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FUELWOOD CHARACTERISTICS OF NORTHWESTERN CONIFERS AND HARDWOODS

**Pamela L. Wilson
James W. Funck
Robert B. Avery**



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Introduction

Published fuelwood values for tree species of the Pacific Northwest have never been collected in one reference. This report is intended to provide a convenient summary of such information, collating the published values and giving accurate ranges by species for each fuelwood characteristic.

We selected the species inventoried by the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, for Washington, Oregon, Idaho, and Northern California. We did not include species that appear in the inventory, but for which no fuelwood information was found in the literature. Thirty-three conifer and 20 hardwood species appear in this report, listed alphabetically by genus within plant group. Scientific names were verified using Little (1979), if the scientific name in the original reference differed from current usage. If the scientific name could not be verified as either a current or a former name, the reference was not included.

The following fuelwood characteristics are included in this report:

- (1) Specific gravity of wood and bark,
- (2) Percent moisture content of wood and bark,
- (3) Higher heating value of wood and bark,
- (4) Percent ash of wood and bark,
- (5) Percent bark by volume,
- (6) Ultimate analysis of wood and bark:
 - (a) Percent carbon,
 - (b) Percent hydrogen,
 - (c) Percent oxygen,
 - (d) Percent nitrogen,
 - (e) Percent sulfur.

The range of values found for each category is given, as well as any finer breakdown supplied in the published reports. For example, in some species the moisture content is given for both heartwood and sapwood, or for both inner and outer bark. Not all categories appear for all species, since pertinent values often were not available.

We used original sources whenever possible. Literature reviews are cited only when values given differ from any other published values and the original source is not easily available. We made no attempt to go back to the original references from Isenberg (1980, 1981). The values we list are as published; they were not necessarily determined according to accepted procedures and we did not convert units.

¹ British/metric conversion factors are provided at the end of the bulletin.

Hale (1933) listed the gross calorific value of wood in Btu per air-dry (AD) cord.¹ The wood was burned in a coal-fired, domestic hot-water heater. In calculating the heating values, we assumed that one cord of split wood cut into 1-foot lengths contained 90 ft³ of solid material and that the moisture content of the split wood was 20 percent on a total-weight (TW) basis. Weights per cubic foot of different species of wood were taken from the records of the Forest Products Laboratories of Canada.

Other references give heating values in Btu per AD pound, Btu per oven-dry (OD) pound, or kcal per kilogram. If heating values originally were given in both Btu's and other units, we list only the Btu heating value.

The values provided by Sargent (1885) were listed in this publication for percent ash of wood but were used for specific gravity only when no other information was available. Sargent's values for specific gravity were determined on an OD-volume basis, while this paper generally reports specific gravity on a green-volume basis.

Specific gravity of wood and bark can be determined on a green-, AD-, or OD-volume basis. The calculation for specific gravity is shown in Equation 1.

$$\text{Specific gravity} = \frac{\text{OD weight}}{\text{Weight of displaced water at 4°C}} \quad [1]$$

In green wood or bark the cell walls are saturated, giving the largest possible volume, the largest water displacement, and, therefore, the lowest specific gravity. Determination of specific gravity with OD volume results in the least displacement of water and gives the highest specific gravity. The density of OD wood in pounds per ft³ can be estimated by multiplying the specific gravity by the weight of 1 ft³ of water at 4°C (62.4 lb./ft³). The higher the density (or specific gravity), the more Btu's per ft³ of wood are available for combustion.

The moisture content of wood and bark is very important to combustion. Moisture reduces both heating value and furnace efficiency. Maintaining combustion at moisture contents over 60 percent (TW basis) is very difficult, if not impossible (Karchesy and Koch 1979). Combustion can be divided into three stages. First, moisture is evaporated, requiring approximately 1100 Btu per pound of water. Second, the fuel temperature rises until the volatiles are driven off and burned. Third, the remaining carbon is burned (Karchesy

and Koch 1979). Thus, much available heat is lost because of the moisture content of the fuel. The minimum amount of air needed for combustion (the theoretical air) does not depend on the moisture content and can be calculated from the ultimate analysis; Karchesy and Koch (1979) provide a good description of this calculation.

In the forest industry, moisture content is given on either a wet or an OD basis. In this report, moisture contents are given on an OD basis; while usually "at test," they approximate the green condition. Methods for calculating the moisture content and for converting between the two bases are shown in Equations 2 through 5 (Table 1).

The higher heating value (HHV) of wood and bark (the maximum energy that can be produced) is determined with an oxygen bomb calorimeter. Any moisture in the wood or bark reduces that maximum proportionately. If the moisture content on a wet basis is known, the heating value at that moisture content can be calculated according to Equation 6 (Table 1). For example, for a moisture content of 50 percent on a TW

basis (100 percent on an OD basis) and a higher heating value of 8500 Btu/lb,

$$\text{Heating value} = \frac{100 - 50}{100} (8500) = 4250 \text{ Btu/lb}$$

Neither HHV (Btu per OD pound) nor percent ash content varies widely between species. In nearly all species the HHV can be considered to be 9000 Btu/OD lb. $\pm$ 10 percent (J.I. Zerbe, personal communication). The ash content generally ranges from 0.1 to 1 percent for wood and from 1 to 3 percent for bark (J.I. Zerbe, personal communication).

Neither ultimate nor proximate analyses vary much between species on a Btu per OD-pound basis. Arola (1976) (Table 2) gives a typical ultimate and proximate analysis by softwood (conifer) and hardwood, and by wood and bark. Some totals are not 100 percent, because different sources of data for ash content were averaged. The ultimate analyses in this publication also may not add up to 100 percent, since the ultimate analysis includes ash and the range of ash content is listed separately.

TABLE 1.

EQUATIONS FOR CALCULATING PERCENT MOISTURE CONTENT (EQUATIONS [2] THROUGH [5]) AND HEATING VALUE (EQUATION [6]) OF WOOD AND BARK.

Equation	Equation number
Percent moisture content = $\frac{\text{wet weight} - \text{OD weight}}{\text{OD weight}} \cdot (100)$ (OD* basis)	[2]
Percent moisture content = $\frac{\text{wet weight} - \text{OD weight}}{\text{wet weight}} \cdot (100)$ (TW* basis)	[3]
Percent moisture content (OD basis) = $\frac{\text{Percent moisture content (TW basis)}}{100 - \text{percent moisture content (TW basis)}} \cdot (100)$	[4]
Percent moisture content (TW basis) = $\frac{\text{Percent moisture content (OD basis)}}{100 + \text{percent moisture content (OD basis)}} \cdot (100)$	[5]
Heating value = $\frac{100 - \text{percent moisture content (TW basis)}}{100} \cdot (\text{HHV}^*)$	[6]

* OD, oven-dry; TW, total weight; HHV, higher heating value

TABLE 2.

TYPICAL PROXIMATE AND ULTIMATE ANALYSES OF WOOD AND BARK.

	Proximate			Ultimate					
	Volatile matter	Fixed carbon	Ash*	C	H	O	N	S	Ash*
	----- percent -----			----- percent -----					
Hardwood									
Wood	77.3	19.4	3.4	50.8	6.4	41.8	0.4	—	0.9
Bark	76.7	18.6	4.6	51.2	6.0	37.9	0.4	—	5.2
Softwood									
Wood	77.2	22.0	1.6	52.9	6.3	39.7	0.1	—	1.0
Bark	73.3	23.7	3.0	53.1	5.9	37.9	0.2	—	2.3

Source: Arola (1976)

* Ash percentages may differ, because different data sources were averaged.

Species List

Conifer Species

SCIENTIFIC NAME	COMMON NAME
<i>Abies amabilis</i>	Pacific silver fir
<i>Abies concolor</i>	White fir
<i>Abies grandis</i>	Grand fir
<i>Abies lasiocarpa</i>	Subalpine fir
<i>Abies magnifica</i>	California red fir (Shasta red fir)
<i>Abies procera</i>	Noble fir
<i>Chamaecyparis lawsoniana</i>	Port-Orford-cedar
<i>Chamaecyparis nootkatensis</i>	Alaska-cedar (yellow-cedar)
<i>Juniperus occidentalis</i>	Western juniper
<i>Larix occidentalis</i>	Western larch
<i>Libocedrus decurrens</i>	Incense-cedar
<i>Picea engelmannii</i>	Engelmann spruce

SCIENTIFIC NAME	COMMON NAME
<i>Picea glauca</i>	White spruce
<i>Picea pungens</i>	Blue spruce
<i>Picea sitchensis</i>	Sitka spruce
<i>Pinus albicaulis</i>	Whitebark pine
<i>Pinus aristata</i>	Bristlecone pine
<i>Pinus attenuata</i>	Knobcone pine
<i>Pinus contorta</i>	Lodgepole pine
<i>Pinus jeffreyi</i>	Jeffrey pine
<i>Pinus lambertiana</i>	Sugar pine
<i>Pinus monticola</i>	Western white pine
<i>Pinus muricata</i>	Bishop pine
<i>Pinus ponderosa</i>	Ponderosa pine
<i>Pinus radiata</i>	Radiata pine (Monterey pine)
<i>Pinus sabiniana</i>	Digger pine
<i>Pseudotsuga menziesii</i>	Douglas-fir
<i>Sequoia sempervirens</i>	Redwood
<i>Sequoiadendron giganteum</i>	Giant sequoia
<i>Taxus brevifolia</i>	Pacific yew
<i>Thuja plicata</i>	Western redcedar
<i>Tsuga heterophylla</i>	Western hemlock
<i>Tsuga mertensiana</i>	Mountain hemlock

Hardwood Species

SCIENTIFIC NAME	COMMON NAME
<i>Acer macrophyllum</i>	Bigleaf maple
<i>Alnus rhombifolia</i>	White alder
<i>Alnus rubra</i>	Red alder
<i>Arbutus menziesii</i>	Pacific madrone
<i>Betula papyrifera</i>	Paper birch
<i>Castanopsis chrysophylla</i>	Giant (golden) chinquapin
<i>Cornus nuttallii</i>	Pacific dogwood
<i>Fraxinus latifolia</i>	Oregon ash
<i>Lithocarpus densiflorus</i>	Tanoak
<i>Populus fremontii</i>	Fremont cottonwood
<i>Populus tremuloides</i>	Quaking aspen
<i>Populus trichocarpa</i>	Black cottonwood
<i>Quercus agrifolia</i>	Coast (California) live oak
<i>Quercus chrysolepis</i>	Canyon live oak
<i>Quercus douglasii</i>	Blue oak
<i>Quercus garryana</i>	Oregon white oak
<i>Quercus kelloggii</i>	California black oak
<i>Quercus lobata</i>	Valley oak (California white oak)
<i>Quercus wislizeni</i>	Interior live oak
<i>Umbellularia californica</i>	California-laurel (Oregon-myrtle)

Fuelwood Characteristics

Conifer Species

Scientific name: *Abies amabilis*
Common name: Pacific silver fir

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.28-0.55	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Maeglin and Wahlgren 1972; U.S. Forest Products Laboratory, no date, Report PP-108
Percent moisture content (OD basis)		
Sapwood	164	Peck 1953; Dobie and Wright 1975
Heartwood	55	Peck 1953; Dobie and Wright 1975
Mixed	66-74	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Dobie and Wright 1975
Higher heating value (Btu/AD cord)	16.5 x 10 ⁶	Hale 1933
Percent ash	0.23-0.47	Sargent 1885; Bray and Martin 1947; Isenberg 1980
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.53	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.58	Smith and Kozak 1971
Mixed (green vol., OD wt.)	0.44	Smith and Kurucz 1969
Mixed (OD vol., OD wt.)	0.68	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	77.4	Smith and Kozak 1971
Outer bark	39.6	Smith and Kozak 1971
Percent bark by volume	12	U.S. Forest Products Laboratory, no date, Report PP-108

Scientific name: *Abies concolor*
Common name: White fir

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.26-0.54	Markwardt and Wilson 1935; Gerhards 1964; Wilcox and Pong 1971; Maeglin and Wahlgren 1972; U.S. Forest Products Laboratory, no date, Report PP-108; U.S. Forest Products Laboratory, no date, Report PP-114

Percent moisture content (OD basis)		
Sapwood	98	Peck 1953
Heartwood	160	Peck 1953
Mixed	110-154	Markwardt and Wilson 1935; Wilcox and Pong 1971; Isenberg 1980
Higher heating value (Btu/OD lb.)	8795	Voorhies and Huntsberger 1983
(Kcal/kg)	4440	Isenberg 1980
Percent ash	0.4-0.85	Sargent 1885; Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-114

BARK

Specific gravity		
Inner bark (vol. at 13% $\pm$ 2% M.C., OD wt.)	0.69	Cassens 1974
Outer bark (vol. at 13% $\pm$ 2% M.C., OD wt.)	0.60	Cassens 1974
Mixed (OD vol., OD wt.)	0.62	Harkin and Rowe 1971
Percent bark by volume	9.7-28.6	Hyttinen and Schafer 1959; U.S. Forest Products Laboratory, no date, Report PP-108

Scientific name: *Abies grandis*

Common name: Grand fir

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.24-0.55	Markwardt and Wilson 1935; Maeglin and Wahlgren 1972
Percent moisture content (OD basis)		
Sapwood	136	Peck 1953
Heartwood	91	Peck 1953
Mixed	94	Markwardt and Wilson 1935
Higher heating value (Btu/AD cord)	17.4 x 10 ⁶	Hale 1933
(Btu/OD lb.)	8664	Voorhies and Huntsberger 1983
Percent ash	0.25-0.49	Sargent 1885; Kurth 1950; Ellis 1962
BARK		
Specific gravity (green vol., OD wt.)		
Inner bark	0.63	Smith and Kozak 1971
Outer bark	0.70	Smith and Kozak 1971
Mixed (OD vol., OD wt.)	0.57-0.64	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	81	Smith and Kozak 1971
Outer bark	51.4	Smith and Kozak 1971
Mixed	50.8	Mingle and Boubel 1968

Higher heating value (Btu/OD lb.)	9641	Kelsey et al. 1979
Percent ash	2.5	Mingle and Boubel 1968

Scientific name: *Abies lasiocarpa*
Common name: Subalpine fir

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.30-0.38	Markwardt and Wilson 1935; Smith 1970; Bendtsen 1973; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	153	Dobie and Wright 1975
Heartwood	56	Dobie and Wright 1975
Mixed	47-67	Markwardt and Wilson 1935; Peck 1953; Smith 1970; Dobie and Wright 1975
Percent ash	0.4-0.5	Sargent 1885; U.S. Forest Products Laboratory, no date, Report PP-114
<u>BARK</u>		
Specific gravity (OD vol., OD wt.)	0.50-0.55	Harkin and Rowe 1971

Scientific name: *Abies magnifica*
Common name: California red fir (Shasta red fir)

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.31-0.46	Markwardt and Wilson 1935; Schniewind 1961; Maeglin and Wahlgren 1972
Percent moisture content (OD basis)	108	Markwardt and Wilson 1935; Peck 1953
Percent ash	0.30	Sargent 1885
<u>BARK</u>		
Specific gravity		
Inner bark		
(vol. at 13% $\pm$ 2% M.C., OD wt.)	0.69	Cassens 1974
Outer bark		
(vol. at 13% $\pm$ 2% M.C., OD wt.)	0.50	Cassens 1974
Mixed (OD vol., OD wt.)	0.50	Harkin and Rowe 1971
Percent moisture content (OD basis)	22.2	Mingle and Boubel 1968
Percent ash	2.6	Mingle and Boubel 1968

Scientific name: *Abies procera*
Common name: Noble fir

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.26-0.44	Markwardt and Wilson 1935; Paul et al. 1959; Maeglin and Wahlgren 1972
Percent moisture content (OD basis)		
Sapwood	115	Peck 1953
Heartwood	34	Peck 1953
Mixed	36-70	Markwardt and Wilson 1935; Paul et al. 1959
Percent ash	0.34-0.71	Sargent 1885; Kurth 1950; Isenberg 1980
BARK		
Specific gravity (OD vol., OD wt.)	0.56	Harkin and Rowe 1971

Scientific name: *Chamaecyparis lawsoniana*
Common name: Port-Orford-cedar

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.39-0.40	Markwardt and Wilson 1935; Stillinger 1953; U.S. Forest Products Laboratory 1974
Percent moisture content (OD basis)		
Sapwood	98-200	Peck 1953; Stillinger 1953
Heartwood	40-50	Peck 1953; Stillinger 1953
Mixed	43	Markwardt and Wilson 1935
Percent ash	0.10	Sargent 1885
BARK		
Specific gravity (OD vol., OD wt.)	0.33-0.52	Harkin and Rowe 1971

Scientific name: *Chamaecyparis nootkatensis*
Common name: Alaska-cedar (yellow-cedar)

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.42	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956

Percent moisture content (OD basis)		
Sapwood	166	Peck 1953
Heartwood	32	Peck 1953
Mixed	34-52	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975
Higher heating value (Btu/OD lb.)	9900	Dobie and Wright 1975
Percent ash	0.22-0.34	Kurth 1950; Sargent 1885
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.41	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.38	Smith and Kozak 1971
Mixed (OD vol., OD wt.)	0.63	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	145	Smith and Kozak 1971
Outer bark	79.4	Smith and Kozak 1971
Percent bark by volume	11-13.1	Smith and Kurucz 1969; Dobie and Wright 1975

Scientific name: *Juniperus occidentalis*
Common name: Western juniper

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (OD vol., OD wt.)	0.58	Sargent 1885
Percent moisture content (OD basis)		
Sapwood	128-216	Kozlik 1976
Heartwood	46-87	Kozlik 1976
Mixed	64-178	Kozlik 1976
Percent ash	0.12-0.36	Sargent 1885; Kurth 1948
BARK		
Specific gravity (OD vol., OD wt.)	0.48	Harkin and Rowe 1971

Scientific name: *Larix occidentalis*
Common name: Western larch

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.37-0.55	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Maeglin and Wahlgren 1972; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-114

Percent moisture content (OD basis)		
Sapwood	110-119	Peck 1953; U.S. Forest Products Laboratory 1974; Dobie and Wright 1975
Heartwood	35-54	Peck 1953; U.S. Forest Products Laboratory 1974; Dobie and Wright 1975
Mixed	49.4-63.9	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	8370-8431	Kelsey et al. 1979; Funck and Hoag 1985
(Btu/AD cord)	26.5 x 10 ⁶	Hale 1933
Percent ash	0.09-0.8	Sargent 1885; Rader Systems, Inc. 1978; Isenberg 1980; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-114

BARK

Specific gravity (green vol., OD wt.)		
Inner bark	0.37-0.43	Smith and Kozak 1971; Isenberg 1980
Outer bark	0.33-0.35	Smith and Kozak 1971; Isenberg 1980
Mixed	0.32-0.33	Smith and Kurucz 1969; Harder and Einspahr 1976; Isenberg 1980
Percent moisture content (OD basis)		
Inner bark	98.6	Smith and Kozak 1971
Outer bark	44.0	Smith and Kozak 1971
Percent bark by volume	21 ± 6.5	Snell and Max 1982
Higher heating value (Btu/OD lb.)	8280-9162	Harder and Einspahr 1976; Rader Systems, Inc. 1978; Kelsey et al. 1979; Cheremisinoff 1980
(Btu/lb. at 6.7% M.C.)	8204	Chang and Mitchell 1955
(Kcal/kg)	4860	Isenberg 1980
Percent ash	1.6-2.4	Chang and Mitchell 1955; Isenberg 1980

Scientific name: *Libocedrus decurrens*
Common name: Incense-cedar

VALUES

REFERENCES

WOOD

Specific gravity (green vol., OD wt.)	0.35	Markwardt and Wilson 1935
Percent moisture content (OD basis)		
Sapwood	213	Peck 1953
Heartwood	40	Peck 1953
Mixed	108	Markwardt and Wilson 1935
Higher heating value Heartwood (Btu/OD lb.)	10668	Voorhies and Huntsberger 1983

Percent ash		
Sapwood	0.47	Isenberg 1980
Heartwood	0.30	Isenberg 1980
Mixed	0.08-0.34	Sargent 1885; Isenberg 1980

BARK

Specific gravity		
Outer bark (vol. at 13% $\pm$ 2% M.C., OD wt.)	0.30	Cassens 1974
Mixed (OD vol., OD wt.)	0.27	Harkin and Rowe 1971
Percent moisture content (OD basis)	25	Mingle and Boubel 1968
Percent bark by volume	29 $\pm$ 9.6	Snell and Max 1982
Percent ash	0.6	Mingle and Boubel 1968

Scientific name: *Picea engelmannii*
Common name: Engelmann spruce

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.23-0.58	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Bendtsen and Wahlgren 1970; Smith 1970; Maeglin and Wahlgren 1972; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	173	Peck 1953
Heartwood	51	Peck 1953
Mixed	58-100	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970
Higher heating value (Btu/AD cord)	17.6 x 10 ⁶	Hale 1933
Percent ash	0.2-2	Sargent 1885; Rader Systems, Inc. 1978; Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-114
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.41-0.45	Smith and Kozak 1971; Isenberg 1980
Outer bark (green vol., OD wt.)	0.52-0.53	Smith and Kozak 1971; Isenberg 1980
Mixed (green vol., OD wt.)	0.43-0.51	Smith and Kurucz 1969; Smith and Kozak 1971; Harder and Einspahr 1976; Isenberg 1980
Mixed (OD vol., OD wt.)	0.80	Harkin and Rowe 1971

Percent moisture content (OD basis)		
Inner bark	121	Smith and Kozak 1971
Outer bark	60.5	Smith and Kozak 1971
Higher heating value (Btu/OD lb.)	8420-9616	Harder and Einspahr 1976; Rader Systems, Inc. 1978; Kelsey et al. 1979; Cheremisinoff 1980
(Btu/lb. at 5.5% M.C.)	8359	Chang and Mitchell 1955
Percent ash	2.5-2.6	Chang and Mitchell 1955; Isenberg 1980

Scientific name: *Picea glauca*

Common name: White spruce

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.35-0.46	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; U.S. Forest Products Laboratory, no date, Report PP-108; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	163	Dobie and Wright 1975
Heartwood	51	Dobie and Wright 1975
Mixed	50-75	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Dobie and Wright 1975
Higher heating value		
(Btu/OD lb.)	8890	Tillman 1978
(Btu/AD cord)	16.2 x 10 ⁶	Hale 1933
Percent ash	0.22-0.3	Clermont and Schwartz 1951; Isenberg 1980
<u>BARK</u>		
Specific gravity		
Inner bark (green vol., OD wt.)	0.45	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.43-0.50	Smith and Kozak 1971; Isenberg 1980
Mixed (green vol., OD wt.)	0.39	Harder and Einspahr 1976; Isenberg 1980
Mixed (OD vol., OD wt.)	0.62-0.68	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	104	Smith and Kozak 1971
Outer bark	50	Smith and Kozak 1971
Percent bark by volume	8.6-11.7	U.S. Forest Products Laboratory, no date, Report PP-108

Higher heating value (Btu/OD lb.)	8340-8913	Millikin 1955; Harder and Einspahr 1976
Ultimate analysis (percent)		
Ash	3.0-4.2	Millikin 1955; Isenberg 1980
Carbon	52.4	Millikin 1955
Hydrogen	6.4	Millikin 1955
Oxygen	38.1	Millikin 1955
Nitrogen	0.1	Millikin 1955
Sulfur	0.0	Millikin 1955

Scientific name: *Picea pungens*
Common name: Blue spruce

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (OD vol., OD wt.)	0.37	Sargent 1885
Percent ash	0.38	Sargent 1885

Scientific name: *Picea sitchensis*
Common name: Sitka spruce

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.35-0.37	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	142	Peck 1953
Heartwood	41	Peck 1953
Mixed	42-43	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975
Higher heating value		
(Btu/OD lb.)	8100	Dobie and Wright 1975
(Btu/AD cord)	15.9 x 10 ⁶	Hale 1933
(Kcal/kg)	4500	Isenberg 1980
Percent ash	0.17-0.45	Sargent 1885; Isenberg 1980
<u>BARK</u>		
Specific gravity		
Inner bark (green vol., OD wt.)	0.44	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.62	Smith and Kozak 1971
Mixed (OD vol., OD wt.)	0.63	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	112	Smith and Kozak 1971
Outer bark	55.3	Smith and Kozak 1971

Scientific name: *Pinus albicaulis*
Common name: Whitebark pine

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (OD vol., OD wt.)	0.42	Sargent 1885; Kasper and Szabo 1970; Keenan et al. 1970
Percent ash	0.27	Sargent 1885

Scientific name: *Pinus aristata*
Common name: Bristlecone pine

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (OD vol., OD wt.)	0.56	Sargent 1885
Percent ash	0.30	Sargent 1885

Scientific name: *Pinus attenuata*
Common name: Knobcone pine

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.35-0.42	Laundrie 1967; Schniewind and Gammon 1983
Percent ash	0.2-0.33	Sargent 1885; Laundrie 1967
<u>BARK</u>		
Percent bark by volume	11.1	Laundrie 1967

Scientific name: *Pinus contorta*
Common name: Lodgepole pine

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)		
Sapwood		
Green	0.36	Lieu et al. 1979
Dead down	0.36	Lieu et al. 1979
Dead standing	0.37	Lieu et al. 1979

Heartwood		
Green	0.38	Lieu et al. 1979
Dead down	0.36	Lieu et al. 1979
Dead standing	0.38	Lieu et al. 1979
Mixed (at test)	0.26-0.55	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Maeglin and Wahlgren 1972; Lieu et al. 1979; U.S. Forest Products Laboratory, no date, Report PP-112
Percent moisture content (OD basis)		
Sapwood		
Green	163	Lieu et al. 1979
Dead down	15	Lieu et al. 1979
Dead standing	18	Lieu et al. 1979
At test	115-120	Peck 1953; Dobie and Wright 1975
Heartwood		
Green	35	Lieu et al. 1979
Dead down	20	Lieu et al. 1979
Dead standing	12	Lieu et al. 1979
At test	38-41	Peck 1953; Dobie and Wright 1975
Mixed (at test)	49-65	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Dobie and Wright 1975
Higher heating value		
Sapwood (mJ/kg ²)		
Green	19.9	Lieu et al. 1979
Dead down	19.5	Lieu et al. 1979
Dead standing	19.6	Lieu et al. 1979
Heartwood (mJ/kg ²)		
Green	20.0	Lieu et al. 1979
Dead down	19.9	Lieu et al. 1979
Dead standing	20.1	Lieu et al. 1979
Mixed (Btu/OD lb.)	8600	Dobie and Wright 1975
Mixed (kcal/kg)	4870	Isenberg 1980
Mixed (Btu/AD cord)	20.1 x 10 ⁶	Hale 1933
Percent ash		
Sapwood		
Green	0.36	Lieu et al. 1979
Dead down	0.51	Lieu et al. 1979
Dead standing	0.53	Lieu et al. 1979
Heartwood		
Green	0.34	Lieu et al. 1979
Dead down	0.43	Lieu et al. 1979
Dead standing	0.55	Lieu et al. 1979
Mixed (at test)	0.19-0.50	Sargent 1885; Kurth 1950; Rader Systems, Inc. 1978; Lieu et al. 1979; Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-112
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.32-0.34	Smith and Kozak 1971; Isenberg 1980
Outer bark (green vol., OD wt.)	0.45-0.51	Smith and Kozak 1971; Isenberg 1980
At 1.0 foot (green vol., OD wt.)	0.42	Smith and Kurucz 1969
At 4.5 feet (green vol., OD wt.)	0.40	Smith and Kurucz 1969
Mixed (green vol., OD wt.)	0.38	Harder and Einspahr 1976; Isenberg 1980
Mixed (OD vol., OD wt.)	0.60	Harkin and Rowe 1971

Percent moisture content (OD basis)		
Inner bark	128	Smith and Kozak 1971
Outer bark	42	Smith and Kozak 1971
Percent bark by volume	10 ± 2.4	Smith and Kurucz 1969; Dobie and Wright 1975; Snell and Max 1982
Higher heating value (Btu/OD lb.)	9310-10760	Johnson and Auth 1951; Dobie and Wright 1975; Harder and Einspahr 1976; Kelsey et al. 1979; Cheremisinoff 1980
(Btu/lb. at 5.6% M.C.)	10190	Chang and Mitchell 1955
Percent ash	0.5-2.2	Johnson and Auth 1951; Chang and Mitchell 1955; Isenberg 1980
Ultimate analysis (percent)		
Carbon	55.0	Johnson and Auth 1951
Hydrogen	5.8	Johnson and Auth 1951
Oxygen and nitrogen	38.7	Johnson and Auth 1951
Sulfur	Trace	Johnson and Auth 1951

Scientific name: *Pinus jeffreyi*
Common name: Jeffrey pine

	<u>VALUES</u>	<u>REFERENCES</u>
_____ WOOD _____		
Specific gravity (green vol., OD wt.)	0.37	Markwardt and Wilson 1935
Percent moisture content (OD basis)	101	Markwardt and Wilson 1935
Percent ash	0.26	Sargent 1885
_____ BARK _____		
Specific gravity Outer bark (vol. at 13% ± 2% M.C., OD wt.)	0.36	Cassens 1974

Scientific name: *Pinus lambertiana*
Common name: Sugar pine

	<u>VALUES</u>	<u>REFERENCES</u>
_____ WOOD _____		
Specific gravity (green vol., OD wt.)	0.28-0.45	Markwardt and Wilson 1935; Maeglin and Wahlgren 1972
Percent moisture content (OD basis)		
Sapwood	219	Peck 1953
Heartwood	98	Peck 1953
Mixed	137	Markwardt and Wilson 1935

Percent ash		
Sapwood	0.2	Isenberg 1980
Heartwood	0.2	Isenberg 1980
Mixed	0.22-0.5	Sargent 1885; Rader Systems, Inc. 1978

BARK

Specific gravity		
Outer bark		
(vol. at 13% $\pm$ 2% M.C., OD wt.)	0.34	Cassens 1974
Mixed (OD vol., OD wt.)	0.38	Harkin and Rowe 1971
Percent ash	0.6	Chang and Mitchell 1955

Scientific name: *Pinus monticola*
Common name: Western white pine

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)		
Sapwood		
Green	0.46	Lieu et al. 1979
Dead down	0.35	Lieu et al. 1979
Dead standing	0.34	Lieu et al. 1979
Heartwood		
Green	0.43	Lieu et al. 1979
Dead down	0.38	Lieu et al. 1979
Dead standing	0.39	Lieu et al. 1979
Mixed (at test)	0.29-0.45	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Maeglin and Wahlgren 1972; Lieu et al. 1979; Funck and Hoag 1985
Percent moisture content (OD basis)		
Sapwood		
Green	27	Lieu et al. 1979
Dead down	34	Lieu et al. 1979
Dead standing	14	Lieu et al. 1979
At test	148	Peck 1953
Heartwood		
Green	28	Lieu et al. 1979
Dead down	35	Lieu et al. 1979
Dead standing	17	Lieu et al. 1979
At test	62	Peck 1953
Mixed (at test)	54-127	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975; Pingrey 1976; Funck and Hoag 1985
Higher heating value		
Sapwood (mJ/kg ²)		
Green	19.8	Lieu et al. 1979
Dead down	19.8	Lieu et al. 1979
Dead standing	19.5	Lieu et al. 1979

Heartwood (mJ/kg ²)		
Green	20.3	Lieu et al. 1979
Dead down	20.4	Lieu et al. 1979
Dead standing	20.2	Lieu et al. 1979
Mixed (Btu/OD lb.)	8366-8620	Kelsey et al. 1979; Funck and Hoag 1985
Mixed (Btu/AD cord)	18.6 x 10 ⁶	Hale 1933
Percent ash		
Sapwood		
Green	0.29	Lieu et al. 1979
Dead down	0.29	Lieu et al. 1979
Dead standing	0.23	Lieu et al. 1979
At test	0.2	Isenberg 1980
Heartwood		
Green	0.36	Lieu et al. 1979
Dead down	0.28	Lieu et al. 1979
Dead standing	0.30	Lieu et al. 1979
At test	0.2	Isenberg 1980
Mixed (at test)	0.2-0.33	Sargent 1885; Lieu et al. 1979; Isenberg 1980; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-112
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.31	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.54	Smith and Kozak 1971
Mixed (green vol., OD wt.)	0.51	Funck and Hoag 1985
Mixed (OD vol., OD wt.)	0.63	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	118	Smith and Kozak 1971
Outer bark	75	Smith and Kozak 1971
Mixed	64-82	Pingrey 1976; Funck and Hoag 1985
Percent bark by volume	17 ± 8.3	Dobie and Wright 1975; Snell and Max 1982; Funck and Hoag 1985
Higher heating value		
(Btu/OD lb.)	8904-9335	Harkin and Rowe 1971; Kelsey et al. 1979; Funck and Hoag 1985
(Kcal/kg)	5040	Isenberg 1980
Percent ash	1.3-2.6	Harkin and Rowe 1971; Funck and Hoag 1985

Scientific name: *Pinus muricata*
Common name: Bishop pine

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.45	Schniewind and Gammon 1980
Percent ash	0.26	Sargent 1885

Scientific name: *Pinus ponderosa*
Common name: Ponderosa pine

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.27-0.54	Markwardt and Wilson 1935; Martin 1951; Forest Products Laboratories of Canada 1956; Smith 1970; Maeglin and Wahlgren 1972; Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-112
Percent moisture content (OD basis)		
Sapwood	148	Peck 1953; Dobie and Wright 1975
Heartwood	40	Peck 1953; Dobie and Wright 1975
Mixed	71-149.2	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Mingle and Boubel 1968; Smith 1970; Dobie and Wright 1975; Pingrey 1976
Higher heating value		
Heartwood (Btu/OD lb.)	8920-8992	Voorhies and Huntsberger 1983
Mixed (Btu/OD lb.)	9100-9140	Willey 1942; Dobie and Wright 1975; Cheremisinoff 1980; Isenberg 1980
Mixed (Btu/AD cord)	22.1 x 10 ⁶	Hale 1933
Percent ash		
Sapwood	0.3	Isenberg 1980
Heartwood	0.2	Isenberg 1980
Mixed	0.18-0.5	Sargent 1885; Mingle and Boubel 1968; Rader Systems, Inc. 1978; Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-112
<u>BARK</u>		
Specific gravity		
Inner bark (green vol., OD wt.)	0.34-0.36	Smith and Kozak 1971; Isenberg 1980
Outer bark (green vol., OD wt.)	0.34-0.35	Smith and Kozak 1971; Isenberg 1980
Outer bark (vol. at 13% $\pm$ 2% M.C., OD wt.)	0.27	Cassens 1974
Mixed (green vol., OD wt.)	0.28-0.35	Smith and Kurucz 1969; Harder and Einspahr 1976; Isenberg 1980
Percent moisture content (OD basis)		
Inner bark	77.8	Smith and Kozak 1971
Outer bark	21	Smith and Kozak 1971
Mixed	15.3-40.4	Mingle and Boubel 1968; Pingrey 1976
Percent bark by volume	5.9-27.2	Martin 1951; Dobie and Wright 1975; Snell and Max 1982; U.S. Forest Products Laboratory, no date, Report PP-112
Higher heating value (Btu/OD lb.)	9415-9616	Harder and Einspahr 1976; Kelsey et al. 1979; Voorhies and Huntsberger 1983
Percent ash	0.7	Mingle and Boubel 1968; Isenberg 1980

Scientific name: *Pinus radiata*
Common name: Radiata pine (Monterey pine)

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.40-0.53	Cockrell 1959
Percent moisture content (OD basis)		
Sapwood	90-145	Cockrell 1959
Heartwood	35	Cockrell 1959
Percent ash	0.30	Sargent 1885

Scientific name: *Pinus sabiniana*
Common name: Digger pine

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.37-0.43	Laundrie 1967; Schniewind and Gammon 1978
Percent moisture content (OD basis)	102	Schniewind and Gammon 1978
Percent ash	0.1-0.40	Sargent 1885; Laundrie 1967
BARK		
Percent bark by volume	18.3	Laundrie 1967

Scientific name: *Pseudotsuga menziesii*
Common name: Douglas-fir

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.33-0.59	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Maeglin and Wahlgren 1972; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-108; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	115-154	Peck 1953; Dobie and Wright 1975
Heartwood	31-39	Peck 1953; Dobie and Wright 1975
Mixed	36-65.6	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Mingle and Boubel 1968; Smith 1970; Dobie and Wright 1975; Funck and Hoag 1985

Higher heating value		
Sapwood (Btu/OD lb.)	8500	Willey 1942
Heartwood (Btu/OD lb.)	7500-9000	Willey 1942; Isenberg 1980; Voorhies and Huntsberger 1983
Mixed (Btu/OD lb.)	8318-9200	de Lorenzi 1949; Dobie and Wright 1975; Rader Systems, Inc. 1978; Cheremisinoff 1980; Voorhies and Huntsberger 1983; Funck and Hoag 1985
Mixed (Btu/AD cord)	22.2 x 10 ⁶	Hale 1933
	24.3 x 10 ⁶	
Percent ash	0.08-0.8	Sargent 1885; Bray and Martin 1947; Kurth 1948; de Lorenzi 1949; Mingle and Boubel 1968; Isenberg 1980; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-114
Ultimate analysis (percent)		
Carbon	52.3	de Lorenzi 1949
Hydrogen	6.3	de Lorenzi 1949
Oxygen	40.5	de Lorenzi 1949
Nitrogen	0.1	de Lorenzi 1949
Sulfur	0	de Lorenzi 1949
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.42-0.46	Smith and Kurucz 1969; Smith and Kozak 1971; Isenberg 1980
Outer bark (green vol., OD wt.)	0.40-0.46	Smith and Kurucz 1969; Smith and Kozak 1971; Isenberg 1980
Outer bark (vol. at 13% ± 2% M.C., OD wt.)	0.48	Cassens 1974
Mixed (green vol., OD wt.)	0.41-0.51	Smith 1969; Harder and Einspahr 1976; Funck and Hoag 1985
Mixed (OD vol., OD wt.)	0.41-0.54	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	133	Smith and Kozak 1971
Outer bark	80.3	Smith and Kozak 1971
Old growth	8.9	Mingle and Boubel 1968
Second growth	97.2	Mingle and Boubel 1968
At test	48-80.2	Corder et al. 1970; Funck and Hoag 1985
Percent bark by volume	9.4-35	Smith and Kurucz 1969; Dobie and Wright 1975; Snell and Max 1982; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-108; U.S. Forest Products Laboratory, no date, Report PP-114
Higher heating value (Btu/OD lb.)		
Old growth	10100	Willey 1942
Second growth	10150	Willey 1942
At test	9373-10845	Johnson and Auth 1951; Corder et al. 1970; Dobie and Wright 1975; Harder and Einspahr 1976; Pingrey 1976; Kelsey et al. 1979; Cheremisinoff 1980; Voorhies and Huntsberger 1983; Funck and Hoag 1985

Percent ash		
Old growth	2.2	Mingle and Boubel 1968
Second growth	1.2	Mingle and Boubel 1968
At test	1.0-3.7	Kurth 1949; Johnson and Auth 1951; Corder et al. 1970; Cheremisinoff 1980; Isenberg 1980; Kester and Pilat 1980; Funck and Hoag 1985
Ultimate analysis (percent)		
Carbon	51.2-56.2	Johnson and Auth 1951; Corder et al. 1970; Cheremisinoff 1980; Kester and Pilat 1980
Hydrogen	5.8-6.2	Johnson and Auth 1951; Corder et al. 1970; Cheremisinoff 1980; Kester and Pilat 1980
Oxygen	38.8-39.3	Corder et al. 1970; Cheremisinoff 1980; Kester and Pilat 1980
Nitrogen	0.0-0.2	Corder et al. 1970; Cheremisinoff 1980; Kester and Pilat 1980
Oxygen and nitrogen	36.7	Johnson and Auth 1951
Sulfur	0.0-Trace	Johnson and Auth 1951; Corder et al. 1970; Cheremisinoff 1980; Kester and Pilat 1980

Scientific name: *Sequoia sempervirens*
Common name: Redwood

WOOD	VALUES	REFERENCES
Specific gravity (green vol., OD wt.)		
Open-grown	0.28	Markwardt and Wilson 1935
Close-grown	0.32	Markwardt and Wilson 1935
Old growth	0.36-0.38	Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-114
Second growth	0.33-0.34	Isenberg 1980; U.S. Forest Products Laboratory, no date, Report PP-114
Mixed	0.24-0.36	Bendtsen 1966
Percent moisture content (OD basis)		
Old-growth sapwood	86	Peck 1953
Old-growth heartwood	210	Peck 1953
Open-grown mixed	146	Markwardt and Wilson 1935
Close-grown mixed	112	Markwardt and Wilson 1935
Second growth mixed	127	Peck 1953
Mixed	75-155	Bendtsen 1966; Mingle and Boubel 1968; Isenberg 1980
Higher heating value (Btu/OD lb.) (Kcal/kg)	8840-9220 5020	de Lorenzi 1949; Rader Systems, Inc. 1978 Isenberg 1980
Percent ash		
Second growth	0.1	U.S. Forest Products Laboratory, no date, Report PP-114
Old growth	0.1	U.S. Forest Products Laboratory, no date, Report PP-114
Mixed	0.14-0.4	Sargent 1885; de Lorenzi 1949; Mingle and Boubel 1968; Isenberg 1980

Ultimate analysis (percent)

Carbon	53.5	de Lorenzi 1949
Hydrogen	5.9	de Lorenzi 1949
Oxygen	40.3	de Lorenzi 1949
Nitrogen	0.1	de Lorenzi 1949
Sulfur	trace	de Lorenzi 1949

BARK

Specific gravity

Inner bark (vol. at 13% $\pm$ 2% M.C., OD wt.)	0.48	Cassens 1974
Outer bark (vol. at 21% M.C., OD wt.)	0.43	Cassens 1974
Mixed (OD vol., OD wt.)	0.46	Harkin and Rowe 1971

Percent moisture content (OD basis)	13.9	Mingle and Boubel 1968
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Percent bark by volume

Second growth	14-16	Pemberton 1924
Old growth	12.6-13	Pemberton 1924

Higher heating value (Btu/OD lb.)	8350	Babcock and Wilcox 1972
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Percent ash	0.4-0.8	Johnson and Auth 1951; Mingle and Boubel 1968; Babcock and Wilcox 1972
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Ultimate analysis (percent)

Carbon	51.9	Johnson and Auth 1951; Babcock and Wilcox 1972
Hydrogen	5.1	Johnson and Auth 1951; Babcock and Wilcox 1972
Oxygen	42.4	Babcock and Wilcox 1972
Oxygen and nitrogen	42.6	Johnson and Auth 1951
Nitrogen	0.1	Babcock and Wilcox 1972
Sulfur	Trace-0.1	Johnson and Auth 1951; Babcock and Wilcox 1972

Scientific name: *Sequoiadendron giganteum*
Common name: Giant sequoia

VALUES

REFERENCES

WOOD

Specific gravity (green vol., OD wt.)

Young growth	0.35	Piirto and Wilcox 1981
Old growth	0.30	Piirto and Wilcox 1981
Mixed	0.34	Cockrell and Knudson 1973

Percent moisture content (OD basis)	180	Cockrell and Knudson 1973
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Percent ash	0.50	Sargent 1885
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Scientific name: *Taxus brevifolia*
Common name: Pacific yew

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.59-0.60	Markwardt and Wilson 1935; Funck and Hoag 1985
Percent moisture content (OD basis)	44-50.2	Markwardt and Wilson 1935; Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	9322	Funck and Hoag 1985
Percent ash	0.22-0.32	Sargent 1885; Kurth 1948; Funck and Hoag 1985
<u>BARK</u>		
Specific gravity (green vol., OD wt.)	0.35	Funck and Hoag 1985
(OD vol., OD wt.)	0.62	Harkin and Rowe 1971
Percent moisture content (OD basis)	97.2	Funck and Hoag 1985
Percent bark by volume	3.4	Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	6961	Funck and Hoag 1985
Percent ash	8.1	Funck and Hoag 1985

Scientific name: *Thuja plicata*
Common name: Western redcedar

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.27-0.42	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; W.J. Smith 1970; Maeglin and Wahlgren 1972; Funck and Hoag 1985
Percent moisture content (OD basis)		
Sapwood	249	Peck 1953
Heartwood	58	Peck 1953
Mixed	34.1-62	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Smith 1970; Dobie and Wright 1975; Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	8588-9700	Willey 1942; Dobie and Wright 1975; Funck and Hoag 1985
(Btu/AD cord)	16.8 x 10 ⁶	Hale 1933
Percent ash	0.27-0.42	Keller and McGovern 1945; Isenberg 1980; Funck and Hoag 1985

BARK

Specific gravity		
Inner bark (green vol., OD wt.)	0.36	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.38	Smith and Kozak 1971
Mixed (green vol., OD wt.)	0.35-0.37	Smith and Kurucz 1969; Funck and Hoag 1985
Mixed (OD vol., OD wt.)	0.44	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	88.5	Smith and Kozak 1971
Outer bark	37.4	Smith and Kozak 1971
Mixed	44.7-47.4	Mingle and Boubel 1968; Funck and Hoag 1985
Percent bark by volume		
Coastal	13.9	Dobie and Wright 1975
Interior	15.2	Dobie and Wright 1975
Mixed	9 ± 4.1	Snell and Max 1982; Funck and Hoag 1985
Higher heating value		
(Btu/ OD lb.)	8694-9014	Dobie and Wright 1975; Pingrey 1976; Kelsey et al. 1979; Cheremisinoff 1980; Funck and Hoag 1985
(Kcal/kg)	4830	Isenberg 1980
Percent ash	1.95-2.25	Mingle and Boubel 1968; Isenberg 1980; Funck and Hoag 1985

Scientific name: *Tsuga heterophylla*
Common name: Western hemlock

WOOD

	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.30-0.52	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Gerhards 1965; Smith 1970; Maeglin and Wahlgren 1972; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-108; U.S. Forest Products Laboratory, no date, Report PP-114
Percent moisture content (OD basis)		
Sapwood	143-170	Peck 1953; Dobie and Wright 1975
Heartwood	55-85	Peck 1953; Dobie and Wright 1975
Mixed	64.6-92	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Gerhards 1965; Smith 1970; Dobie and Wright 1975; Funck and Hoag 1985
Higher heating value		
(Btu/OD lb.)	8410-8620	Willey 1942; de Lorenzi 1949; Dobie and Wright 1975; Cheremisinoff 1980; Funck and Hoag 1985
(Btu/AD cord)	19.3 x 10 ⁶	Hale 1933

Percent ash		
Sapwood	0.37	Isenberg 1980
Heartwood	0.51	Isenberg 1980
Mixed	0.3–2.2	Keller and McGovern 1945; de Lorenzi 1949; Isenberg 1980; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-114
Ultimate analysis (percent)		
Carbon	50.4	de Lorenzi 1949
Hydrogen	5.8	de Lorenzi 1949
Oxygen	41.4	de Lorenzi 1949
Nitrogen	0.1	de Lorenzi 1949
Sulfur	0.1	de Lorenzi 1949
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.38–0.46	Smith and Kurucz 1969; Smith and Kozak 1971; Isenberg 1980; Meyer et al. 1981
Outer bark (green vol., OD wt.)	0.45–0.56	Smith and Kurucz 1969; Smith and Kozak 1971; Isenberg 1980; Meyer et al. 1981
Mixed (green vol., OD wt.)	0.44–0.46	Smith and Kurucz 1969; Harder and Einspahr 1976; Isenberg 1980; Funck and Hoag 1985
Mixed (OD vol., OD wt.)	0.59	Harkin and Rowe 1971
Percent moisture content (green vol., OD wt.)		
Inner bark	86–134	Smith and Kozak 1971; Meyer et al. 1981
Outer bark	38–65.2	Smith and Kozak 1971; Meyer et al. 1981
Mixed	65–74	Corder et al. 1970; Funck and Hoag 1985
Percent bark by volume		
Coastal	16.3	Dobie and Wright 1975
Interior	17.9	Dobie and Wright 1975
Mixed	6.3–16.3	Snell and Max 1982; Funck and Hoag 1985; U.S. Forest Products Laboratory, no date, Report PP-108
Higher heating value (Btu/OD lb.)	8900–9943	Corder et al. 1970; Dobie and Wright 1975; Harder and Einspahr 1976; Pingrey 1976; Kelsey et al. 1979; Cheremisinoff 1980; Isenberg 1980; Funck and Hoag 1985
Percent ash	1.5–3.7	Corder et al. 1970; Cheremisinoff 1980; Isenberg 1980; Funck and Hoag 1985
Ultimate analysis (percent)		
Carbon	51.2–53.0	Corder et al. 1970; Cheremisinoff 1980
Hydrogen	5.8–6.2	Corder et al. 1970; Cheremisinoff 1980
Oxygen	39.2–39.3	Corder et al. 1970; Cheremisinoff 1980
Nitrogen	0.0–0.1	Corder et al. 1970; Cheremisinoff 1980
Sulfur	0.0–trace	Corder et al. 1970; Cheremisinoff 1980

Scientific name: *Tsuga mertensiana*
Common name: Mountain hemlock

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.37-0.45	Markwardt and Wilson 1935; Youngs 1963
Percent moisture content (OD basis)	62-68	Markwardt and Wilson 1935; Youngs 1963
Percent ash	0.5	Isenberg 1980
BARK		
Specific gravity (OD vol., OD wt.)	0.46	Harkin and Rowe 1971

Hardwood Species

Scientific name: *Acer macrophyllum*
Common name: Bigleaf maple

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.44–0.62	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Funck and Hoag 1985
Percent moisture content (OD basis)	39–72	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975; Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	8140–8410	Corder 1973; Dobie and Wright 1975; Funck and Hoag 1985
Percent ash	0.26–0.54	Sargent 1885; Kurth 1950; Funck and Hoag 1985
BARK		
Specific gravity		
Inner bark (green vol., OD wt.)	0.66	Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.45	Smith and Kozak 1971
Mixed (green vol., OD wt.)	0.56	Funck and Hoag 1985
Mixed (OD vol., OD wt.)	0.55	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	134	Smith and Kozak 1971
Outer bark	70.1	Smith and Kozak 1971
Mixed	60.5	Funck and Hoag 1985
Percent bark by volume	7.8–10.5	Dobie and Wright 1975; Funck and Hoag 1985
Higher heating value (Btu/OD lb.)	8277	Funck and Hoag 1985
Percent ash	6.9	Funck and Hoag 1985

Scientific name: *Alnus rhombifolia*
Common name: White alder

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (OD vol., OD wt.)	0.41	Sargent 1885
Percent ash	0.31	Sargent 1885

Scientific name: *Alnus rubra*
Common name: Red alder

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.37-0.41	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; U.S. Forest Products Laboratory, no date, Report PP-110
Percent moisture content (OD basis)		
Sapwood	97	Peck 1953
Mixed	98-101	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975
Higher heating value		
(Btu/OD lb.)	7990-8000	Dobie and Wright 1975; Cheremisinoff 1980
(Btu/AD cord)	17.4 x 10 ⁶	Hale 1933
Percent ash	0.23-2.00	Sargent 1885; Kurth 1950; Rader Systems, Inc. 1978; Isenberg 1981
BARK		
Specific gravity (green vol., OD wt.)		
Inner bark	0.52	Smith and Kozak 1971
Outer bark	0.62	Smith and Kozak 1971
Mixed	0.58	Harder and Einspahr 1978
Percent moisture content (OD basis)		
Inner bark	87.8	Smith and Kozak 1971
Outer bark	66.0	Smith and Kozak 1971
Percent bark by volume	13.5	Dobie and Wright 1975
Higher heating value		
(Btu/OD lb.)	8406-8760	Pingrey 1976; Harder and Einspahr 1978; Cheremisinoff 1980
(Btu/lb. at 5.8% M.C.)	7947	Chang and Mitchell 1955
Percent ash	2.4-5.9	Chang and Mitchell 1955; Rader Systems, Inc. 1978; Isenberg 1981

Scientific name: *Arbutus menziesii*
Common name: Pacific madrone

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.54-0.58	Markwardt and Wilson 1935; Torgeson 1950; Schniewind 1957

Percent moisture content (OD basis)	68-93	Markwardt and Wilson 1935; Torgeson 1950; Peck 1953; Schniewind 1957
Percent ash	0.09-0.40	Sargent 1885; Kurth 1948

Scientific name: *Betula papyrifera*
Common name: Paper birch

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.48-0.52	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Kennedy 1965; Dobie and Wright 1975; U.S. Forest Products Laboratory, no date, Report PP-107
Percent moisture content (OD basis)		
Sapwood	72	Peck 1953; Dobie and Wright 1975
Heartwood	74-89	Peck 1953; Dobie and Wright 1975
Mixed	65-73	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Dobie and Wright 1975
Higher heating value		
(Btu/OD lb.)	8334	Tillman 1978
(Btu/AD cord)	23.4 x 10 ⁶	Hale 1933
Percent ash		
Sapwood	0.24	Isenberg 1981
Heartwood	0.21	Isenberg 1981
Mixed	0.2-0.4	Sargent 1885; Isenberg 1981; U.S. Forest Products Laboratory, no date, Report PP-110
<u>BARK</u>		
Specific gravity		
Inner bark(green vol., OD wt.)	0.57-0.63	Smith and Kozak 1971; Isenberg 1981
Outer bark (green vol., OD wt.)	0.54-0.66	Smith and Kozak 1971; Isenberg 1981
Mixed (green vol., OD wt.)	0.56	Isenberg 1981
Mixed (OD vol., OD wt.)	0.69	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Outer bark	22.5	Smith and Kozak 1971
Inner bark	67.7	Smith and Kozak 1971
Percent bark by volume	8-15.7	Smith and Kurucz 1969; Dobie and Wright 1975; U.S. Forest Products Laboratory, no date, Report PP-107
Higher heating value		
(Btu/OD lb.)	9490-10310	Millikin 1955; Cheremisnoff 1980
(Btu/lb. at 4.8% M.C.)	9434	Chang and Mitchell 1955
Percent ash	1.5-2.4	Chang and Mitchell 1955; Millikin 1955; Isenberg 1981

Ultimate analysis (percent)

Carbon	57.4	Millikin 1955
Hydrogen	6.7	Millikin 1955
Oxygen	33.8	Millikin 1955
Nitrogen	0.3	Millikin 1955
Sulfur	0	Millikin 1955

Scientific name: *Castanopsis chrysophylla*
Common name: Giant (golden) chinquapin

VALUES

REFERENCES

WOOD

Specific gravity (green vol., OD wt.)

Sapwood	0.40-0.41	Resch and Huang 1965
Heartwood	0.42	Resch and Huang 1965
Mixed	0.41-0.43	Markwardt and Wilson 1935; Torgeson 1950; Resch and Huang 1965; U.S. Forest Products Laboratory, no date, Report PP-107

Percent moisture content (OD basis)

Mixed	111-166	Markwardt and Wilson 1935; Torgeson 1950; Peck 1953; Resch and Huang 1965
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Percent ash

0.30-0.35	Sargent 1885; Kurth 1950
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BARK

Percent bark by volume

11.1	U.S. Forest Products Laboratory, no date, Report PP-107
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Scientific name: *Cornus nuttallii*
Common name: Pacific dogwood

VALUES

REFERENCES

WOOD

Specific gravity (green vol., OD wt.)

0.58	Markwardt and Wilson 1935
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Percent moisture content (OD basis)

52	Markwardt and Wilson 1935
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Percent ash

0.22-0.50	Sargent 1885; Kurth 1948
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Scientific name: *Fraxinus latifolia*
Common name: Oregon ash

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.50	Markwardt and Wilson 1935
Percent moisture content (OD basis)	48	Markwardt and Wilson 1935
Higher heating value (Btu/OD lb.)	8200	Willey 1942
Percent ash	0.34	Sargent 1885
BARK		
Specific gravity (OD vol., OD wt.)	0.50	Harkin and Rowe 1971

Scientific name: *Lithocarpus densiflorus*
Common name: Tanoak

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.48-0.62	Torgeson 1950; Espenas 1953; Paul et al. 1955; Randall 1956; Schniewind 1958b; U.S. Forest Products Laboratory 1967; U.S. Forest Products Laboratory, no date, Report PP-110
Percent moisture content (OD basis)	43.6-120	Torgeson 1950; Espenas 1953; Peck 1953; Paul et al. 1955; Randall 1956; Schniewind 1958b; U.S. Forest Products Laboratory 1967
Percent ash	0.31-1.49	Sargent 1885; Kurth 1950; U.S. Forest Products Laboratory, no date, Report PP-110
BARK		
Specific gravity (OD vol., OD wt.)	0.75	Harkin and Rowe 1971
Percent bark by volume	15.7	U.S. Forest Products Laboratory, no date, Report PP-110

Scientific name: *Populus fremontii*
Common name: Fremont cottonwood

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.41	Dost and Gorvad 1976
Percent moisture content (OD basis)	139	Dost and Gorvad 1976
Percent ash	0.77-1.13	Sargent 1885

Scientific name: *Populus tremuloides*
Common name: Quaking aspen

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.33-0.39	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Kennedy 1965; U.S. Forest Products Laboratory, no date, Report PP-110
Percent moisture content (OD basis)		
Sapwood	113	Peck 1953
Heartwood	95	Peck 1953
Mixed	90-123	Markwardt and Wilson 1935; Forest Products Laboratories of Canada 1956; Mackay 1974; Marden et al. 1975
Higher heating value		
(Btu/AD lb.)	5785	Isenberg 1981
(Btu/AD cord)	17.7×10^6	Hale 1933
Percent ash	0.2-2.1	Sargent 1885; Clermont and Schwartz 1951; Wilde and Paul 1959; Isenberg 1981
Percent nitrogen	0.09-0.15	Wilde and Paul 1959

<u>BARK</u>		
Specific gravity		
Inner bark (green vol., OD wt.)	0.4	Isenberg 1981
Outer bark (green vol., OD wt.)	0.55	Isenberg 1981
Mixed (green vol., OD wt.)	0.50	Harder and Einspahr 1976; Isenberg 1981
Mixed (OD vol., OD wt.)	0.61-0.73	Harkin and Rowe 1971
Percent moisture content (OD basis)	65.1-67.2	Marden et al. 1975

Percent bark by volume	8.9-16.5	Dobie and Wright 1975; Marden et al. 1975; U.S. Forest Products Laboratory, no date, Report PP-110
Higher heating value (Btu/OD lb.)	8430-8712	Harder and Einspahr 1976; Cheremisinoff 1980; Isenberg 1981
(Btu/lb. at 5.5% M.C.)	8433	Chang and Mitchell 1955
Percent ash	2.8	Chang and Mitchell 1955

Scientific name: *Populus trichocarpa*
Common name: Black cottonwood

	<u>VALUES</u>	<u>REFERENCES</u>
<u>WOOD</u>		
Specific gravity (green vol., OD wt.)	0.28-0.40	Markwardt and Wilson 1935; Kennedy 1965; Maeglin and Wahlgren 1972
Percent moisture content (OD basis)		
Sapwood	146	Peck 1953
Heartwood	162	Peck 1953
Mixed	132-175	Markwardt and Wilson 1935; Dobie and Wright 1975
Higher heating value (Btu/OD lb.)	8800	Dobie and Wright 1975
(Btu/AD cord)	15.5×10^6	Hale 1933
Percent ash	0.3-1.27	Sargent 1885; Isenberg 1981
<u>BARK</u>		
Specific gravity		
Inner bark (green vol., OD wt.)	0.38-0.41	Isenberg 1981; Smith and Kozak 1971
Outer bark (green vol., OD wt.)	0.42-0.44	Isenberg 1981; Smith and Kozak 1971
Mixed (green vol., OD wt.)	0.40-0.46	Smith and Kurucz 1969; Harder and Einspahr 1978; Isenberg 1981
Mixed (OD wt., OD vol.)	0.60	Harkin and Rowe 1971
Percent moisture content (OD basis)		
Inner bark	130	Smith and Kozak 1971
Outer bark	77.4	Smith and Kozak 1971
Percent bark by volume	18.3	Dobie and Wright 1975
Higher heating value (Btu/OD lb.)	8765-9000	Dobie and Wright 1975; Pingrey 1976; Harder and Einspahr 1978
Percent ash	5.0	Isenberg 1981

Scientific name: *Quercus agrifolia*
Common name: Coast (California) live oak

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (OD vol., OD wt.)	0.83	Sargent 1885
Percent ash	1.28	Sargent 1885

Scientific name: *Quercus chrysolepis*
Common name: Canyon live oak

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.70	Markwardt and Wilson 1935
Percent moisture content (OD basis)	62	Markwardt and Wilson 1935
Percent ash	0.60	Sargent 1885

Scientific name: *Quercus douglasii*
Common name: Blue oak

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.64	U.S. Forest Products Laboratory, no date, Report PP-110
Percent ash	0.84-1.4	Sargent 1885; U.S. Forest Products Laboratory, no date, Report PP-110

Scientific name: *Quercus garryana*
Common name: Oregon white oak

<u>WOOD</u>	<u>VALUES</u>	<u>REFERENCES</u>
Specific gravity (green vol., OD wt.)	0.63-0.64	Markwardt and Wilson 1935; Paul et al. 1958
Percent moisture content (OD basis)	67-72	Markwardt and Wilson 1935; Paul et al. 1958

Higher heating value (Btu/OD lb.)	8110	Corder 1973
Percent ash	0.39	Sargent 1885
BARK		
Specific gravity (OD vol., OD wt.)	0.80	Harkin and Rowe 1971

Scientific name: *Quercus kelloggii*
Common name: California black oak

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.46-0.51	Markwardt and Wilson 1935; U.S. Forest Products Laboratory, no date, Report PP-110; Schniewind 1958a
Percent moisture content (OD basis)		
Sapwood	75	Peck 1953
Heartwood	76	Peck 1953
Mixed	106-108	Markwardt and Wilson 1935; Schniewind 1958a
Percent ash	0.26-0.4	Sargent 1885; U.S. Forest Products Laboratory, no date, Report PP-110

Scientific name: *Quercus lobata*
Common name: Valley oak (California white oak)

	<u>VALUES</u>	<u>REFERENCES</u>
WOOD		
Specific gravity (green vol., OD wt.)	0.53-0.58	Paul et al. 1958; U.S. Forest Products Laboratory, no date, Report PP-110; Schniewind and Bryan 1959
Percent moisture content (OD basis)	91-103	Paul et al. 1958; Schniewind and Bryan 1959
Percent ash	0.30-0.9	U.S. Forest Products Laboratory, no date, Report PP-110; Sargent 1885
BARK		
Specific gravity (OD vol., OD wt.)	0.66	Harkin and Rowe 1971

Scientific name: *Quercus wislizeni*
Common name: Interior live oak

WOOD	VALUES	REFERENCES
Specific gravity (OD vol., OD wt.)	0.79	Sargent 1885
Percent ash	1.02	Sargent 1885

Scientific name: *Umbellularia californica*
Common name: California-laurel (Oregon-myrtle)

WOOD	VALUES	REFERENCES
Specific gravity (green vol., OD wt.)	0.51-0.59	Markwardt and Wilson 1935; Torgeson 1950
Percent moisture content (OD basis)	59.8-70	Markwardt and Wilson 1935; Torgeson 1950; Peck 1953
Percent ash	0.16-0.39	Sargent 1885; Kurth 1948

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Metric/British Conversion

1 cubic foot (ft³) = 0.0283 cubic meters (m³)

1 cord = 3.62 cubic meters

(based on 128 ft³ of stacked roundwood,
approximately 90 ft³ of solid material)

1 pound (lb) = 0.454 kilogram (kg)

1 British thermal unit (BTU) = 0.252 kilocalorie (kcal) = 1055.06 joule (J)
(°F) = 1.8(°C) + 32

WILSON, PAMELA L., JAMES W. FUNCK, and ROBERT B. AVERY. 1986. FUELWOOD CHARACTERISTICS OF NORTH-WESTERN CONIFERS AND HARDWOODS. Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 60. 42 p.

This publication collates the published ranges of fuelwood characteristics for 33 conifer and 20 hardwood species in the Pacific Northwest. The following characteristics are covered: specific gravity, percent moisture content, higher heating value, and percent ash of wood and bark; percent bark by volume; and ultimate analysis (percent carbon, hydrogen, oxygen, nitrogen, and sulfur) of wood and bark.

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