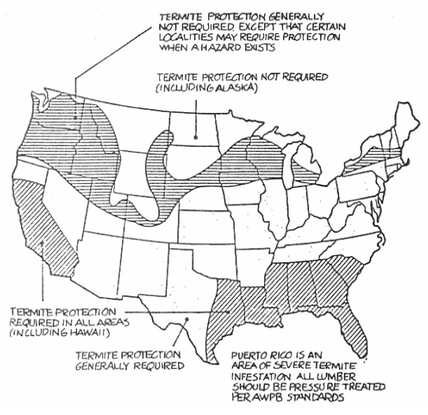
Class	Flame Spread Range	Example Location
I or A	0-25	Enclosed vertical exits
II or B	26-75	Exit access corridors
III or C	76-200	Other rooms and areas

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

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

Toxicity: Can cause dermatitis, septic splinter wounds, or contact eczema.

Durability: The heartwood is moderately resistant to decay. The wood can be susceptible to attack by dry wood termites, ambrosia (pinhole borer) beetles, longhorn beetles, and Buprestid beetles.



Additional Information

The Wood Handbook: Wood as an Engineering Material, FPL-GTR-113. USDA Forest Products Laboratory, Madison, WI.

National Design Specification for Wood Construction. American Forest and Paper Association, Washington, DC.

Western Lumber Grading Rules. Western Wood Products Association, Portland, OR.

Colorado Wood Utilization and Marketing Assistance Center

Product Use Guide

Douglas-fir

By David G. Bueche

"We may use wood with intelligence only if we understand wood."

—Frank Lloyd Wright
In the Cause of Architecture: Wood
The Architectural Record
May 1928

Wood is used in many forms throughout the world. However, few people fully understand the properties and peculiarities that must be considered for optimum application. This publication was developed as an aid for furthering the understanding of wood. It is a compilation of scientific and trade names, tree and wood characteristics, including: weight; physical and mechanical properties; drying, shrinkage, and working properties; durability, preservation, toxicity, and uses for wood species native to Colorado.

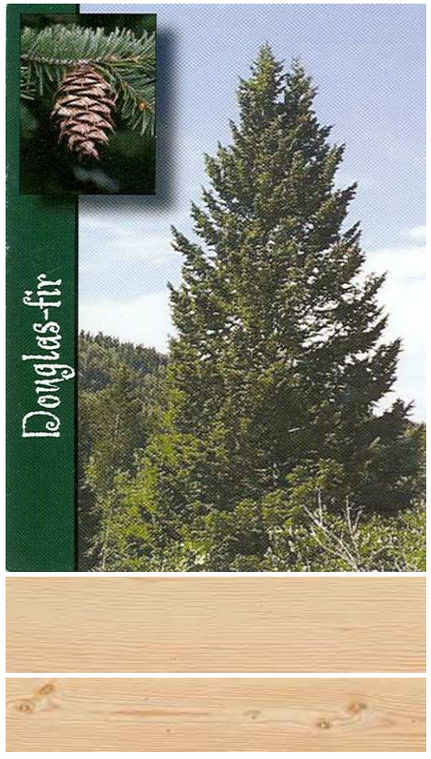
Inside Douglas-fir:

Colorado State University
Knowledge to Go Places

Colorado Woods

Douglas-fir

Pseudotsuga mensiesii



Description

Douglas-fir is named for Henry Douglas (1798-1834), a Scottish botanist who traveled in North America. The word *Pseudotsuga* means "false hemlock," and *menziesii* is used in recognition of Archibald Menzies (1754–1842), a Scottish physician and naturalist, who discovered Douglas-fir in 1793 on Vancouver Island, British Columbia.

The Tree: Rocky Mountain Douglas-fir [*P. menziesii* var *glauca* (Biessn.) Franco] reaches heights of 100 to 130 ft.

Bark: Gray and smooth with resin blisters on young trees; red-brown, very thick and deeply furrowed with broad, often corky ridges at maturity.

Leaves: Evergreen needles are ½ to 1½ inches long with bracts at the base.

Fruit: Light brown, short-stalked cones that hang down from the branches; 1½ to 3 inches long; many thin, rounded cone scales on top of a long, 3-pointed, winged seed that sticks out beyond scales.

Elevation: 6,000 to 9,500 feet.

Habitat: Rocky soils of moist northern slopes; in pure stands and mixed coniferous forests.

Relation to Fire: Thin, resinous bark of young trees makes them highly susceptible to fire; after 40 years, trees have developed a very thick layer of bark to protect them during hot ground and surface fires.

General Wood Characteristics

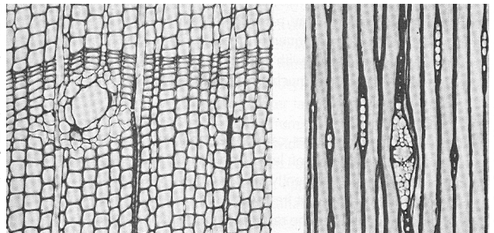
The wood of Douglas-fir varies widely in color, weight, strength, and working properties. The *sapwood* of Douglas-fir is narrow in old-growth trees but can be as much as 3 in. wide in second-growth trees of commercial size. *Sapwood* whitish to pale yellowish or reddish white, narrow (Rocky Mountain type); *heartwood* ranging from yellowish or pale reddish yellow (slow-grown stock) to orange-red or deep red (fast-grown stock), the color varying greatly in different samples; *wood* with a characteristic resinous odor when fresh (different from that of pine), without characteristic taste, usually straight- and even- or uneven-grained, medium- to fairly coarse-textured, moderately light (Rocky Mountain type), moderately hard. *Growth rings* very distinct, frequently wavy, delineated by a pronounced band of darker late wood, narrow (known as "yellow fir" in the trade) to very wide (sometimes sold as "red fir") which is coarser-grained and more unevenly textured than the narrow-ringed stock and also stronger and more refractory under tools; growth increments (striae) usually less conspicuous than those in pine on the radial surface. Early-wood zone usually several times wider than the band of late wood; transition from early to late wood generally abrupt (in wide rings sometimes more or less gradual); late-wood zone pronounced, very narrow in slow-grown stock to very wide and dense in wide rings. Douglas-fir grown in the Rocky Mountains, especially in the southern parts of the range, tends to contain smaller percentages of late wood, at any rate of growth, and to be lower in specific gravity and strength than Douglas-fir grown in the coastal areas, the Cascades, and the Sierras.

Uses

Douglas-fir is used mostly for building and construction purposes in the form of lumber, timbers, piles, and plywood. Considerable quantities are used for railroad crossties, cooperage stock, mine timbers, poles, and fencing. Douglas-fir lumber is used in the manufacture of various products, including sashes, doors, laminated beams and arches (for churches, schools, and other commercial buildings), general millwork, boxes, pallets, crates, railroad-cars, and containers for corrosive chemicals. Small amounts are used for flooring, furniture, ship and boat construction, and tanks. Douglas-fir plywood has found ever-increasing usefulness in construction, furniture, cabinets, and many other products such as motion picture and theatrical scenery and signs. Applications for Douglas-fir plywood is slowly being replaced by southern pine plywood and oriented strand board.

Minute Anatomy

Tracheids up to 55 (avg 35-45) µm in diameter, characterized (especial! y in early wood) by fine, closely spaced spiral thickening arranged in systems consisting of 4-6 parallel spirals; bordered pits in 1 row or occasionally paired on the radial walls; tangential pitting present in the last few rows of late-wood tracheids; pits leading to ray parenchyma piceoid, small, quite uniform in size, with distinct border, 1-6 (generally 4) per cross field. *Longitudinal parencyma* marginal and very sparse, or wanting. *Rays* of 2 types, uniseriate or rarely in part biseriate, and fusiform; *(a)* uniseriate rays numerous *(t)*/ 1-25 plus cells in height; biseriate rays very sparse and scattered, or wanting; *(b)* fusiform rays scattered, with 1 or very rarely 2 transverse resin canals, 3-5-seriate through the central thickened portion, tapering above and below to uniseriate margins similar to the *(a)* rays, up to 16 plus cells in height; end walls nodular; ray tracheids present in both types of rays, marginal and very rarely interspersed, nondentate, occasionally with spiral thickening; marginal tracheids usually in 1 row. *Resin canals* with thick-walled epithelium, constricted at intervals and occasionally with tylosoids in the heartwood, longitudinal canals with maximum diameter of 150 (avg 60-90) µm; transverse canals much smaller (usually less than 25 µm). Douglas-fir wood is sometimes confused with southern pine and western larch. It can usually be separated from the former on the basis of color, distinctive odor, and the smaller resin canals. It is more brown than western larch.



x—75x

t —75x

Drying and Shrinkage

Wood shrinks as it dries, and swells as it absorbs moisture. Dimensional changes generally take place from 0% to 28% moisture content, based on its oven-dry weight. In a dry atmosphere, wet or "green" wood loses moisture in the form of water vapor. Dry wood, on the other hand, absorbs moisture from a humid atmosphere. The moisture content of wood also may be increased by wetting with liquid water. If wet wood is put into place, it eventually dries to a moisture content in equilibrium with the water vapor pressure of the surrounding air. This is the equilibrium moisture content (EMC). This drying is accompanied by shrinkage. If wood has been dried too far below the moisture content reached in use, it absorbs water until the equilibrium moisture content is achieved, and swelling results.

When changes in moisture content are great and occur quickly, shrinkage and swelling may cause, not only dimensional changes, but also splitting, cracking, glue-line failures, or other defects in woodwork, furniture and other wood products. Small changes that take place slowly usually cause very small, hardly noticeable dimensional changes. However, slight drying taking place over a fairly long period of time may generate cracks and distortions when wooden parts are severely restrained-for example, by mechanical fastenings such as staples, screws, nails, and bolts-so that shrinkage is inhibited. When drying stresses exceed the strength of either the wood itself or an adhesive bonding agent, failures will also occur, either in the wood itself or in the glue-lines.

	Percentage of shrinkage (green to final moisture content)		
Type of shrinkage	0% MC	6% MC	20% MC
Tangential	7.5	6.0	2.5
Radial	4.8	3.8	1.6
Volumetric	11.8	9.4	3.9

Physical and Mechanical Properties

	Moisture Content		
Property	Green	(12%)	Ovendry
SG	0.43	0.46	—
Weight (lb/ft^3)	—	32	NA
MOE (lb/in^2)	1,160,000	1,490,000	—
MOR (lb/in^2)	6,800	11,900	—
C (lb/in^2)	3,110	6,230	—
C ⊥ (lb/in^2)	340	740	—
WML (in-lb/in^3)	8.0	9.0	—
Shear (lb/in^2)	950	1,510	—
Tension ⊥ (lb/in^2)	250	330	—
Toughness (in-lb)	130	120	—
Hardness (lb)	360	510	—
Conductivity (Btu•in/h•ft^2•°F)	—	1.00	0.83
Resistivity (h•ft^2•°F/Btu•in)	—	1.0	1.2
Heat of combustion (Btu/lb)	7150	8940	—
Flame Spread ASTM E-84	—	70-100	—

The values reported in this table are the results of tests on small clear specimens with moisture contents (MC) in the green, airdry and ovendry conditions. MC is the total amount of water in a given piece of wood and is expressed as a percentage of the ovendry weight of the wood. The ovendry weight is used as a basis because it is an indication of the amount of solid substance present. Solid wood substance is heavier than water, its specific gravity being about 1.5 regardless of species. Variation among species in the size of cells and in the thickness of cell walls affects the amount of solid wood substance present and, therefore, the specific gravity. Thus, specific gravity of wood is a measure of its solid wood substance and an index of its strength properties. Specific gravity is based on weight when ovendry and volume when green or at 12% moisture content.

Definition of properties: Modulus of elasticity measured from a simply supported, center-loaded beam, on a span depth ratio of 14/1. To correct for shear deflection, the modulus can be increased by 10%. impact bending is height of drop that causes complete failure, using 0.71-kg (50-lb) hammer; compression parallel to grain is also called

Continued on next page

Design Values for Visually Graded Structural Lumber

Douglas-fir		Extreme fiber in bending, "F_b"		Tension parallel to grain, "F_t"	Horizontal shear, "F_v"	Compression perpendicular to grain, "$F_{c\perp}$"	Compression parallel to grain, "F_c"	Modulus Of elasticity, "E"
Commercial grade	Size classification	Single member uses	Repetitive member uses					
Select structural		2000	2300	1150	90	520	1400	1,400,000
No.1	2" to 3" thick 2" to 4" wide	1700	1950	975	90	520	1150	1,400,000
No.2		1400	1600	825	90	520	900	1,300,000
No.3		775	875	450	90	520	550	1,100,000
Appearance		1700	1950	975	90	520	1350	1,400,000
Stud		775	875	450	90	520	550	1,100,000
Construction	2" to 4" thick 4" wide	1000	1150	600	90	520	1000	1,100,000
Standard		550	650	325	90	520	850	1,100,000
Utility		275	300	150	90	520	550	1,100,000
Select structural		1700	1950	1150*	90	520	1250	1,400,000
No.1	2" to 4" thick 5" and wider	1450	1650	975*	90	520	1150	1,400,000
No.2		1200	1350	625*	90	520	950	1,300,000
No.3		700	800	350*	90	520	600	1,100,000
Appearance		1450	1650	975*	90	520	1350	1,400,000
Stud		700	800	350*	90	520	600	1,100,000
Select structural	Beams and Stringers	1550	—	1050	85	520	1000	1,200,000
No.1		1300	—	850	85	520	850	1,200,000
No.2		825	—	425	85	520	525	1,000,000
Select structural	Posts and Timbers	1400	—	950	85	520	1050	1,200,000
No.1		1150	—	775	85	520	925	1,200,000
No.2		650	—	400	85	520	425	1,000,000
Select	Decking	—	2050	(Surfaced at 15% maximum MC and used at 15% maximum MC)			—	1,500,000
Commercial		—	1750				—	1,300,000

The design values listed were reproduced from *Design Values for Wood Construction*, a supplement to the 1986 edition of the *National Design Specification for Wood Construction* by the American Forest and Paper Association (AFPA). This supplement is revise periodically, so the designer should check with AFPA for the latest information.

Design values listed are for normal loading conditions.

Surfaced dry or surfaced green; used at 19% maximum MC.

The design values shown are applicable to lumber that will be used under dry conditions such as in most covered structures. For 2" to 4" thick lumber, the dry surfaced size shall be used. In calculating design values, the natural gain in strength and stiffness that occurs as lumber dries has been taken into consideration as well as the reduction in size that that occurs when unseasoned lumber shrinks. The gain in load-carrying capacity due to increased strength and stiffness resulting from drying more than offset the design effect of size reduction due to shrinkage. For 5" and thicker lumber, the surfaced sizes also may be used because design values have been adjusted to compensate for any loss in size by shrinkage which may occur.

*Tabulated tension parallel to grain values for 5" and wider, 2 to 4" thick size classification apply to 5" and 6" widths only. For lumber wider than 6" the tabulated "F_t" values shall be multiplied by the following:

Grade	Multiply Tabulated F_t Values by 8"	10" and wider
Select Structural	0.90	0.80
No.1, No.2, No.3, & Appearance	0.80	0.60
Stud	—	—

Design values for Stud grade in 5" and wider size classifications apply to 5" and 6" widths only.

Values for F_b, F_t, and F_c for the grades of Construction, Standard, and Utility apply only to 4" widths. Design values for 2" and 3" widths of these grade are available from the Western Wood Products Association (WWPA).

The values in the table for dimension lumber 2 to 4" in thickness are based on edgewise use. When such lumber is used flatwise, the design values for extreme fiber in bending may be multiplied by the factors in the table to the right.

Dimension Lumber Used Flatwise	Thickness (in.)		
Width	2	3	4
2 in. to 4 in.	1.10	1.04	1.00
5 in. and wider	1.22	1.16	1.11

The design values for F_b for decking may be increased by 10% for 2" thick and 4% for 3" thick decking.

When 2" to 4" thick lumber is manufactured at a maximum MC of 15% and used in a condition where the MC does not exceed 15%, the design values may be multiplied by the following factors: F_b, 1.08; F_t, 1.08; F_v, 1.05 $F_{c\perp}$, 1.00; F_c, 1.17; and E, 1.05.

When 2" to 4" thick lumber is designed for use where the MC will exceed 19% for an extended period of time, design values shall be multiplied by the following: F_b, 0.86; F_t, 0.84; F_v, 0.97; $F_{c\perp}$, 0.67; F_c, 0.70; and E, 0.97.

When lumber 5" and thicker is designed for use where the MC will exceed 19% for an extended period of time, the design values shall be multiplied by the following factors: F_b, 1.00; F_t, 1.00; F_v, 1.00; $F_{c\perp}$, 0.67; F_c, 0.91; and E, 1.00.

When split, check or shake is absent from wide face of lumber, F_v may be multiplied by a factor of 2.00. When length of split, check or shake on wide face of lumber is known and no increase in them is anticipated, see NDS supplement for additional adjustments.

Stress rated boards of nominal 1", 1¼" and 1½" thickness, 2" and wider are permitted design values shown for Select Structural, No. 1, No. 2, No. 3, Construction, Standard, Utility, and Appearance grades as shown in the 2" to 4" thick category when graded in accordance with stress rated board provions in the grading rules (see WWPA).

When Decking graded to WWPA rules is surfaced at 15% maximum MC and used where the MC will exceed 15% for an extended period of time, the tabulated design values for Decking shall be multiplied by the following factors: F_b, 0.79; E, 0.92.

When the depth of a rectangular sawn lumber member 5" or thicker exceeds 12", the design value for F_b, shall be multiplied by the size factor, C_F, as determined by the following formula: $C_F = (12/d)^{1/9}$.