use of wood in architecture =

SELECTION OF SPECIES

THESIS toward degree of Master in
Architecture, School of Architecture, Massachusetts
Institute of Technology, March 19, 1942

[Signature]
Walter R. MacCornack, Dean
School of Architecture
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Dean MacCornack:

I herewith respectfully submit my thesis,
Use of Wood in Architecture: Selection of Species, as partial fulfillment of the requirements for the Master of Architecture Degree.

Very sincerely yours

William Hoskins Brown

33 Woodland Road
Auburndale, Mass.
March 19, 1942
ACKNOWLEDGEMENT

For their cooperation and advice in the preparation of this thesis, I wish to express my sincere gratitude to:

Dean Walter R. MacCornack
Professor Lawrence B. Anderson
Professor Albert G. Dietz
Massachusetts Institute of Technology

and, for invaluable suggestions and technical data, to:

Professor Herbert Beckwith
Professor Bissell Alderman
Massachusetts Institute of Technology

Forest Products Laboratory, Madison, Wis.

Appalachian Hardwood Manufacturers, Inc.
California Redwood Association
Maple Flooring Manufacturers' Association
National Hardwood Lumber Association
National Oak Flooring Manufacturers' Assn.
Northern Pine Manufacturers' Association
Southern Cypress Manufacturers' Association
Southern Hardwood Producers, Incorporated
Southern Pine Association
West Coast Lumbermen's Association
Western Pine Association

Freeman-Carder Corporation, West Newton, Mass.
Geo. C. McQuesten, Inc., East Boston, Mass.
EXPOSITION

This thesis surveys 46 commercially important U.S.-grown woods used in architecture.\(^1\) It focuses on selection of species, the choosing of the best wood for a definite job.\(^2\) It aims to expedite examination of alternative woods when customary woods cannot be got (or when their fitness is suspect).\(^3\)

The major part of the thesis is the presentation in chart form of comparative data on wood properties. Much of this material has been available only in widely scattered references. Some of it has not been presented in comparative form. Correlated with the Charts are Properties and Species Surveys. These give more detailed information, and a bibliography, for each property and each wood.

CHARTS

4 charts cross-tabulate 23 hardwoods and 23 softwoods with the properties usually considered when selecting a wood. Comparisons are given, from "A", for those woods highest or best in a particular property, to "E", for

1. Recognized as a desirable extension of this study, but not here included, is the field of imported woods used in the U.S., as teak, mahogany.

2. An introductory diagram, Chart No.1, outlines wood manufacture from tree to graded lumber. It shows selection of species, the main emphasis of this survey, as only one in a series of selections: What material, wood or other? What species? What grade? What method of sawing? What special process or treatment, if any, to alter properties?
EXPOSITION —continued, 2

those lowest or worst. For the strength properties, comparisons are also given graphically, in percentages of the corresponding values for White Oak. Actual values are listed in the Charts in cases where they may be used directly in design or calculation, as for weight, stiffness, strength, thermal conductivity.

Woods have been arranged in the approximate order of the amount of each cut annually, except for the arbitrary grouping together of all related woods, as the Pines, the Cedars, the Oaks.

PROPERTIES SURVEY

The Properties Survey (1) defines or describes the particular property when not self-evident; (2) lists woods in the order of their excellence in a particular property and allocates them into ABCDE groups; (3) gives sources for data used in (2); (4) lists references for general and technical information about the property, noting cases where more recent data have supplanted those in standard reference works.

3. Other woods of slight general commercial importance but exceptionally high or low in this property are included parenthesized.

4. The Properties Survey lists references pertaining to, but does not attempt to cover, such general problems in the use of wood as design, assembly, finishing, except insofar as the various woods differ in their potentialities.
EXPOSITION -continued, 3

SPECIES SURVEY

For each wood, the Species Key summarizes outstanding properties and major uses, lists bibliography, grading rules, and grades.

The summary of outstanding properties revaluates each wood according to the ABCDE groupings established in the Charts and Properties Key. It attempts to bring more precision to terminology which has often been vague or antithetic. (These contradictions may have arisen through comparison, for instance, of a softwood with other softwoods, which it may surpass, instead of with all woods, where it may have an average value.)

Wood-uses other than architectural are listed parenthesized if they (1) consume a large percentage of the total of that wood produced or (2) indicate by their unusual nature the existence of a rare combination of properties.
EXPOSITION

USE-PROPERTIES GUIDE

PROPERTIES SURVEY

Explanation

a. Amount of lumber produced.  MARKET

b-1. Cost: at mill, average value of all grades
    of each wood.

b-2. Cost: market value of hardwoods, based on
    stock of equivalent grade.


c. Grading.

d-1. Product, availability in required size and
    form: size.

d-2. Product, availability in required size and
    form: references; form and use of products;
    products usually available in retail yards.

d-3. Product, availability in required size and
    form: plywood, references and available woods.

d-4. Product, availability in required size and
    form: special plywood products, references.

e. Weight.

f-1. Strength: basic stresses.  STRENGTH


f-3. Strength: percentage stresses, ABCDE groups.

f-4. Strength: references to the application of
    working stresses in design.

f-5. Strength: references on the effect on strength
    of moisture, seasoning method, angle of grain,
    size, thinness of section.
f-6. Strength: references on built-up sections, frame walls, trusses, laminated arches.

f-7. Strength: plywood.

g. Stiffness, rigidity, resistance to deflection: modulus of elasticity.

h. Hardness.

i. Wear and abrasion resistance.

j. Shock resistance, toughness.

k. Thermal conductivity.

l. Ability to stay in place.

m-1. Shrinkage due to moisture change: references, computation methods.

m-2. Shrinkage due to moisture change: continued.

n-1. Checking and warping.

n-2. Checking and warping: continued.

o. Resistance of heartwood to decay under moisture-inducing conditions.

p. Penetrability.

q. Appearance weathered.

r-1. Workability: ease, with hand tools.

r-2. Workability: quality, with machine tools.

s. Bendability.

t. Connection strength: nails, bolts, connectors.

u. Ease of gluing.

v-1. Ease of painting.

v-2. Finishing: references.

w-1. Appearance and identification: references.

w-2. Appearance and identification: continued.
SPECIES SURVEY

Explanation.

SOFTWOODS
1-2. Longleaf YP, Shortleaf YP.
7. Sugar Pine.
8-9. Coast DF, Mountain DF.
10. Eastern Hemlock.
11. Western Hemlock.
12. Southern Cypress.
15. Sitka Spruce.
16. Redwood.
17. Western Red Cedar.
18. Eastern Red Cedar.
21. Western Larch.
22. White Fir.
23. Balsam Fir.

HARDWOODS
24-25. Red Oak, White Oak.
29-30. Yellow Birch, Sweet Birch.
31. Beech.
32. Black Gum and Tupelo Gum.
33. Yellow Poplar.
34. Cottonwood.
35. Basswood.
36-37. White Ash, Black Ash.
38. Chestnut.
41. Hickory.
42. Black Walnut.
43. Sycamore.
44. Magnolia.
45. Red Alder.
46. Black Cherry.

ABBREVIATIONS

CHARTS
1. Diagram of wood manufacture and grading.
2. Softwoods: market; strength; weathering; working; finishing.
3. Hardwoods: market; strength; weathering; working; finishing.
There are many special uses for which the required wood properties are obvious. Listed below are some typical standard uses together with required properties in order of importance. The degree of excellence in each property is suggested in terms of ABCDE grouping.

<table>
<thead>
<tr>
<th>Use</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Framing</td>
<td>Cost-b-A; Size and moisture content available-d; Stiffness-g-D; Connection strength-t-D; Freedom from warp-n-B.</td>
</tr>
<tr>
<td>Wall sheathing</td>
<td>Cost-b-A; Workability-r-C; Shrinkage-m-C.</td>
</tr>
<tr>
<td>Roofing</td>
<td>Cost-b-A; Stiffness-g-D; Connection strength-t-D; Freedom from warp-n; Workability-r-C.</td>
</tr>
<tr>
<td>Sub-flooring</td>
<td>Cost-b-A; Stiffness-g-D; Shrinkage-m-C; Freedom from warp-n; Workability-r-C.</td>
</tr>
<tr>
<td>Siding</td>
<td>Cost-b-C; Paintability-v-B; Workability-r-C; Freedom from warp-n-B.</td>
</tr>
<tr>
<td>Porch flooring</td>
<td>Decay resistance-o-C; Wear resistance-h,i-D; Freedom from warp-n-B.</td>
</tr>
<tr>
<td>Exterior trim, ptd</td>
<td>Freedom from warp-n-B; Paintability-v-B; Decay resistance-o-C.</td>
</tr>
<tr>
<td>Exterior trim, nat</td>
<td>Decay resistance-o-A; Freedom from warp-n; Appearance weathered-q; Appearance-w.</td>
</tr>
<tr>
<td>Sash</td>
<td>(Decay resistance-o-A, for exposed locations); Shrinkage-m-C; Paintability-v-B; Freedom from warp-n; Workability-r-C; Connection strength-t-D, for screws.</td>
</tr>
<tr>
<td>Flooring</td>
<td>Wear resistance-h,i-B; Attractive figure and color-w; Freedom from warp-n; Shrinkage-m-C; Workability-r-D.</td>
</tr>
<tr>
<td>Kitchen flooring</td>
<td>Wear resistance-h,i-C; Fine texture-w; Washability-p; Workability-r-D.</td>
</tr>
</tbody>
</table>
Interior trim, ptd. Uniform texture-w; Hardness-h-D; Paintability-v-B; Absence of pitch-w; Freedom from warp-n-B; Shrinkage-m-C; Workability-r-C.

Interior trim, nat. Attractive figure and color-w; Hardness-h-C; Ability to stay put-l-B; Workability-r-C.

Shelving, ptd. Stiffness-g-D; Workability-r-C; Ability to stay put-l-C; Freedom from pitch-w; Paintability-v-C.

Shelving, nat. Stiffness-g-C; Finishability-v; Ability to stay put-l-C; Freedom from pitch-w; Attractive figure and color-w.

1. This listing is adapted from the following reference, reorganized, and checked with the Properties Key:
Sweet, C.V. and Johnson, R.P.A.: Selection of Lumber for Farm and Home Building, 1936, USDA Farmers' Bulletin No.1756; 46p., GPO. (pp. 1-8 and 8-13 were reprinted in October 1940 and are available as USDA FPL Technical Notes Nos. 245 and 246, FPL, Madison, Wisconsin.)
KEY LETTER

NAME OF PROPERTY
Further definition of property, discussion.

Sources for data (values or relationships) used in the table below; explanation of any further analysis of data; explanation of ABCDE grouping where this is not self-evident.

TABLE
Softwoods
Hardwoods

(Listed in order of their excellence in this property and allocated into ABCDE groups. Less important woods of exceptional merit in this property are parenthesized.)

Sources for general information about this property.
Sources for specific information about unusual aspects of this property.
AMOUNT OF LUMBER PRODUCED.

Amounts of each species (or group of species considered as one by the lumber industry) in thousand feet board measure, produced in the United States in 1939.

Values, except for white pines, hemlocks, spruces, are taken directly from:
Dept. of Commerce, Bureau of the Census, 16th Census of the U.S., Preliminary report on census of manufactures for 1939, Industry No. 520, Production of Lumber, Lath, and Shingles. Northern and western pine, eastern and western hemlock, eastern and western spruce values are compiled from the tables of production by states.
(Values exclude lath and shingles, not given by species.)

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>M ft., b.m.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>21,242,387</td>
<td>85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardwoods</th>
<th>M ft., b.m.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3,733,087</td>
<td>15</td>
</tr>
</tbody>
</table>

YP, llf, slf, other 7 803 991 31.
DF, cst, inld, mtn 6 494 301 26.
Pine, ponderosa 3 360 004 13.

(Pine, white, tot. 1 313 191) 5.3
(Hemlock, total 665,259) 2.7
Pine, N. white 513 702 2.1
Pine, W. white 490 560 2.0

Cypress, S. 421 584 1.7
Hemlock, E. 370 800 1.5
(Spruce, total 346,159) 1.4
Redwood 345 003 1.4
Pine, sugar 308 929 1.2
Hemlock, W. 294 459 1.2

Cedar, total 263 693 1.1
Spruce, W. 238 668 1.0

Larch 111 488 .45
Spruce, E. 107 491 .43
Fir, white 97 712 .39

Basswood 95 688 .38
Ash, total 90 428 .36
Chesnut 74 051 .29
Elm, hard, soft 73 845 .29
Hickory 37 759 .15
Sycamore 27 104 .11
Walnut 27 007 .11

Fir, balsam 20 002 .08

Cherry, Magnolia, Alder, and other 109 201 .44
COST.
Average value per thousand feet, board measure, of lumber at the mill, by kinds, 1939.
Values, except for white pines, hemlocks, spruces, are taken directly from:
Dept. of Commerce, Bureau of the Census, 16th Census of the U.S., Preliminary report on census of manufactures for 1939, Industry No. 520, Average Values of Lumber by Kinds of Wood. Northern and western pine, eastern and western hemlock, eastern and western spruce values are compiled by the tables of values by states.

These average figures do not always give a true relationship between prices for different species at the same grade; for they include all qualities and all grades of a species, and some species have a higher percentage of select material. Prices, and the spread between prices for different grades, vary frequently according to the supply and demand in any locality. In softwoods, the price range between the lower select grades and the upper board grades is often 30 to 50%. In hardwoods, the grade of Firsts & Seconds is usually 75 to 100% higher in price than the highest common grade. (U.S.D.A. Farmers' Bulletin No. 1756). For current prices consult quotations in such lumber industry periodicals as Southern Lumberman.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Average</th>
<th>$20.97</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemlock, W.</td>
<td>16.70</td>
<td></td>
</tr>
<tr>
<td>Larch</td>
<td>16.80</td>
<td></td>
</tr>
<tr>
<td>Fir, white</td>
<td>17.34</td>
<td></td>
</tr>
<tr>
<td>DF, all types</td>
<td>17.91</td>
<td></td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>19.43</td>
<td></td>
</tr>
<tr>
<td>YP, all types</td>
<td>19.70</td>
<td></td>
</tr>
<tr>
<td>Hemlock, E.</td>
<td>21.40</td>
<td></td>
</tr>
<tr>
<td>Pine, N. white</td>
<td>22.40</td>
<td></td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>22.75</td>
<td></td>
</tr>
<tr>
<td>Spruce, E.</td>
<td>24.60</td>
<td></td>
</tr>
<tr>
<td>Spruce, W.</td>
<td>27.70</td>
<td></td>
</tr>
<tr>
<td>Pine, W. white</td>
<td>29.50</td>
<td></td>
</tr>
<tr>
<td>Pine, sugar</td>
<td>30.10</td>
<td></td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cypress</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar, all types</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardwoods</th>
<th>Average</th>
<th>$27.66</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>21.41</td>
<td></td>
</tr>
<tr>
<td>Chestnut</td>
<td>21.94</td>
<td></td>
</tr>
<tr>
<td>Beech</td>
<td>22.03</td>
<td></td>
</tr>
<tr>
<td>Tupelo</td>
<td>22.09</td>
<td></td>
</tr>
<tr>
<td>Sycamore</td>
<td>22.26</td>
<td></td>
</tr>
<tr>
<td>Gum, red</td>
<td>23.28</td>
<td></td>
</tr>
<tr>
<td>Elm, all types</td>
<td>24.54</td>
<td></td>
</tr>
<tr>
<td>Alder</td>
<td>24.63</td>
<td></td>
</tr>
<tr>
<td>Oak, white, red</td>
<td>26.32</td>
<td></td>
</tr>
<tr>
<td>Hickory, all types</td>
<td>26.75</td>
<td></td>
</tr>
<tr>
<td>Poplar, yellow</td>
<td>26.98</td>
<td></td>
</tr>
<tr>
<td>Magnolia</td>
<td>27.26</td>
<td></td>
</tr>
<tr>
<td>Basswood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maple, hard, soft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birch, all types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash, all types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walnut, black</td>
<td>63.18</td>
<td></td>
</tr>
</tbody>
</table>
COST—continued.
Market values of hardwood lumber (and Cypress) per M ft.b.m.,
for rough, air-dried 4/4" stock, of grades indicated, and
f.o.b. as follows:
S - Southern hardwoods, f.o.b. mill.
A - Appalachian hardwoods, f.o.b. Cleveland, Ohio.
N - Northern Hardwoods, f.o.b., Wausau, Wisconsin.
NE- average wholesale market prices, Boston, Mass.
Values for S, A, N, to the nearest even dollar, are
those pertaining at January 1, 1941, and are from the
American Lumberman, January 11, 1941 (or as near it
as any particular combination of wood, grade, and 4/4"
thickness is quoted). Boston market values are for
same date and are through the courtesy of the George
McQuesten Co., Inc. and the Freeman-Carder Corp. This
date is chosen to discount 1941 price rises which
range from 0 to 66% and average about 10%.

<table>
<thead>
<tr>
<th>Woods:</th>
<th>Grades:</th>
</tr>
</thead>
<tbody>
<tr>
<td>all 4/4&quot;</td>
<td>FAS, Firsts &amp; Seconds</td>
</tr>
<tr>
<td>unless noted</td>
<td>S  A  N  NE</td>
</tr>
</tbody>
</table>

| Cottonwood   | '36. |       |       |
| Chestnut     | 37.  | 135.  | 27.   |
| Beech        | 38.  | 54.   | 28.   |
| Elm, rock    | 42.  |       |       |
| Elm, soft    | 40.  |       |       |
| Magnolia     | 42.  |       |       |
| Gum, Bl. & Tupelo | 40. |       |   |
| " qtd.       | 30.  |       |       |
| Basswood     | 49.  | 82.   | 78.   |
| Ash, black   | 50.  | 80.   | 70.   |
| Oak, red     | 45.  | 84.   | 110.  |
| Gum, sap     | 47.  | 31.   |       |
| " qtd.       | (53.)|       |       |
| Gum, red     | 35.  |       |       |
| " qtd.       | (90.)|       |       |
| Poplar, yellow| 58. | 92.   | 118.  |
| Cypress, S   | 59.  | 120.  | 48.   |
| Maple, soft  | 65.  | 140.  |       |
| Hickory      | 150. |       |       |
| Maple, hard  | 108. | 79.   | 165.  |
| Birch, unsel. | 115. | 140.  | 75.   |
| Oak, white   | 60.  | 118.  | 165.  |
| " qtd.       | (103.)| (220.)| (47.)|
| Cherry       | 160. |       |       |
| Walnut, black| 200. |       |       |

B
C
D
E
Because of the diversity of sizes, products, and grading methods, it is impossible to establish a table of direct price relationships for equivalent grades of softwoods. The grouping below is based on various estimates and interpolations and should serve only as a general guide.

Some woods produce lumber of a fairly constant grade and value; others produce lumber over a broad price range. This is indicated by the use of letters showing the upper and lower limits of the price variation.

Softwoods:
- Fir, balsam
- Spruce, Engelmann
- Spruce, E.
- Hemlock, E.
- Fir, white
- Pine, Norway
- Larch, W.
- Hemlock, W.
- DF, all types
- YP, shortleaf
- YP, longleaf
- Pine, N. white
- Pine, ponderosa
- Pine, W. white
- Pine, sugar
- Spruce, Sitka
- Cypress, S.
- Cedar, E. red
- Cedar, white
- Cedar, W. red
- Cedar, Pt. Orford
- Redwood
COST —continued.

Average milling charges, per M board feet:
   (as of January, 1942)                  Softwoods  Hardwoods

<table>
<thead>
<tr>
<th>Service</th>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surfacing 1 or 2 sides</td>
<td>$4.00</td>
<td>$8.00</td>
</tr>
<tr>
<td>Surfacing 3&quot; or 4 sides</td>
<td>.60</td>
<td>12.00</td>
</tr>
<tr>
<td>Matching or shiplapping</td>
<td>6.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Grooving for splines</td>
<td>6.00</td>
<td>12.00</td>
</tr>
<tr>
<td>Surfacing and chamfering</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Cutting to lengths 7' and over</td>
<td>7.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Cutting to lengths 7' to 2'</td>
<td>8.00</td>
<td>11.00</td>
</tr>
<tr>
<td>Cutting to lengths 2' and under</td>
<td>10.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Butting timber, two ends</td>
<td></td>
<td>7.00</td>
</tr>
<tr>
<td>Running sheathing, flooring, and siding</td>
<td>15.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Sanding 1 side</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Sanding 2 sides</td>
<td>15.00</td>
<td>15.00</td>
</tr>
<tr>
<td>Sanding 3 or 4 sides</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Man and machine, per hour</td>
<td>4.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>
c.

**GRADING**

For actual grading rules and specifications for any wood, write to the controlling lumber association. Proper associations for each wood are indicated in the Charts and the Species Key.

References to grading in general:

**NLMA**: Lumber Grade-Use Guide for Softwood and Hardwood Lumber, 1935 and later sectional revisions, NLMA, Washington, D.C.

(Pamphlet I: General discussion, classes, grading, abbreviations, index; Pamphlets II-XIV: Softwoods, for each a grade-use guide and description of standard grades; Pamphlet XV: Hardwoods, selection factors, commercial structural grades (finish-grades not included).)

**Luxford and Trayer**: Wood Handbook, 1935, USDA, FPL.

(Fp.71-98. Softwoods: yard, structural, and factory lumber grades; hardwoods: finish lumber, trim, and flooring grades (structural grades not included).)


(Pp.61-9. Description of defects and blemishes considered in grading; softwoods: grades and illustrations; hardwoods: grades of finish lumber, trim, and flooring (structural grades not included).)

**Hayward, P.A.**: Wood, Lumber and Timbers, 1930, Chandler Cyclopedia, New York, N.Y.

(Pp.55-124. Use-, size-, and manufacturing classifications; defects; abbreviations; softwood yard, structural, and factory grades; hardwood finish grades (flooring and structural grades not included); ordering, checking, and inspection.


(Pp.46-98,114. Similar to preceding reference, but does not include hardwoods and has less emphasis on ordering and inspection methods.)
PRODUCT: AVAILABILITY IN REQUIRED SIZE AND FORM.

This table establishes a general size-classification for woods, based on one or more of the following kinds of "size":

1. Large area cross section commercially available.
2. Great width cross section commercially available.
3. Large size of tree permitting special cuttings of big stock.

(Where possible, maximum dimensions of commercial stock, or special stock*, are listed, as w (width) 22 (inches), t (thickness) 4.)

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redwood</td>
<td>A</td>
</tr>
<tr>
<td>DF, coast w24 t24</td>
<td>Cottonwood w17 t2½</td>
</tr>
<tr>
<td>Hemlock, W.</td>
<td>Sycamore t14</td>
</tr>
<tr>
<td>YP, longleaf w16 t16</td>
<td>Gum, red t2</td>
</tr>
<tr>
<td>Larch, W.</td>
<td></td>
</tr>
<tr>
<td>Cypress, S. *w30 t24</td>
<td>Poplar, yellow t2</td>
</tr>
<tr>
<td>YP, shortleaf</td>
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<tr>
<td>Pine, sugar</td>
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<tr>
<td>Pine, ponderosa</td>
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<tr>
<td>DF, mountain</td>
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<tr>
<td>Hemlock, E. w16 t16</td>
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<tr>
<td>Spruce, Sitka</td>
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<tr>
<td>Cedar, W. red</td>
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<tr>
<td>Cedar, Ft.Orfd.</td>
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<tr>
<td>Pine, N. white w14 t3</td>
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<tr>
<td>Cedar, E. red w5 t1</td>
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</tr>
<tr>
<td>Fir, white</td>
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<td>Spruce, E. w12/t10</td>
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<tr>
<td>Cedar, white</td>
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<td>Spruce, Engln.</td>
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<tr>
<td>Fir, balsam</td>
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</tr>
</tbody>
</table>

* (* denotes special stock)
PRODUCT: AVAILABILITY IN REQUIRED SIZE AND FORM

General references: Form and Use of Product:
Lumber Grade-Use Guide for Softwood and Hardwood Lumber in
Building and General Construction, 1935 (some sections re-
vised to 1940), National Lumber Manufacturers Association.
(Lists the recommended grade, "in high cost, medium cost,
and low cost work, for various items or products, in
each of the following types of structures:
1. Buildings, light framed or light joisted construction,
   rough carpentry.
2. Buildings, heavy framed, heavy joisted, or heavy tim-
   bered mill construction, rough carpentry.
3. Buildings, framed, joisted, or heavy timbered mill con-
   struction, exterior finished carpentry and millwork.
4. Buildings, fireproofed construction, rough and exterior
carpentry.
5. Buildings, framed, joisted, heavy timbered mill, or
   fireproofed construction, interior finished carpentry,
millwork and cabinet work.
25. Subway construction.
--for each softwood, in Pamphlets II thru XIV.,
and, with modifications, for hardwoods in general, in
Pamphlet XV.)

(Grades of yard-lumber products cut from various species
of softwood, pp.601-605; range of grades of various soft-
woods used for specific purposes, pp.606-689:

<table>
<thead>
<tr>
<th>Softwood</th>
<th>Dwellings</th>
<th>Indust. Bldgs.</th>
<th>Stadia</th>
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<tbody>
<tr>
<td>Cypress, Redwood</td>
<td>606</td>
<td>614</td>
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</tr>
<tr>
<td>Hemlock E., Spruce E</td>
<td>615</td>
<td>623</td>
<td>623</td>
</tr>
<tr>
<td>DF, Larch, White fir</td>
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<td></td>
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</tr>
<tr>
<td>Hemlock W, DF,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>633</td>
<td>646</td>
<td>647</td>
</tr>
<tr>
<td>YP, long- &amp; shortleaf</td>
<td>648</td>
<td>668</td>
<td>669</td>
</tr>
<tr>
<td>Pine, N&amp;W white,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine, sugar,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine, Norway,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>670</td>
<td>688-9</td>
<td>688-9</td>
</tr>
</tbody>
</table>

General references: Lumber Products Usually Available in
Retail Yards: Catalog of Plywood and Allied Products, Fall

Sweet and Johnson: Selection of Lumber for Farm and Home
Building, 1936, USDA Farmers' Bulletin No.1756, GPO,
pp.32-6.
PRODUCT: AVAILABILITY IN REQUIRED SIZE AND FORM - PLYWOOD

General references:

(Available woods, thicknesses, sizes.)

(Colors, figures, price range, sizes.)

Homefurnishing Arts: Faces and Figures- A Story of the Manufacture of Plywood and Veneer, 1935; reprinted by the Veneer Association, Chicago, Ill...
(16 color plates, other illustrations.)


Woods usually used and available as plywood:

- because of hardness, wear resistance, connection strength, and/or attractive finish:
  Birch
  Walnut, black
  Maple, hard
  Beech
  Oak, white
  Ash, white

- because of attractive or unusual finish:
  Elm, soft
  Gum, red
  Maple, soft
  Sycamore

- because of high (f. or c.) strength per weight:
  Basswood
  Poplar, yellow
  Gum, tupelo

DF
Hemlock, W.
Cedar, Pt. Orford
Redwood
Spruce, Sitka
Spruce, E.
Pines, white: N., Idaho, sugar
Pine, ponderosa
Fir, white
PRODUCT: AVAILABILITY IN REQUIRED SIZE AND FORM - PLYWOOD

-continued.

Special technical references: (For strength data see Properties, Key f-6.)

Stamm, A.J. and Seborg, R.M.: Resin Treated Plywood, July 1939, Industrial and Engineering Chemistry, Washington, D.C. (Formation of phenol-formaldehyde resins within all walls: reduces shrinkage; increases decay and acid resistance; increases compression strength; reduces face checking.)


Special plywood products:
Resin treated plywood for extra moisture resistance
decay resistance
combustion resistance
Super-pressed plywood for extra strength
Wood veneers with cloth
metal
Plywood with core of Bakelite
other plastics
corrugated steel
asbestos
Plywood core for facing of linoleum
plastic
cork
marble
**WEIGHT**

Pounds per cubic foot air-dry (12% moisture content).

Figures are adapted from:
USDA FPL: Technical Note No.218, July, 1931.
Luxford and Trayer; Wood Handbook, 1935, USDA FPL
(Table 6, p.46.)

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>YP, longleaf 41</td>
<td>(Ironwood 80)</td>
</tr>
<tr>
<td>YP, shortleaf 36</td>
<td>Hickory, true 51</td>
</tr>
<tr>
<td>Larch, W. 36</td>
<td>Oak, white 47</td>
</tr>
<tr>
<td>Pine, Norway 34</td>
<td>Beech 45</td>
</tr>
<tr>
<td>DF, coast 34</td>
<td>Birch, av.sweet&amp;yel. 44</td>
</tr>
<tr>
<td>Cedar, E.red 33</td>
<td>Elm, rock 44</td>
</tr>
<tr>
<td>Cypress, S. 32</td>
<td>Oak, red 44</td>
</tr>
<tr>
<td>DF, mountain 30</td>
<td>Maple, hard 42</td>
</tr>
<tr>
<td>Cedar, Pt.Orford 29</td>
<td>Ash, white 41</td>
</tr>
<tr>
<td>Hemlock, W. 29</td>
<td>Walnut, black 38</td>
</tr>
<tr>
<td>Hemlock, E. 28</td>
<td>Elm, soft 36</td>
</tr>
<tr>
<td>Pine, ponderosa 28</td>
<td>Maple, soft 35</td>
</tr>
<tr>
<td>Redwood 28</td>
<td>Cherry, black 35</td>
</tr>
<tr>
<td>Spruce, E. 28</td>
<td>Gum, black&amp;Tupelo 35</td>
</tr>
<tr>
<td>Spruce, Sitka 28</td>
<td>Magnolia 34</td>
</tr>
<tr>
<td>Pine, Idaho 27</td>
<td>Sycamore 34</td>
</tr>
<tr>
<td>Fir, white 27</td>
<td>Gum; red 34</td>
</tr>
<tr>
<td>Pine, N.white 25</td>
<td>Ash, black 34</td>
</tr>
<tr>
<td>Pine, sugar 25</td>
<td>Chestnut 30</td>
</tr>
<tr>
<td>Fir, balsam 25</td>
<td>Alder, red 28</td>
</tr>
<tr>
<td>Cedar, white 23</td>
<td>Poplar, yellow 28</td>
</tr>
<tr>
<td>Cedar, W.red 23</td>
<td>Basswood 26</td>
</tr>
<tr>
<td>Spruce, Engelmann 23</td>
<td>Cottonwood,av.E&amp;N. 26</td>
</tr>
</tbody>
</table>
STRENGTH. For: Extreme fiber in bending (beam strength)
Compression parallel to grain (post strength)
Compression perpendicular to grain
Maximum horizontal shear
charts give: Basic working stress, kips/square inch
Grades named by stress, kips/square inch
Percentage stress and relation to white oak

Basic stresses, in kips/square inch, are for clear, dry material. They are included in this survey to show strength properties of woods not generally used structurally and not graded according to stress. Basic stresses are not for immediate use but are for determining working stresses according to conditions of exposure and quality of material.

Values in the charts have been adapted from the following sources, which are in essential agreement except for values for Western Larch.
NLMA: Wood Structural Design Data, Volume I, 1935, Table 1, p.17.
USDA: Guide to the Grading of Structural Timbers and the Determination of Working Stresses, 1934, Misc. Publication No. 185, Table 8, p.20.

Note: Any so-called basic or working stresses published before 1934 may be substantially lower than those now recommended under improved manufacturing and grading methods.

1. Average deduction of stress for different exposures:

<table>
<thead>
<tr>
<th>Type of exposure:</th>
<th>Always dry</th>
<th>Occasion-</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kind of stress:</td>
<td></td>
<td>or always wet.</td>
<td>ally wet.</td>
</tr>
<tr>
<td>Extreme fiber, bending</td>
<td>100%</td>
<td>85%</td>
<td>71%</td>
</tr>
<tr>
<td>Compression perp. to grain</td>
<td>100</td>
<td>70</td>
<td>58</td>
</tr>
<tr>
<td>Compression parallel grain</td>
<td>100</td>
<td>92</td>
<td>78</td>
</tr>
<tr>
<td>Horizontal shear</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Modulus of elasticity</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
STRENGTH, continued

Structural grades named by stress are in kips/square inch for woods having grades named according to their allowable working stress value (as 1200#c. White Ash). Such values of course are subject to occasional change to reflect improved manufacturing and grading methods.

Current values may be got from one of following:
NLMA: Working Stresses for Structural Lumber, 4p. Latest revised grading rules of the various lumber associations.
NLMA: Lumber Grade-Use Guide for Softwood and Hardwood Lumber, Pamphlets I to XV (all revised to 1935, and some more recently).

2. Basic stresses for clear, dry stock were established in 1929 by USDO Bureau of Standards: Revised Simplified Practice Recommendation R 16-29, and variously reprinted. For fiber stress in bending (beam strength) and compression parallel to the grain (post strength), these values were only 75% (select material) or 60% (common) of the present basic stresses. For compression perpendicular to the grain and modulus of elasticity, the values are unchanged.

3. Comprehensive tables in the following references are already in part obsolete or revised:
STRENGTH, continued

Percentage stresses. For maximum horizontal shear and compression perpendicular to the grain, the percentage stress of a species has been obtained by comparing its basic stress to that of white oak @ 100. For fiber stress in bending and for compression parallel to the grain, the percentage stress of a species has been obtained by comparing its "composite strength value" to that of white oak @ 100. "Composite strength values" are listed in Comparative Strength Properties of Woods Grown in the United States, 1930, U.S.D.A. Tech. Bul. 158, Table 1, pp.10-13, and are based: for bending strength, on a weighting of green and air-dry values for fiber stress at elastic limit in static bending, fiber stress at elastic limit in impact bending, modulus of elasticity in static bending; for compressive strength, on a weighting of green and air-dry values for fiber stress at elastic limit in compression parallel to the grain, and maximum crushing strength in compression parallel to the grain.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>% Stress</th>
<th>Hardwoods</th>
<th>% Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bend.</td>
<td>Comp.</td>
<td>Bend.</td>
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<td>A+</td>
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<td></td>
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<td></td>
<td>A+</td>
</tr>
<tr>
<td>(Locust, black)</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Hickory, true, av.</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Hickory, pec., av.</td>
<td></td>
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<td>A+</td>
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<tr>
<td>Birch, sweet</td>
<td></td>
<td></td>
<td>A+</td>
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<tr>
<td>Walnut, black</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Ash, comm. white</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Birch, yellow</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Elm, rock</td>
<td></td>
<td></td>
<td>A+</td>
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<tr>
<td>Maple, hard, bk&amp;sg</td>
<td></td>
<td></td>
<td>A+</td>
</tr>
<tr>
<td>Beech</td>
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<td>A+</td>
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<tr>
<td>Oak, red</td>
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<td>A+</td>
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<td>Oak, white</td>
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<td>Cherry, black</td>
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<td>B</td>
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<tr>
<td>DF, coast</td>
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<td>B</td>
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<td>B</td>
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<tr>
<td>Tamarack</td>
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<td>B</td>
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<td></td>
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<td></td>
<td>B</td>
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<tr>
<td>Cedar, Pt. Orford</td>
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<td>B</td>
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<td>Cypress, S.</td>
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<tr>
<td>DF, inland</td>
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<td>B</td>
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<td>Hemlock, W</td>
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<td>C</td>
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<td></td>
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<td></td>
<td>C</td>
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<tr>
<td>DF, mountain</td>
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<tr>
<td>Spruce, red&amp;white</td>
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<td>Pine, W white</td>
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<td>D</td>
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<tr>
<td>Cedar, W red</td>
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<td>D</td>
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<tr>
<td>Pine, ponderosa</td>
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<td>D</td>
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<td>D</td>
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<tr>
<td>Pine, N white</td>
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<td>D</td>
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<td></td>
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<td></td>
<td>D</td>
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<tr>
<td>Fir, balsam</td>
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<td>E</td>
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<td></td>
<td>E</td>
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<td>Spruce, Engelmann</td>
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<td></td>
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<td></td>
<td>E</td>
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<tr>
<td>Cedar, white, N&amp;S</td>
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<td>E</td>
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<td></td>
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<td></td>
<td>E</td>
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<tr>
<td>(Willow, black)</td>
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<td></td>
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<td></td>
<td>E</td>
</tr>
</tbody>
</table>
STRENGTH, continued

Other strength properties.
For modulus of rupture, fiber stress at proportional limit, work to maximum load, or impact bending values, see:


Luxford and Trayer: Wood Handbook, 1935, USDA FPL, (Table 8, pp. 50-3.)

Application of stresses in design.
For general explanation of procedure of wood design, see:

(Formulae for the design of beams and columns, application; tables of safe uniform loads, figured by bending or deflection, for beams of various cross sections, spans, and fiber stresses; tables of safe loads for columns of various cross sections, unsupported heights, compression strengths, and moduli of elasticity.)

(Mechanical properties of wood; design. Pp. 48-58.)

Luxford and Trayer: Wood Handbook (see ref. above).
(General design of beams and columns, formulae and applications- pp. 149-68; effect of decay, insects, seasoning, defects, grain angle, and wetness of place used,- on strength and on percentage of basic stress to be used in design- pp. 63-9, 99-118.)

(Technical reference and design data.)

(Structural Data and Design Tables.)

Note: The following, and other references dated before 1934, do not include lumber marked by strength-grade, and other recent developments, and it is recommended not to use tables therein without first checking.

STRENGTH, continued

Effect of moisture
(Derivation of a type formula to express the relation between uniformly distributed moisture content and various strength properties.)
(For effect of moisture on wood shrinkage, see Section m., this report, and references therein.)

Effect of seasoning method

Effect of angle of grain
(Scholten nomograph, devised at F.P.L. and based on Hankinson Formula, for bearing values for any intervening grain angle between 0 and 90 degrees.)

Large columns
(Table 8, pp.24-28, gives safe working stresses, by species, by select and common grades, by exposure conditions, and by L/d ratios from "short" (10) to 50. This table has later, and slightly revised, values than does table on pp.102-107 in Wood Construction; but none of the values are as high as would be indicated by the more recent F.P.L. basic stresses.)

Thin sections
A study of stresses in thin sections of wood, has been begun by the Department of Building Construction at M.I.T., but no definite results are yet available.
(Examination of type of fracture of some species under tension, bending, compression.)
STRENGTH, continued

Strength of various built-up wood structural elements.¹

Frame walls


NLMA: Stud Walls- Safe Axial Loads, Supplement No.7 to Wood Structural Design Data, NLMA, Washington, D.C. (8pp. of data on 7' to 10' stud walls.)


Erickson, E.C.O.: The Rigidity and Strength of Braced and Unbraced Walls Covered with Bevel Siding, 1941, USDA FPL Publication R-1261, 13pp. (Chart showing relative strength and rigidity of various types of wall construction.)

Wood trusses


NLMA: Modern Timber Roof Trusses, 12pp., NLMA, Washington, D.C. (Timber connector type trusses.)

Laminated wooden arch construction

Wilson, T.R.C.: The Glued Laminated Wooden Arch, October 1939, USDA Technical Bulletin No.691, 123pp. GPO. (Test data; recommended design stresses; construction practice; arch theory.)

¹. For references to bolts, nails, connectors and to strength of joints so connected, see Properties, Key t. For strength of plywood, see next page, Properties, Key f-7.
Strength of various built-up wood structural elements, continued

Plywood

DFPA: Plywood Structural Data, December 1937, printed in American Builder, p.84 et seq. (Bending, deflection, tension, compression.)


Gross: A Study of the Moduli of Elasticity and Rupture of Laminated Wood and Plywood, 1938, M.I.T. Department of Building Construction B.S. Thesis. (Conclusions: Laminated wood- no appreciable difference between moduli of elasticity and rupture for laminated wood and for the wood of which it was made; Plywood- modulus of elasticity varies according to the transformed moments of inertia (see section III A, et seq.).)
STIFFNESS (RIGIDITY, RESISTANCE TO DEFLECTION)  
Modulus of elasticity in 1000# per square inch, air-dry (12% moisture content)  
Figures adapted from Table 8, pages 50-53, Wood Handbook, and from Table 1, inserts facing page 4, U.S.D.A. Technical Bulletin No.479; converted to percentages of white oak values.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>%</th>
<th>%</th>
<th>Hardwoods</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>YP, longleaf</td>
<td>1990</td>
<td>123</td>
<td>(Ironwood, black(^1))</td>
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</tr>
<tr>
<td>Douglas fir, coast</td>
<td>1920</td>
<td>118</td>
<td>(Mangrove(^2))</td>
<td>2950</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Gum, blue(^3))</td>
<td>2370</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hickory, true</td>
<td>2180</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Birch, av: sweet &amp; yel.</td>
<td>2070</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Locust, black)</td>
<td>2050</td>
</tr>
<tr>
<td>Pine, Norway</td>
<td>1800</td>
<td>111</td>
<td>Magnolia, cucumber</td>
<td>1820</td>
</tr>
<tr>
<td>YP, shortleaf</td>
<td>1760</td>
<td>109</td>
<td>Oak, red</td>
<td>1810</td>
</tr>
<tr>
<td>Cedar, Port Orford</td>
<td>1730</td>
<td>107</td>
<td>Hickory, pecan</td>
<td>1780</td>
</tr>
<tr>
<td>Larch, western</td>
<td>1710</td>
<td>105</td>
<td>Maple, hard(^4)</td>
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</tr>
<tr>
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<td></td>
<td>Beech</td>
<td>1720</td>
</tr>
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<td>Tamarack</td>
<td>1640</td>
<td>101</td>
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<td>1680</td>
</tr>
<tr>
<td>Douglas fir, inland</td>
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<td>99</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Ash, black</td>
<td>1600</td>
</tr>
<tr>
<td>Pine, western white</td>
<td>1510</td>
<td>93</td>
<td>Elm, rock</td>
<td>1540</td>
</tr>
<tr>
<td>Hemlock, western</td>
<td>1490</td>
<td>92</td>
<td>Poplar, yellow</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cherry, black</td>
<td>1490</td>
</tr>
<tr>
<td>Fir, white</td>
<td>1470</td>
<td>91</td>
<td>Elm, slippery</td>
<td>1490</td>
</tr>
<tr>
<td>Cypress, southern</td>
<td>1440</td>
<td>89</td>
<td>Gum, red</td>
<td>1490</td>
</tr>
<tr>
<td>Spruce, eastern</td>
<td>1440</td>
<td>89</td>
<td>Basswood</td>
<td>1460</td>
</tr>
<tr>
<td>Cedar, Alaska</td>
<td>1420</td>
<td>88</td>
<td>Sycamore</td>
<td>1420</td>
</tr>
<tr>
<td>Douglas fir, mtn.</td>
<td>1400</td>
<td>86</td>
<td>Maple, soft(^5)</td>
<td>1410</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Magnolia, evergreen</td>
<td>1400</td>
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<tr>
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<td></td>
<td></td>
<td>Alder</td>
<td>1380</td>
</tr>
<tr>
<td>Redwood</td>
<td>1340</td>
<td>83</td>
<td>Ash, Oregon</td>
<td>1360</td>
</tr>
<tr>
<td>Pine, northern wht</td>
<td>1280</td>
<td>79</td>
<td>Elm, American</td>
<td>1340</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>1260</td>
<td>78</td>
<td>Cottonwood, av: e. &amp; n.</td>
<td>1315</td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>1230</td>
<td>76</td>
<td>(Ash, Oregon)</td>
<td>1360</td>
</tr>
<tr>
<td>Hemlock, eastern</td>
<td>1200</td>
<td>74</td>
<td>ELM, American</td>
<td>1340</td>
</tr>
<tr>
<td>Pine, sugar</td>
<td>1200</td>
<td>74</td>
<td>Cottonwood, av: black &amp; Tupelo</td>
<td>1230</td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td>1180</td>
<td>72</td>
<td>Chestnut</td>
<td>1230</td>
</tr>
<tr>
<td>Cedar, western red</td>
<td>1120</td>
<td>69</td>
<td>Gum, av: black &amp; Tupelo</td>
<td>1230</td>
</tr>
<tr>
<td>Cedar, eastern red</td>
<td>880</td>
<td>55</td>
<td>(Aspen)</td>
<td>1180</td>
</tr>
<tr>
<td>Cedar, white av: n&amp;s</td>
<td>865</td>
<td>53</td>
<td>Willow, black(^6)</td>
<td>720</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Palmetto, cabbage(^7))</td>
<td>560</td>
</tr>
</tbody>
</table>

1. Krugiodendron ferreum, Fla.  2. Rhizophora mangle, Fla.  
3. Eucalyptus globulus, Cal. 4. Average of sugar and black maples.  5. Average of red, bigleaf, and silver maples.  

\*NOTE: For modulus of elasticity for structural design, use value of allowable working stress for proper grade of material and condition of use, listed elsewhere.
HARDNESS
Load required to embed a 0.444" ball to \( \frac{3}{4} \) its diameter, air-dry (12% moisture content)

Figures adapted from Table 8, Pages 50-53, Wood Handbook, and from Table 1, inserts facing Page 4, U.S.D.A. Technical Bulletin No.479; end and side values averaged, and converted to percentages of white oak values.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>End Side Av. %</th>
<th>Hardwoods</th>
<th>End Side Av. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Oak, live)</td>
<td>313 268 290 212</td>
<td>(Persimmon)</td>
<td>252 230 2410 176</td>
</tr>
<tr>
<td>(Dogwood)</td>
<td>2430 2150 2290 167</td>
<td>(Apple)</td>
<td>2150 1730 1940 141</td>
</tr>
<tr>
<td>Hickory, true</td>
<td>no tests</td>
<td>Hickory, pecan</td>
<td>1930 2018 2075 136</td>
</tr>
<tr>
<td>(Locust, black)</td>
<td>1580 1700 1640 119</td>
<td>Maple, hard</td>
<td>1770 1310 1540 112</td>
</tr>
<tr>
<td>Birch</td>
<td>1660 1340 1500 109</td>
<td>Ash, white</td>
<td>1680 1260 1470 107</td>
</tr>
<tr>
<td>Beech</td>
<td>1590 1300 1445 105</td>
<td>Elm, rock</td>
<td>1510 1320 1415 103</td>
</tr>
<tr>
<td>Oak, red</td>
<td>1490 1300 1395 101</td>
<td>Oak, white</td>
<td>1420 1331 1375 100</td>
</tr>
<tr>
<td>(Ash, Oregon)</td>
<td>1430 1160 1245 91</td>
<td>Cherry, black</td>
<td>1470 950 1210 88</td>
</tr>
<tr>
<td>Magnolia, egg</td>
<td>1280 1020 1150 84</td>
<td>Maple, soft</td>
<td>1300 840 1070 78</td>
</tr>
<tr>
<td>Gum, blk&amp;Tup.</td>
<td>1220 840 1030 75</td>
<td>Walnut, black</td>
<td>1050 1010 1030 75</td>
</tr>
<tr>
<td>Ash, black</td>
<td>1150 850 1000 73</td>
<td>Elm, slip&amp;Am</td>
<td>711 845 980 71</td>
</tr>
<tr>
<td>Magnolia, cec</td>
<td>950 700 825 60</td>
<td>Sycamore</td>
<td>920 770 845 62</td>
</tr>
<tr>
<td>Gum, red</td>
<td>950 690 820 60</td>
<td>Alder</td>
<td>980 590 785 57</td>
</tr>
<tr>
<td>Larch, western</td>
<td>1110 760 935 68</td>
<td>Chestnut</td>
<td>720 540 630 46</td>
</tr>
<tr>
<td>YP, longleaf</td>
<td>920 870 895 65</td>
<td>(Poplar, yel)</td>
<td>560 450 505 37</td>
</tr>
<tr>
<td>Cedar, east.</td>
<td>900 no tests</td>
<td>Cottonwood</td>
<td>560 390 475 35</td>
</tr>
<tr>
<td>Hemlock, west</td>
<td>940 580 760 55</td>
<td>Basswood</td>
<td>520 410 465 34</td>
</tr>
<tr>
<td>YP, shortleaf</td>
<td>750 690 720 52</td>
<td>(Fir, balsam)</td>
<td>510 400 455 33</td>
</tr>
<tr>
<td>Doug, fir, coast</td>
<td>760 670 715 52</td>
<td>Pine, sugar</td>
<td>530 380 455 33</td>
</tr>
<tr>
<td>Cedar, Alaska</td>
<td>790 580 685 50</td>
<td>Pine, no. white</td>
<td>500 400 450 33</td>
</tr>
<tr>
<td>Doug, fir, inlRM</td>
<td>730 630 680 49</td>
<td>Pine, w. white</td>
<td>440 370 405 29</td>
</tr>
<tr>
<td>Hemlock, east</td>
<td>810 500 655 48</td>
<td>Spruce, Engel.</td>
<td>450 310 380 28</td>
</tr>
<tr>
<td>Cedar, F6. Orfd.</td>
<td>730 560 645 47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>760 510 635 46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Tamarack)</td>
<td>670 590 630 46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine, Norway</td>
<td>670 580 625 45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redwood</td>
<td>790 480 635 46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cypress, south.</td>
<td>660 510 585 43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fir, white</td>
<td>710 460 585 43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce, east.</td>
<td>630 490 560 41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar, west.</td>
<td>660 350 505 37</td>
<td>Poplar, yel</td>
<td>560 450 505 37</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>550 450 500 36</td>
<td>Cottonwood</td>
<td>560 390 475 35</td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>510 400 455 33</td>
<td>Basswood</td>
<td>520 410 465 34</td>
</tr>
<tr>
<td>Pine, sugar</td>
<td>530 380 455 33</td>
<td>Aspen</td>
<td>510 350 430 31</td>
</tr>
<tr>
<td>Pine, no. white</td>
<td>500 400 450 33</td>
<td>(Poplar, balsam)</td>
<td>380 300 340 25</td>
</tr>
<tr>
<td>Pine, w. white</td>
<td>440 370 405 29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spruce, Engel.</td>
<td>450 310 380 28</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Quercus virginiana, Fæa 2. Diospyros virginiana, Mo.
3. Cornus florida, Tenn. 4. Average of sugar and black maple.
5. Average of sweet and yellow birch. 6. Average of red, silver, bigleaf maple. 7. Average.
WEAR RESISTANCE

Resistance to abrasion and wear is probably not an exact function of hardness. However, for an estimate of the relative wear-resistance or abrasion-resistance, current practice is to refer to relative hardness values (Key h.), which give probably the clearest indication available pending more specialized tests.

Usually wear-resistance is only one of several factors in the selection of a certain species of wood, along with, for example, cost and the ability to stay in place; the final choice may not need more exact determination than the current hardness-values permit.
SHOCK RESISTANCE (TOUGHNESS). 12% moisture content Work to maximum load in static bending, in inch pounds per cubic inch. Values are of less use in design than in establishing the relative toughness in bending of the various species.

Figures are from Wood Handbook, 1935, Table 8, pp.50-3, or Garratt: Mechanical Properties of Wood, 1931, pp. 43-47.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hickory, true, av.</td>
</tr>
<tr>
<td></td>
<td>Birch, av. sweet &amp; yellow</td>
</tr>
<tr>
<td></td>
<td>Elm, rock</td>
</tr>
<tr>
<td></td>
<td>Hickory, pecan</td>
</tr>
<tr>
<td></td>
<td>Locust, black</td>
</tr>
<tr>
<td></td>
<td>Elm, slippery</td>
</tr>
<tr>
<td></td>
<td>Ash, white</td>
</tr>
<tr>
<td></td>
<td>Beech</td>
</tr>
<tr>
<td></td>
<td>Oak, red</td>
</tr>
<tr>
<td></td>
<td>Maple, hard (sug. &amp; blk.)</td>
</tr>
<tr>
<td></td>
<td>Oak, white</td>
</tr>
<tr>
<td></td>
<td>Elm, American</td>
</tr>
<tr>
<td></td>
<td>Magnolia, av. everg. &amp; mag.</td>
</tr>
<tr>
<td>YP, longleaf</td>
<td>11.8</td>
</tr>
<tr>
<td>YP, shortleaf</td>
<td>11.0</td>
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<tr>
<td>Pine, Norway</td>
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</tr>
<tr>
<td>Spruce, Sitka</td>
<td>9.4</td>
</tr>
<tr>
<td>Cedar, Pt. Orford</td>
<td>9.1</td>
</tr>
<tr>
<td>Pine, W. white</td>
<td>8.8</td>
</tr>
<tr>
<td>DF, coast</td>
<td>8.6</td>
</tr>
<tr>
<td>Spruce, E.</td>
<td>8.4</td>
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<tr>
<td>Cedar, E. red</td>
<td>8.3</td>
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<tr>
<td>Cypress, S.</td>
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</tr>
<tr>
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<td>8.0</td>
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<tr>
<td>Hemlock, W.</td>
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<tr>
<td>Fir, white</td>
<td>7.0</td>
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<tr>
<td>Redwood</td>
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<tr>
<td>Hemlock, E.</td>
<td>6.8</td>
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<tr>
<td>Pine, N. white</td>
<td>6.7</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>6.6</td>
</tr>
<tr>
<td>DF, mountain</td>
<td>6.4</td>
</tr>
<tr>
<td>Cedar, W. red</td>
<td>5.8</td>
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<tr>
<td>Spruce, Engelmann</td>
<td>5.6</td>
</tr>
<tr>
<td>Pine, sugar</td>
<td>5.5</td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>5.1</td>
</tr>
<tr>
<td>Cedar, W. white, N&amp;S</td>
<td>4.4</td>
</tr>
</tbody>
</table>
# THERMAL CONDUCTIVITY

Thermal conductivity, "K" (B.T.U. per hour, per square foot, per one inch thickness, per one degree F temperature change) for several building materials and for various woods at 12% moisture content and across the grain.


<table>
<thead>
<tr>
<th>Material</th>
<th>K</th>
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</thead>
<tbody>
<tr>
<td>Granite</td>
<td>13 to 28</td>
</tr>
<tr>
<td>Concrete</td>
<td>6 to 9</td>
</tr>
<tr>
<td>Glass</td>
<td>5 to 6</td>
</tr>
<tr>
<td>Brick</td>
<td>3 to 6</td>
</tr>
<tr>
<td>Plaster</td>
<td>2 to 5</td>
</tr>
<tr>
<td>Cinder concr.</td>
<td>2 to 3</td>
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</tbody>
</table>

**Softwoods**

<table>
<thead>
<tr>
<th>Material</th>
<th>K</th>
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</thead>
<tbody>
<tr>
<td>Oak, white</td>
<td>1.22</td>
</tr>
<tr>
<td>Oak, red</td>
<td>1.20</td>
</tr>
<tr>
<td>Maple, hard</td>
<td>1.16</td>
</tr>
<tr>
<td>Ash, white</td>
<td>1.05</td>
</tr>
<tr>
<td>Birch, yellow</td>
<td>1.00</td>
</tr>
<tr>
<td>Larch</td>
<td>.99</td>
</tr>
<tr>
<td>YP, shortleaf</td>
<td>.98</td>
</tr>
<tr>
<td>YP, longleaf</td>
<td>.96</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>.85</td>
</tr>
<tr>
<td>Pine, Norway</td>
<td>.84</td>
</tr>
<tr>
<td>Pine, N. white</td>
<td>.83</td>
</tr>
<tr>
<td>Cypress, S.</td>
<td>.83</td>
</tr>
<tr>
<td>Hemlock, W.</td>
<td>.80</td>
</tr>
<tr>
<td>DF</td>
<td>.77</td>
</tr>
<tr>
<td>Hemlock, E.</td>
<td>.76</td>
</tr>
<tr>
<td>Redwood</td>
<td>.76</td>
</tr>
<tr>
<td>Cedar, W. red</td>
<td>.72</td>
</tr>
<tr>
<td>Pine, sugar</td>
<td>.69</td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td>.68</td>
</tr>
<tr>
<td>Fir, white</td>
<td>.65</td>
</tr>
<tr>
<td>(Balsa @ 7.3#/cu.ft.)</td>
<td>.33</td>
</tr>
</tbody>
</table>

Average of 40 insulating materials .35

*United States Forest Service F.P.L. Technical Note #248, April, 1941, shows thermal conductivity of wood to be very closely related to specific gravity and moisture content, regardless of species. For conditions (usual) where moisture content (M) is under 40%:

\[ K = S \left( 1.39 + 0.028M \right) + 0.165 \]

where S is specific gravity based on volume at current moisture content and weight when oven-dry.

Tech. Note #248 presents a chart to give K for any moisture content and any specific gravity based on volume green and weight oven-dry. (Use of this chart gives K values up to 15% higher than the 1935 Wood Handbook tables.)
ABILITY TO STAY IN PLACE

The ability of wood to stay in place is a function of its change in dimension and shape. It depends on the shrinkage factor, the rate of moisture absorption, whether the piece is quarter-sawn or plain-sawed, direction of grain, and conditions of seasoning. Proper kiln-drying and use of finishes which act as retardants to the absorption of moisture are two ways of increasing the ability to stay in place; another way is the selection of a wood with high inherent resistance to change in size and form.


<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar,N.white &amp; W.red</td>
<td>A</td>
</tr>
<tr>
<td>Fir,balsam &amp; white</td>
<td></td>
</tr>
<tr>
<td>Pine,N.white &amp; sugar</td>
<td>B</td>
</tr>
<tr>
<td>Cedar, Pt.Orford</td>
<td></td>
</tr>
<tr>
<td>Cypress,S.</td>
<td></td>
</tr>
<tr>
<td>Hemlock,E. &amp; W.</td>
<td></td>
</tr>
<tr>
<td>Pine, ponderosa &amp; W.white</td>
<td></td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
</tr>
<tr>
<td>Spruce, E. &amp; Sitka</td>
<td></td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B-C</td>
</tr>
<tr>
<td></td>
<td>C-B</td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>D-C</td>
</tr>
<tr>
<td></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>E-C (D)</td>
</tr>
<tr>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(C - most able to stay in place)
**SHRINKAGE DUE TO MOISTURE CHANGE**

Chart shows shrinkage from green to oven-dry condition based on dimension when green, in a radial direction, in a tangential direction.


For computation with these values, see: rad. tang.


For longitudinal shrinkage, see:


General: is

End grain more rapidly hygroscopic than side grain.

Sapwood is more rapidly hygroscopic than heartwood.

Kiln-drying at high temperatures reduces moisture holding capacity of wood.


In all species the tangential shrinkage is more than the radial. average .9 to 5. Hence quarter-sawed boards shrink less in width than flat-sawed. The ratio of radial to tangential shrinkage for a species is of value in determining the desirability of using quarter-sawed wood and indicates the checking which may be expected in large pieces containing pith. (The smaller the tangential/radial ratio) the less is the tendency...to check in drying." — Comparative Strength Properties of Woods Grown in the U.S., 1930, U.S.D.A. Tech. Bul. #158, pp. 20-21.

For composite shrinkage value (a combination of radial, tangential, and volumetric percentages):

U.S.D.A. Tech. Bul. #158 (above), p. 32 and Table 1, pp. 6-13.

Other references:

F.P.L. Technical Note #241, 1933, Shrinkage Table for Softwood Lumber. (Shrinkage in 1/64"s, on 1" x 6" boards, by width and thickness, under 5 typical moisture change conditions, for edge-grained and flat-grained heartwood and flat-grained sapwood of 14 softwood species.)

F.P.L. Technical Note #D-5, Correct Moisture Content of Lumber.

F.P.L. Technical Note #P-13, Moisture Content of Wood at Different Humidities. (Table with 8 woods and humidities from 20 to 95%, showing incidentally that humidity of atmosphere is far more important than species in controlling moisture content of wood.)
SHRINKAGE DUE TO MOISTURE CHANGE, continued

Other references, continued:
House Framing Lumber Should be Kiln Dried, July, 1933, U.S.D.A., F.F.L. Publication R-1009, 7pp. (Example, charts, and analysis of effect of moisture-content changes on shrinkage and on 1st and 2nd floor plaster cracks in a typical frame house.)
Wood Subflooring Unjustly Blamed for Moisture Pickup in Finish Flooring, May, 1934, U.S.D.A., F.F.L. Publication R-1048, 3pp. (Tests on a typical house to determine moisture content of subflooring and finish flooring during the construction period and effect on cracks and cupping.)
CHECKING AND WARPING
Warping includes both cupping and twisting. Both warping and checking are more apt to occur in edge-grain boards than in flat-grain boards of the same species. While warping is in general controllable, some species demand more care to prevent it. The table below indicates the relative inherent warping and checking tendencies of various woods.


The main divisions, A to D, are based on tendency to warp (cup), A for woods with only a slight tendency and D for woods with a very pronounced tendency. Division E is for woods with a very pronounced tendency to cup plus a tendency to twist because of interlocking grain. Woods on which weather checks are inconspicuous are marked A*; other woods, on which checks are conspicuous, are here unmarked and are marked D in charts.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar, Pt. Orford</td>
<td>A* Chestnut</td>
</tr>
<tr>
<td>Cedar, W. red</td>
<td>A Poplar, yellow</td>
</tr>
<tr>
<td>Cypress, S.</td>
<td>A*</td>
</tr>
<tr>
<td>Redwood</td>
<td>A*</td>
</tr>
<tr>
<td>DF</td>
<td>B</td>
</tr>
<tr>
<td>Fir, white</td>
<td>A*</td>
</tr>
<tr>
<td>Hemlock, E. &amp; W.</td>
<td></td>
</tr>
<tr>
<td>Larch, W.</td>
<td></td>
</tr>
<tr>
<td>Pine, N. &amp; W. white</td>
<td></td>
</tr>
<tr>
<td>Pine, sugar &amp; ponderosa</td>
<td></td>
</tr>
<tr>
<td>YP</td>
<td></td>
</tr>
<tr>
<td>Spruce, E. &amp; Sitka</td>
<td></td>
</tr>
</tbody>
</table>
n-2.

CHECKING AND WARPING, continued

For reasons, other than species, which cause warping, see:

For effect of wrinkling and twisting on design, and compensating formulae, see:
RESISTANCE OF HEARTWOOD TO DECAY
Charts give a rough grouping, based on service records and general experience, of woods according to the resistance of their heartwood to decay under conditions favorable to decay (moisture change, high temperatures, high humidities). Untreated sapwood of all species has very low resistance to decay.

The grouping below, only approximate and subject to variation in individual boards, is based on listings in:

Group A - high durability; group E - low durability.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar, E. &amp; W. red</td>
<td>Chestnut</td>
</tr>
<tr>
<td>Cedar, N. &amp; S. white</td>
<td>(Locust, black)</td>
</tr>
<tr>
<td>Cedar, P. Orford</td>
<td>Walnut, black</td>
</tr>
<tr>
<td>Cypress, S.</td>
<td></td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
</tr>
<tr>
<td>DF, dense; Pine, Idaho</td>
<td></td>
</tr>
<tr>
<td>YP, dense; Pine, N. white</td>
<td></td>
</tr>
<tr>
<td>DF, unselected</td>
<td></td>
</tr>
<tr>
<td>YP, unselected</td>
<td></td>
</tr>
<tr>
<td>Larch, W; Pine, sugar</td>
<td></td>
</tr>
<tr>
<td>Hemlock, E. &amp; W.</td>
<td></td>
</tr>
<tr>
<td>Spruce, E. &amp; Sitka</td>
<td></td>
</tr>
<tr>
<td>Spruce, Engelmann</td>
<td></td>
</tr>
<tr>
<td>Fir, balsam</td>
<td></td>
</tr>
<tr>
<td>Fir, white</td>
<td></td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td></td>
</tr>
<tr>
<td>Pine, Norway</td>
<td></td>
</tr>
<tr>
<td>YP, soft (N.C., Ark.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:*Absence of adequate service or test data preclude an FPL rating. Of the white pines, N.W. & sugar, and ponderosa pine—opinion is that the latter is less durable under conditions favoring decay.

1: For ability of heartwoods to absorb preservative and decay resisting liquids, see Properties/Key -p.
**PENETRABILITY**


<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heartwood easy to penetrate</strong></td>
<td><strong>Heartwood very difficult to penetrate</strong></td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>DF, mountain</td>
</tr>
<tr>
<td></td>
<td>Cedar, northern white</td>
</tr>
<tr>
<td></td>
<td>Cedar, western red</td>
</tr>
<tr>
<td></td>
<td>Tamarack</td>
</tr>
<tr>
<td><strong>Heartwood moderately difficult to penetrate</strong></td>
<td><strong>Heartwood difficult to penetrate</strong></td>
</tr>
<tr>
<td>DF, coast</td>
<td>Hemlock, eastern *</td>
</tr>
<tr>
<td>YP, longleaf</td>
<td>Fir, white *</td>
</tr>
<tr>
<td>YP, shortleaf</td>
<td>Larch, western</td>
</tr>
<tr>
<td>Pine, Norway</td>
<td>Spruce, eastern (white) *</td>
</tr>
<tr>
<td>Hemlock, western</td>
<td>Spruce, Engelmann *</td>
</tr>
<tr>
<td></td>
<td>Spruce, Sitka *</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>(Hackberry)</td>
</tr>
<tr>
<td>Birch, yellow</td>
<td>Elm, rock</td>
</tr>
<tr>
<td>Hickory (mockernut)</td>
<td>Sycamore</td>
</tr>
<tr>
<td>Maple, hard (sugar)</td>
<td>Maple, soft (silver)</td>
</tr>
</tbody>
</table>

**Note:** Sapwood in general is not difficult to penetrate, except with species starred * above where it is almost as difficult as the respective heartwood.

**Reference—Penetrability by other liquids:**

Beazley, W.B., Johnston, H.W., and Maass, O.: The Penetration into Wood of Cooking Liquors and Other Media, 1939, Dominion Forest Service, Bulletin No. 95, Department of Mines and Resources, Canada. 48 pp. (Primarily a study of penetration in the production of chemical pulps.)
APPEARANCE, WEATHERED
Exposure to the weather without protective coating grays all woods, some darker than others, and gives to some woods an attractive silvery sheen.

The following grouping is that of the Wood Handbook, 1935, p.40.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>A- Light-gray color and silvery sheen</td>
<td></td>
</tr>
<tr>
<td>Cedar, Pt. Orford</td>
<td>Basswood</td>
</tr>
<tr>
<td>Cypress, S.</td>
<td>Birch</td>
</tr>
<tr>
<td>C- Light-gray color and moderate sheen</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>Hemlock, E.</td>
<td>Gum, red</td>
</tr>
<tr>
<td>Hemlock, W.</td>
<td>Hickory</td>
</tr>
<tr>
<td>Pine, N. white</td>
<td>Maple</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td>Poplar, yellow</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td></td>
</tr>
<tr>
<td>Pine, sugar</td>
<td></td>
</tr>
<tr>
<td>Pine, W. white</td>
<td></td>
</tr>
<tr>
<td>Spruce, E.</td>
<td></td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td></td>
</tr>
<tr>
<td>E- Dark-gray color and little or no sheen</td>
<td>Ash</td>
</tr>
<tr>
<td>Cedar, W. red</td>
<td>Chestnut</td>
</tr>
<tr>
<td>DF</td>
<td>Oak, red</td>
</tr>
<tr>
<td>Fir, white</td>
<td>Oak, white</td>
</tr>
<tr>
<td>Larch, W.</td>
<td>Walnut, black</td>
</tr>
<tr>
<td>YP</td>
<td></td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
</tr>
</tbody>
</table>
WORKABILITY
EASE OF WORKING WITH HAND TOOLS

Group A- "easy to work"; C- "medium"; E- "difficult".

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar, white, N&amp; S.</td>
<td>Alder</td>
</tr>
<tr>
<td>Cedar, W, red</td>
<td>Basswood</td>
</tr>
<tr>
<td>Cedar, Pt. Orford</td>
<td>Chestnut</td>
</tr>
<tr>
<td>Pine, N, white</td>
<td>Poplar, yellow</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td></td>
</tr>
<tr>
<td>Pine, sugar</td>
<td></td>
</tr>
<tr>
<td>Pine, W, white</td>
<td></td>
</tr>
<tr>
<td>Cedar, E, red</td>
<td>Cottonwood</td>
</tr>
<tr>
<td>Cypress, S.</td>
<td>Gum, black &amp; tupelo</td>
</tr>
<tr>
<td>Fir, balsam</td>
<td>Gum, red</td>
</tr>
<tr>
<td>Fir, white</td>
<td>Magnolia</td>
</tr>
<tr>
<td>Hemlock, E.</td>
<td>Sycamore</td>
</tr>
<tr>
<td>Hemlock, W.</td>
<td>Walnut, black</td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
</tr>
<tr>
<td>Spruce, E.</td>
<td></td>
</tr>
<tr>
<td>Spruce, Sitka</td>
<td></td>
</tr>
<tr>
<td>DF</td>
<td></td>
</tr>
<tr>
<td>YP</td>
<td></td>
</tr>
<tr>
<td>Larch, W.</td>
<td></td>
</tr>
</tbody>
</table>

| DF                        |                      |
| YP                        |                      |
| Larch, W.                 |                      |
WORKABILITY
QUALITY OF MACHINE-TOOL WORKING

Almost all hardwoods, and some softwoods, may be machined well, given proper conditions of moisture content, speed, angle of grain, or angle of cutting edge. However, certain woods have a wider range of satisfactory conditions, and have under average conditions a higher percentage of well-machined pieces. In an effort to reach a grouping according to "composite machining ability", the results of various F.P.L. tests on planing, shaping, and turning are here tabulated and combined.

Figures in columns marked** are from Recent Tests in Planing Southern and Other Hardwoods, 1937, Davis, E.M., Southern Lumberman, Dec. 15, 1937.

For recommendations on proper conditions for turning, planing:

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods *</th>
<th>**</th>
<th>***</th>
<th>*</th>
<th>**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oak, white, red</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Hickory, pecan</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Beech</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Poplar, yellow</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Walnut, black</td>
<td>-</td>
<td>C</td>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ash</td>
<td>C</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Gum, red</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Hickory</td>
<td>E</td>
<td>C</td>
<td>-</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Maple, hard</td>
<td>E</td>
<td>C</td>
<td>C</td>
<td>A</td>
<td>-</td>
</tr>
<tr>
<td>Birch, yellow</td>
<td>E</td>
<td>C</td>
<td>B</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Birch, sweet</td>
<td>E</td>
<td>-</td>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sycamore</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Chestnut</td>
<td>E</td>
<td>E</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Maple, soft</td>
<td>E</td>
<td>E</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Magnolia</td>
<td>A</td>
<td>C</td>
<td>B</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Gum, black</td>
<td>C</td>
<td>-</td>
<td>C</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>Tupelo</td>
<td>C</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Elm, soft</td>
<td>E</td>
<td>E</td>
<td>D</td>
<td>C</td>
<td>E</td>
</tr>
<tr>
<td>Basswood</td>
<td>E</td>
<td>E</td>
<td>B</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

1, 2.- Degree of difficulty in avoiding pitmarks and chipped, raised, or fuzzy grain.
3.- Best results under best operating conditions for each particular species.
4.- Ease of achieving smoothness of cut and absence of chipping or splintering.
5.- Relative % smooth turnings over range of moisture %s.
Important factors in bending are the amount of steaming and the manner of application of pressure; however, the wood itself is important as some species require care in selection and handling. The F.P.L. has made tests on 2" squares bent on 20" radius without pressure on ends or outside of bend and with no selection of material beyond exclusion of knotty, unsound, or checked pieces. Table below indicates the percent of broken pieces in this test and the type of failure most frequent. Grouping is based on the test results, plus the general opinion about the extent of deformation possible with the particular species.


### Softwoods

| A | Hickory (sharp bends) | 25 tens. |
|   | Elm (sharp bends)     | 9 brash  |
|   | Ash (sharp bends)     | 14 brash |
|   | Oak, white             | 36 tens. |
|   | Oak, red               | 22 -     |
|   | Birch                  |          |

### Hardwoods

| A | Magnolia              |
|   | Beech                 |
|   | Maple                 |
|   | Gum, red              |
|   | Chestnut              |
|   | Poplar, yellow        |
|   | Cottonwood            |
|   | All other softwoods   |

Note: No available data on walnut, black cherry, alder.

### General:

CONNECTION STRENGTH (Lateral resistance, nailed; Basic stresses, bolted; Proportional stresses, modern timber connectors.)

Figures and proportions adapted from Wood Handbook, pages 123-5, 130-6, 136-48, which references see for use of figures in design.

K is lateral resistance factor per nail, by species, as expressed in equation: lbs. per nail = K x"diameter of nail to 3/2 power.
B is basic stress, lbs./sq.in., bolted; parallel to the grain; then perpendicular to the grain.
TC% is recommended %, by species, of timber-connector stresses for structural YP and coast DF.

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>K 1700</td>
<td>Ash, white</td>
</tr>
<tr>
<td>B 1500,400</td>
<td>Beech</td>
</tr>
<tr>
<td>TC% 100</td>
<td>Birch, sweet &amp; yel.</td>
</tr>
<tr>
<td></td>
<td>Cherry, black</td>
</tr>
<tr>
<td></td>
<td>Elm, rock</td>
</tr>
<tr>
<td></td>
<td>Hickory, true &amp; pecan</td>
</tr>
<tr>
<td></td>
<td>Maple, hard</td>
</tr>
<tr>
<td></td>
<td>Oak, red and white</td>
</tr>
<tr>
<td></td>
<td>Walnut, black</td>
</tr>
<tr>
<td>K 1375</td>
<td>YP (Dense *)</td>
</tr>
<tr>
<td>B 1300,275</td>
<td>DF, coast (Dense *)</td>
</tr>
<tr>
<td>TC% 100 (110)</td>
<td>Larch, western</td>
</tr>
<tr>
<td>K 1125</td>
<td>Cedar, E.red * 1250</td>
</tr>
<tr>
<td>B 1300,275</td>
<td>Tamarack * 1200,250</td>
</tr>
<tr>
<td>TC% 90 (110)</td>
<td>Cypress, south. 85</td>
</tr>
<tr>
<td></td>
<td>Redwood</td>
</tr>
<tr>
<td>K 1125</td>
<td>Cedar, Pt.Orf. 1250</td>
</tr>
<tr>
<td>B 1000,200</td>
<td>Cedar, W.red 925,175</td>
</tr>
<tr>
<td>TC% 85</td>
<td>Hemlock, W. 80</td>
</tr>
<tr>
<td></td>
<td>Pine, Norway</td>
</tr>
<tr>
<td>K 900</td>
<td>Cedar, white 900</td>
</tr>
<tr>
<td>B 800,150</td>
<td>Fir, wh. Balsam 925,175</td>
</tr>
<tr>
<td>TC% 80</td>
<td>Pine, ponderosa 80</td>
</tr>
<tr>
<td></td>
<td>Pine, wh., N&amp;W 80</td>
</tr>
<tr>
<td></td>
<td>Pine, sugar</td>
</tr>
<tr>
<td></td>
<td>Spruce, E.</td>
</tr>
<tr>
<td></td>
<td>Spruce, Sitka</td>
</tr>
<tr>
<td></td>
<td>Spruce, Engelm.</td>
</tr>
<tr>
<td></td>
<td>Alder, red</td>
</tr>
<tr>
<td></td>
<td>Ash, black</td>
</tr>
<tr>
<td></td>
<td>Birch, paper</td>
</tr>
<tr>
<td></td>
<td>Elm, soft</td>
</tr>
<tr>
<td></td>
<td>Gum, red, black &amp; Tup.</td>
</tr>
<tr>
<td></td>
<td>Magnolia</td>
</tr>
<tr>
<td></td>
<td>Maple, soft</td>
</tr>
<tr>
<td></td>
<td>Sycamore</td>
</tr>
<tr>
<td></td>
<td>Ash, black</td>
</tr>
<tr>
<td></td>
<td>Birch, paper</td>
</tr>
<tr>
<td></td>
<td>Basswood</td>
</tr>
<tr>
<td></td>
<td>Chestnut</td>
</tr>
<tr>
<td></td>
<td>Cottonwood</td>
</tr>
<tr>
<td></td>
<td>Poplar, yellow</td>
</tr>
</tbody>
</table>

Note: Withdrawal resistance of nails is largely a function of the specific gravity, moisture content, nail coating, nail shank, nail point, and direction of driving,—and not particularly a function of species as such.
GLUEABILITY

Woods differ in glueability. Denser woods are usually harder to glue but may result in stronger joints. Softer woods usually fail in the wood; denser woods usually fail both in the wood and in the joint.

Relationships in the charts and below are from:
Wood Handbook, 1935, Table 39, p.169. For woods that:
- glue easily, any glues, most any conditions— A
- glue OK, any glues, moderate care— B
- glue OK, under careful control— C
- require special treatment before gluing— D
- have heartwood E and sapwood C— E

Softwoods

<table>
<thead>
<tr>
<th>Softwoods</th>
<th>Hardwoods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar, W. red</td>
<td>A</td>
</tr>
<tr>
<td>Fir, white</td>
<td>Chestnut</td>
</tr>
<tr>
<td>Hemlock, W.</td>
<td></td>
</tr>
<tr>
<td>Pine, N. white</td>
<td>A-B</td>
</tr>
<tr>
<td>Redwood</td>
<td></td>
</tr>
<tr>
<td>Spruce</td>
<td></td>
</tr>
<tr>
<td>Cypress, S.*</td>
<td>A-B</td>
</tr>
<tr>
<td>Pine, ponderosa</td>
<td></td>
</tr>
<tr>
<td>Cedar, E. red*</td>
<td>B</td>
</tr>
<tr>
<td>DF</td>
<td>Alder</td>
</tr>
<tr>
<td>Larch, W.</td>
<td>Basswood*</td>
</tr>
<tr>
<td>YP</td>
<td>Cottonwood</td>
</tr>
<tr>
<td></td>
<td>Hickory, pecan</td>
</tr>
<tr>
<td></td>
<td>Poplar, yellow</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Ash, white</td>
</tr>
<tr>
<td></td>
<td>Cherry, black</td>
</tr>
<tr>
<td></td>
<td>Elm, hard &amp; soft</td>
</tr>
<tr>
<td></td>
<td>Magnolia</td>
</tr>
<tr>
<td></td>
<td>Maple</td>
</tr>
<tr>
<td></td>
<td>Oak, red &amp; white</td>
</tr>
<tr>
<td></td>
<td>Sycamore</td>
</tr>
<tr>
<td></td>
<td>Walnut, black</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Beech</td>
</tr>
<tr>
<td></td>
<td>Birch, sweet &amp; yellow</td>
</tr>
<tr>
<td></td>
<td>Gum, red</td>
</tr>
<tr>
<td></td>
<td>Gum, black &amp; tupelo*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
</tr>
<tr>
<td></td>
<td>Hickory, true*</td>
</tr>
</tbody>
</table>

General references:
Wood Handbook, 1935, pp.169-177. (Glue types; procedures; moisture-conditioning; surfacing; joint types; durability.)
FINISHING: PAINTABILITY

Length of service of exterior paints on wood depends on (1) kind of wood, (2) composition of paint, (3) technic of application, (4) severity of exposure conditions. Even with best paints and procedures coatings remain serviceable much longer on some woods than on others. Species is not an important factor in the amount of paint used, affecting only the priming coat.


(Paints of type A are those that fail by checking and crumbling, such as pure white lead paint; those of type B fail by cracking, curling, and flaking, such as paints containing zinc oxide mixed with other pigments.)

Softwoods

A- Woods on which paints of types A and B disintegrate slowly

Cedar, white, N&S
Cedar, W. red
Cypress, S.
Redwood

B- Woods on which paints of type A disintegrate slowly but those of type B disintegrate somewhat more rapidly than they do on woods of group A.

Pine, N. white
Pine, W. white
Pine, sugar

C- Woods on which paints of types A and B disintegrate more rapidly than they do on woods of group A.

Fir, white
Hemlock, E.
Hemlock, W.
Pine, ponderosa
Spruce, E.
Spruce, Engelmann
Spruce, Sitka

D- Woods on which paints of types A and B disintegrate more rapidly than they do on woods of group C.

DF
Pine, Norway
YP
Larch, western

Beech
Birch
(Cherry)
Gum, red
Gum, black and tupelo
Maple

NS (E)
NS (E)
NS
NS
NS
NS

E- Woods unsuited for conventional house painting because wood filler is required to fill the (large) pores properly.

Ash
Chestnut
Elm, hard & soft
Hickory
Oak, red & white
Walnut

NS
NS
NS
NS
NS
NS

(Note: Usual hardwood finishes: E-enamel, L-lacquer, N-natural, P-paint, S-stain.—Hardwood Buyer’s Guide, So.Hdwd.Producers.)
FINISHING: PAINTABILITY, continued.

General painting references:
Behavior of House Paints on Different Woods, Browne, F.L., Dec. 1934, F.P.L. Publication, R-1053, 19pp., 2 charts, 911 p. (Summarizes most of the information on paint behavior and testing of interest to the builder in earlier F.P.L. Publications by same author. Contains, beside the Behavior-grouping: consumption of paints by different softwoods; hardening of paint on different woods; painting over defects; effect of distribution and amount of summerwood; effect of grain; variation within species.)


F.P.L. Technical Note #181, 1933, Coatings for Minimizing Changes in the Moisture Content of Wood. (Tables of moisture-excluding effectiveness of coatings for exterior use, for interior use.)


Wood Handbook, 1935, pp. 227-247. (Painting characteristics of wood (softwoods); porous woods requiring filler; effect of nature of wood on wearing of paint; effect of extractives; effect of impregnated preservatives on painting; choice of paints for exterior work; mixing and application of paint; repainting; blistering; back and mill priming; uncoated exterior woodwork; interior finishing.)

Wood Construction, 1929, pp. 194-209. (Kinds of paint; application; schedule of paints for various purposes; defects in painting; finishes for interior wood surfaces.)

The Two-Coat System of House Painting, Browne, F.L., 1941, F.P.L. Publication R-1259, 19pp. & 11pp. of tables and illustrations of test fences. (Tests on durability of variously primed two coat and three coat paintings on test fences.)


Bibliography:
APPEARANCE AND IDENTIFICATION

Notes on the color, value, contrast, grain, and texture of heartwood and sapwood; special markings; odor and taste; identification.

References used for Chart:

w-xxx. Luxford and Trayer: Wood Handbook, 1935, 326 pp., USDA FPL; GPO.
w-xxxx. Sweet, C.V. and Johnson, R.P.A.: Selection of Lumber for Farm and Home Building, 1936, USDA Farmers' Bulletin No.1756, 46pp. (Table 1, p.14-15.)

General references- Appearance:


General references- Identification:


Brown and Panshin: Commercial Timbers of the U.S., their Structure, Identification, Properties, and Uses, 1940, 554p

APPEARANCE AND IDENTIFICATION -continued

General references - Identification -continued


Architectural Record: Radiography, February, 1937, p.41. (Note on the X-raying of woods to detect internal defects such as cavities, worm holes, metallic inclusions.)
and other commercial names.

Description:
(All summaries have been checked with the values and relationships established in the Properties Survey and shown in the Charts.
The adverb very is reserved for woods and properties classed as A or E.
The adverb quite is used for woods and properties classed as B or D.
The adjective average is used for woods and properties classed as C.)

Uses:
(Uses are listed in the approximate order of importance. Non-architectural uses are included if they either comprise a substantial percentage of the total produced or indicate by their unusual nature a special combination of requirements; such uses are parenthesized.)

Related minor woods:
(Whenever confusion results from the similar nomenclature of related, minor woods, such woods are listed along with any marked deviation in their properties.)

References:
1st Group: Standard works on all woods which include descriptions of the separate species. (These are selected on the basis of their widespread availability and the usual accuracy of their information.)

2nd Group: Special books, pamphlets, reports, papers concerned with an individual wood and presented by some disinterested party (as the U.S.D.A. Forest Products Laboratory).

3rd Group: Special books, pamphlets, reports, papers concerned with an individual wood and presented usually by the lumber association marketing it. (These references are included because, in spite of a healthy enthusiasm which tends to stress the wood's better properties, they include sound technical data and illustrations not found elsewhere.)

Grading:
(Rules, date, controlling association, address.)

1. See next page for standard reference works used in Species Survey.
Standard reference works listed in Species Survey:

Luxford and Trayer: Wood Handbook, 1935, 326pp, USDA Forest Products Laboratory; GPO. (Brief discussion of the principle localities of growth, characteristics, and uses of important commercial species.)


Voss and Henry: Architectural Construction, Volume I. An Analysis of the Design and Construction of American Buildings, 1925, 1267pp., Wiley, New York City. (Brief summaries of commercially important U.S. woods, with illustrations of the grain as seen by naked eye and by microscope. Woods with no illustrations are so noted in the Species Key.)

Hayward: Wood, Lumber and Timbers, 1930, 521pp., Chandler Cyclopedia, New York City. (Annual production and value in 1928, stand, range, usual and local names, description, classifications, grading, shipping weights, limitations- of commercially important U.S. woods. The bibliography, while very comprehensive, contains many references which have since become out of print and unobtainable.)


1. Longleaf Yellow Pine  
   (Pinus palustris)  
2. Shortleaf Yellow Pine  
   (Pinus echinata)  

also called Southern Yellow Pine, which is the general name for above species and for related species such as Loblolly Pine (Pinus taeda) and Slash Pine (Pinus caribaea). Yellow Pine may be graded according to species or according to density. Description below will differentiate between the inherent characteristics of fairly dense Longleaf and Shortleaf material; the Uses listed below will make distinction between dense structural material and stock of low density for general purposes.

Description:

<table>
<thead>
<tr>
<th>Longleaf YP</th>
<th>Shortleaf YP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very heavy.</td>
<td>Quite heavy.</td>
</tr>
<tr>
<td>Very strong as beam.</td>
<td>Quite strong as beam.</td>
</tr>
<tr>
<td>Exceptionally strong as post.</td>
<td>Very strong as post.</td>
</tr>
<tr>
<td>Very stiff.</td>
<td>Quite stiff.</td>
</tr>
<tr>
<td>Average hardness. (With Larch, Slightly less than average hardest softwood.)</td>
<td>All YP</td>
</tr>
</tbody>
</table>

All YP

- Resinous
- Tendency to split.
- Average durability of heartwood.
- Sapwood easily treated.
- Difficult to work with hand tools.
- Average bendability.
- Quite easy to glue.
- Quite high joint strength.
- Holds paint quite poorly.

High vs. low density

Low density material checks less, splits less in nailing, holds finish better, and is more easily worked, but is less hard, tough, and strong and has less durable heartwood under moisture conditions favoring decay.

Uses:

<table>
<thead>
<tr>
<th>High density YP</th>
<th>Low density YP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural timbers.</td>
<td>Interior trim.</td>
</tr>
<tr>
<td>Heavy duty flooring.</td>
<td>Temporary construction.</td>
</tr>
<tr>
<td>Heavy duty roof decking.</td>
<td>Millwork.</td>
</tr>
<tr>
<td></td>
<td>Flooring.</td>
</tr>
<tr>
<td></td>
<td>(Boxes and crates- low grades.)</td>
</tr>
</tbody>
</table>

Related woods:

Loblolly Pine is lightweight, soft, easily worked, wide-ringed; it is also known as North Carolina Pine and in its denser material is often graded and sold with Shortleaf YP. The Shortleaf YP from the Ozark Mountains varies from other stands of the species, is lighter, weaker, of more uniform texture, and is called Arkansas Soft Pine.
1. Longleaf YP

2. Shortleaf YP - continued

References:
Voss and Henry, p.1020 (Shortleaf), p.1021 (Longleaf).
Hayward, pp. 162, 407-19. (Pages 410-3 give full outlines and lists of botanical, commercial, and local YP terminology.)
Lumber Grade-Use Guide, Pamphlet IX. (1935, 16pp.)
A Statement on Behalf of the Southern Pine Industry Committee, 1941, US.D.L., mimeo.; 19pp, 10 tabs. (Production and consumption statistics.)
Southern Pine Heavy Duty Flooring and Roof Decking, 1941, Southern Pine Association; 8pp. (Technical data, sizes, patterns, grades; spans; wood-block flooring.)

Grading:
3. **Ponderosa Pine**  
*(Pinus Ponderosa)*

also called Western Yellow Pine and California White Pine

**Description:**
Botanically a western yellow pine; physically similar to white pine group.
Quite light weight.
Very low strength.
Very soft.
Relatively low shrinkage; stays in place quite well.
Very low shock resistance; sometimes brittle.
Very easily worked with hand tools.
Holds nails well.
Uniform texture.
Resinous.
Very low resistance to moisture-induced decay.

**Uses:**
Siding.
General millwork; sash, frames, doors.
Interior and exterior finish and molding.
Sheathing; general construction, as furring, sub-flooring.
(Boxes- lower grades.)

**References:**
Wood Construction, p. 122.
Voss and Henry, p. 1019 (no il.).
Hayward, pp. 162, 401-5.
Lumber Grade-Use Guide, Pamphlet XI. (1937, 19pp.)

American Western Pines and Their Uses, Neubrech, W. L., 1938, U.S.D.C., Forest Products Division, Bureau of Trade Promotion Series No. 180; 3&1/2 & 3 pp., il., tabs.; G.P.O.


**Grading:**
Standard Grading Rules, April 1, 1939, Western Pine Association, Portland, Oregon; 112pp.
4. Norway Pine
(Pinus resinosa)
also called Northern Red Pine and often sold with Northern White Pine although botanically closer to the Yellow Pines

Description:
In strength and related properties, somewhat similar to the Northern White Pine it is marketed with; Norway Pine is stronger, heavier, more resinous, coarser in grain and texture, harder to work.
Not as heavy and strong as most of the other (and admittedly) yellow pines.
Average weight.
Average strength, as beam.
Quite strong, as post.
Quite stiff.
Quite soft.
Average toughness.
Resinous.
Strongly marked annual rings.
Coarse in grain and texture.

Uses:
General construction.
Secondary construction purposes, as sheathing, furring.
Flooring.
Poles.
Piles.

References:
Voss and Henry, p.1019 (no ill.)
Hayward, no description.
Lumber Grade-Use Guide, Pamphlet X, includes Northern White Pine also. (1935, 8pp.)

Grading:
Graded with Northern White Pine in lower grades; graded by Northern Pine Manufacturers Association, Minneapolis, Minn; Standard Grading Rules; May 1, 1939; 36pp.
5. Northern White Pine
(Pinus Strobus)

Description:
Least resinous of the pines.
Warps less than other pines.
Very light weight.
Very low strength.
Very easily worked with hand tools.
Holds place very well.
Glues very easily.
Nails very easily.
Dries rapidly.
Straight grain and soft, uniform texture.

Uses:
Planing mill products (over 50%); sash, doors, molding, blinds.
Siding.
Paneling (available knotty).
Sheathing.
Kitchen cabinets.

References:
Wood Handbook, p.29.
Wood Construction, p.120.
Voss and Henry, not listed.
Hayward, pp.162, 395-400.
Lumber Grade-Use Guide, Pamphlet X. (1935, 8pp.)

Grading:
Graded by the Northern Pine Manufacturers Association,
Minneapolis, Minnesota;
Standard Grading Rules, May 1, 1939; 36 pp.
6. Idaho Pine
(Pinus monticola)
also called Idaho White Pine and Western White Pine

Description:
For most purposes Idaho Pine, Northern White Pine, and
Sugar Pine are interchangeable, selection depending on
cost, size, and availability.
Idaho Pine is slightly heavier, stiffer, harder, more
resinous than Northern White Pine.
Quite light weight.
Quite low strength.
Very soft.
Very easily worked with hand tools.
Quite easy to paint.

Uses: (as Northern White Pine)
Planing mill products; sash, doors, molding, screens,
frames, shutters.
Siding.
Outside finish and trim.
Paneling, knotty, enameled.
Turned stairwork.
(Drawing boards.)

References:
Wood Construction, p.121.
Voss and Henry, p.1018.
Hayward, pp.162, 389-94.
Lumber Grade-Use Guide, Pamphlet VIII. (1940, 18pp.)

The Story of Western Pines, n.d., Western Pine Association,
Portland, Oregon; 64pp.
Beautiful Paneled Walls of Genuine White Pine, n.d., Western
Pine Association; 17pp. (Illustrations and recommendations
for finishing methods.)

Grading:
Standard Grading Rules, April 1, 1939, Western Pine Associa-
tion, Portland, Oregon; 112pp.
7. **Sugar Pine**  
*(Pinus Lambertiana)*

**Description:**

For most purposes Sugar Pine, Northern White Pine, and Idaho Pine are interchangeable, selection depending on size, cost, and availability.

Sugar Pine is the largest (both tree and lumber) of all the pines.  
More obvious resin ducts than Northern White Pine.  
Slightly less durable than Idaho Pine when exposed to conditions favoring decay.  

Very light weight.  
Very low strength.  
Stays in place very well; quite low warping and twisting tendencies.  
Very easily worked with hand tools; very soft.  
Quite easy to paint.  
Straight grained.

**Uses:**

Planing mill products; frames, sash, doors.  
Wide, thick lumber.  
Drainboards.  
Siding.  
Sheathing- lower grades.  
General construction- lower grades, (furring, sub-flooring.)

**References:**

Wood Construction, p.121.  
Voss and Henry, not listed.  
Hayward, pp.420-4.  
Lumber Grade-Use Guide, Pamphlet XII. (1938, 15pp.)


**Grading:**

Standard Grading Rules, April 1, 1939, Western Pine Association, Portland, Oregon; 112pp.
8. Douglas Fir- Coast

9. Douglas Fir- Mountain

(Pseudotsuga taxifolia)

Coast type DF is most numerous and strongest; Rocky Mountain type is weakest. These two are included in charts as showing extremes in the properties of this species; however, Inland Empire DF is as important as Mountain DF and in properties lies about half way between Mountain DF and Coast DF. Douglas Fir is graded according to density and strength, the densest material going to the structural uses listed below. Existing DF stand is larger than that of any other species.

Description:

<table>
<thead>
<tr>
<th>Coast DF</th>
<th>Mountain DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average weight.</td>
<td>Average weight.</td>
</tr>
<tr>
<td>Quite strong as beam.</td>
<td>Quite low strength as beam.</td>
</tr>
<tr>
<td>Very strong as post.</td>
<td>Average strength as post.</td>
</tr>
<tr>
<td>Very stiff.</td>
<td>Average stiffness.</td>
</tr>
<tr>
<td>Shrinks more.</td>
<td>Shrinks less.</td>
</tr>
<tr>
<td>Average penetrability.</td>
<td>Very poor penetrability.</td>
</tr>
<tr>
<td>Quite low hardness.</td>
<td>Quite low hardness.</td>
</tr>
<tr>
<td>Average durability, better when dense.</td>
<td>Average durability.</td>
</tr>
<tr>
<td>Quite low shock resistance.</td>
<td>Very low shock resistance.</td>
</tr>
</tbody>
</table>

All DF

Resinous.

Very difficult to work by hand tools.

Large timbers and board widths available.

Attractive grain when flat sawed.

Average bendability.

Quite difficult to paint.

Quite easy to glue.

Uses:

Structural timbers.

Dimension lumber.

Veneer and plywood.

Interior and exterior trim.

Flooring.

Windows, doors, frames.

Poles, piling.

References:


Voss and Henry, pl022.

Hayward, pl61, 360-8.

Lumber Grade-Use Guide, Pamphlet IV. (1935, 31pp.)

" " " " , Pamphlet VII- Inland DF and Larch.

(1949y 19pp.)

Douglas Fir Use Book, 1935, West Coast Lumbermen's Association; pp. (Structural data and design tables.)
8. Douglas Fir - Coast
9. Douglas Fir - Mountain - continued

References - continued:

Grading:
Standard Grading Rules No. 11, Jan 1, 1941, West Coast Lumbermen's Association, Seattle, Washington; 154pp.
Standard Grading Rules, April 1, 1939, Western Pine Association; 112pp., 68-70 Larch-Douglas Fir.
10. Eastern Hemlock
(Tsuga canadensis)

also called Northern Hemlock.

Description:
Coarse, brittle, tends to splinter.
Quite low weight.
Quite low strength.
Subject to ring shake.
Subject to warp.
Very low shock resistance.
Quite low decay resistance.
Resistance to dry-rot (Wood Construction.)
Non resinous.
Small knots.
Very poor bendability.
Average difficulty in painting.

Uses:
General construction.
Sheathing.
Roofing.
Sub flooring.

References:
Wood Construction, p.127.
Voss and Henry, 1024.
Hayward, pp.161, 376-9.
Lumber Grade-Use Guide, Pamphlet VI. (1935, 15pp., including also Tamarack and Northern White Cedar.)

Grading:
Rules and regulations of Northern Hemlock and Hardwood Manufacturers Association, Oshkosh, Wisconsin. (Occasionally small amounts of Tamarack, heavier and stronger, are included with Eastern Hemlock.)
Western Hemlock  
(Tsuga heterophylla)

Description:
Larger tree than Eastern Hemlock; can be obtained in wide clear sizes in vertical grain stock.  
Finer texture, more uniform, less brittle than Eastern Hemlock.
Quite light weight.
Quite low strength.
Non resinous.
Usually straight grained; comparatively free of ring shakes.
Firm knots.
Quite low decay resistance.
Odor believed somewhat insect and rodent repellant.

Uses:
Framing, sheathing, subflooring.
Interior trim and paneling; general millwork.
Flooring.
Siding.
Sash, doors.

References:
Wood Construction, p.127.
Voss and Henry, not listed.
Hayward, p.162, 380, as West Coast Hemlock.
Lumber Grade-Use Guide, Pamphlet IV. (1935, 31pp., including also Douglas Fir, Western Red Cedar, Sitka Spruce.)

Grading:
Standard Grading Rules No.11, Jan 1, 1941, West Coast Lumbermen's Association. (In lower grades, Western Hemlock is mixed with, sold with, and accepted as equal to Douglas Fir.)
also called Tidewater Red Cypress (coastal regions) and Yellow or White Cypress (inland).

Description:
Heartwood very highly resistant to decay under moisture conditions (sapwood not resistant).
Very easily worked with hand tools.
Holds paint very well.
Average weight.
Average strength.
Quite soft.
Average stiffness.
Stays in place quite well.
Available in large dimensions.
Available pecky.
Resistant to acids.
Rancid odor when green.
Imparts no taste to food.

Uses:
(Wherever moisture conditions favor decay.)
Siding.
Outside finish.
Porches; steps.
Gutters.
Doors and sash.
Interior finish and paneling.
Beams, posts, dimension lumber.
Sheathing (lower grades).
(Tanks, vats.)
(Food containers.)
(Greenhouses.)

References:
Voss and Henry, p.1025, as Bald Cypress.
Hayward, pp.161, 352-9.
Lumber Grade-Use Guide, Pamphlet III. (1935, 20pp.)

American Southern Cypress, Neubrech, W.L., 1939, U.S.D.C.
Forest Products Division, Bureau of Trade Promotion
Series No.194; 30pp.; G.P.O.
Southern Lumberman, July 1, 1941, Southern Hardwoods Series
No.17. (Cypress is frequently marketed by hardwood dealers.)

Grading:
Standard Specifications for Grades of Tidewater Red Cypress,
1941, Southern Cypress Manufacturers Association,
Jacksonville, Florida; 64pp. (over)
12. Southern Cypress—continued

Grading—continued


Grades:

Factory lumber: FAS, Selects, #1 Shop, #2 Shop, Box.

Yard lumber, finish: Clear Heart, Grade A, Grade B, Grade C, Grade D.

Yard lumber: #1 Com., #2 Com., #3 Com., #4 Com., Pecky.
13. Eastern Spruce
(Picea glauca, P. rubra, P. mariana)
also called White Spruce, Red Spruce, or Black Spruce.

Description:
Quite light weight.
Quite low strength.
Quite low hardness.
Average stiffness.
Quite low toughness.
Dries easily and stays in place quite well; average shrinkage.
Average workability with hand tools.
Quite low resistance to decay in unfavorable moisture conditions.
Very easy to glue.

Uses:
Framing material.
General millwork.
(Boxes and crates.)

References:
Wood Handbook, p.32.
Wood Construction, p.123.
Voss and Henry, not listed, see Engelmann Spruce.
Hayward, pp.163, 433-40.
Lumber Grade-Use Guide, Pamphlet X.(1935, 8pp., including also Northern White Pine and Norway Pine.)

Grading:
Engelmann Spruce
(*Picea Engelmannii*)

Description:
The lightest, weakest, and softest of the spruces.
Very light weight.
Very low strength.
Very low stiffness.
Very low toughness.
Quite low durability exposed to adverse moisture conditions.
Very low bendability.
Very low connection strength.
Average difficulty of painting.

Uses:
General construction: furring, subflooring, sheathing (not framing).
Low cost siding.
Exterior trim.
Low cost painted interior trim.

References:
Wood Handbook, not listed.
Wood Construction, not listed.
Voss and Henry, p.1021.
Hayward, not listed.
Lumber Grade-Use Guide, Pamphlet XIV. (1935, 4pp.)

Grading:
Standard Grading Rules, April 1, 1939, Western Pine Association, Portland, Oregon; 112pp. (Engelmann Spruce, p.64, is inspected and graded under rules for Idaho Pine.)
Sitka Spruce  
(Picea sitchensis) 

a western spruce.

Description:
Larger lumber than Eastern Spruce and Engelmann.  
More uniform in quality than Eastern Spruce and Engelmann.  
Quite light weight.  
Quite low strength but fairly high strength/weight ratio.  
Quite low hardness.  
Quite high stiffness and very high stiffness/weight ratio.  
Quite low toughness.  
Produces some large, clear, straight grained pieces.  
Dries easily; moderate shrinkage.  
Quite low decay resistance in adverse moisture conditions.  
Average workability.  
Very easy to glue.  Odorless. Tasteless.

Uses:
Siding.  
Exterior finish.  
Interior finish to be painted or enameled.  
General millwork. (Veneer core stock.)  
(Aircraft construction.)  
Flooring.  
Doors and sash.  
(Boxes and crates - lower grades.) (Cooperage; food containera)  
(Piano and violin sounding boards.)

References:
Wood Construction, p.123.  
Voss and Henry, not listed.  
Hayward, pp.163, 433-40.  
Lumber Grade-Use Guide, Pamphlet IV: (1935, 31pp, including  
also Douglas Fir, Western Hemlock, Western Red Cedar.)

Sitka Spruce, 1940, West Coast Lumbermen's Association,  
Seattle Washington; 36pp; photos, grades, uses, data.

Grading:
Standard Grading and Dressing Rules, No.11, January 1, 1941,  
West Coast Lumbermen's Association, Seattle, Washington;  
154pp, Sitka Spruce 95-117:
16. Redwood
(Sequoia sempervirens)
also called Sequoia and California Redwood.

Description:
Rich reddish brown colored heartwood; sapwood lighter and easily distinguishable.
Wide, clear lumber easily obtained.
Very resistant to decay in adverse moisture conditions (heartwood).
Resistant to termites.
Low shrinkage; stays in place well.
Quite light weight.
Quite strong as beam.
Very strong as post.
Average workability.
Holds paint very well, but seldom necessary to paint.

Uses:

<table>
<thead>
<tr>
<th>High density</th>
<th>Low density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural timbers.</td>
<td>Siding.</td>
</tr>
<tr>
<td>Mill roofing.</td>
<td>Exterior finish and trim.</td>
</tr>
<tr>
<td>Foundation work (untreated).</td>
<td>Interior finish and trim.</td>
</tr>
<tr>
<td>(Trestles.)</td>
<td>Paneling and ceiling.</td>
</tr>
<tr>
<td>(Highway bridges.)</td>
<td>Veneer and plywood.</td>
</tr>
<tr>
<td>(Pipes.)</td>
<td>(Greenhouse construction.)</td>
</tr>
<tr>
<td>(Tanks.)</td>
<td></td>
</tr>
</tbody>
</table>

References:
Wood Handbook, p.32.
Voss and Henry, p.1025.
Hayward, pp.163, 425-32.
Lumber Grade-Use Guide, Pamphlet XIII. (1935, 12pp.)


Structural Redwood, n.d., California Redwood Association, San Francisco; 26pp.; il., properties, design data, grades.
Redwood, 1941, California Redwood Association; 12pp., properties, data, products.

Grading:
Graded under rules of California Redwood Association, San Francisco, California.
Western Red Cedar
(Thuja plicata)

Description:
The largest and finest of the cedars.
Available in wide range of sizes and lengths.
Heartwood very resistant to decay in adverse moisture conditions.
Aromatic.
Very light weight.
Very soft.
Very low strength as beam.
Quite low strength as post; apt to crush under heavy driving.
Very low shrinkage; almost no tendency to warp and check.
Even textured.
Free of pitch.
Very easily worked.
Very easily glued.
Very easily finished.

Uses:
Planing mill products (over half).
Siding.
Shingles.
Sleepers (foundation timbers).
Exterior trim and finish
Frames sash and doors.
Porch construction.
Interior trim and finish.
Mouldings.
(Greenhouse construction.)
Piling.
(Posts, poles.)

References:
Wood Construction, p.128.
Voss and Henry, p.1026.
Hayward, pp.161, 341-51 especially 346.
Lumber Grade-Use Guide, Pamphlet IV. (1935, 31pp., including
also Douglas Fir, Western Hemlock, Sitka Spruce.)
1936, p.15.

Western Red Cedar, the Enduring Wood of the Ages, 1927,
West Coast Lumbermen's Association, Seattle, Wash.; 26pp.
il., uses, technical data, recommended grades.

Grading:
Standard Grading and Dressing Rules, No.11, January 1, 1941,
West Coast Lumbermen's Association, Seattle, Wash.; 154pp.,
Western Red Cedar 118-31.
18. Eastern Red Cedar
(Juniperus virginiana)
also called Aromatic Cedar and Pencil Cedar.

Description:
Aromatic fragrance.
Generally knotty.
Average weight but weak and low-strength/weight ratio.
Quite soft.
Very low stiffness; brittle.
Very high resistance to decay under adverse moisture conditions.

Uses:
Interior finish.
Interior lining of mothproof closets and chests.
Sills.
Posts.
(Ties.)

References:
Wood Handbook, no description.
Wood Construction, p.128.
Voss and Henry, not listed.
Hayward, pp. 161, 341-51 especially 346.
Lumber Grade-Use Guide, Pamphlet II. (1934, 1p.)

Grading:
Graded by Hardwood Manufacturers Institute, Memphis, Tenn.
Grades: FAS, #1Com., #1Com.&Better, #2Com.
19. White Cedar
(Thuja occidentalis, N.)
(Chamaecyparis thyoides, S.)
also called Northern White Cedar or Arborvitae, and Southern White Cedar.

Description:
Fragrant, aromatic odor.
Very light weight.
Very soft.
Very low strength,
Brittle; splits readily.
Heartwood extremely resistant to decay in adverse moisture conditions.
Low shrinkage.
Fine, uniform texture.
Very easily worked with hand tools.
Very easy to paint.
Very knotty.

Uses:
Shingles.
Foundation work, posts, poles, crossties.
(Small boat construction.)
Siding.
Porch construction.
(Tanks.)

References:
Wood Construction, p.128.
Voss and Henry, p.1027 Northern White Cedar only.
Hayward, pp.161, 341-51 especially 345.
Lumber Grade-Use Guide, Pamphlet VI. (1935, 15pp. including also Eastern Hemlock and Tamarack.) (Northern White Cedar only.)

Related woods:
Alaska Cedar, Chamaecyparis nootkatensis, is similar to, and for most purposes interchangeable with, White Cedar. It is also called Sitka Cypress, Yellow Cypress, Yellow Cedar.
Alaska Cedar is the strongest of the cedars except Port Orford.

Grading:
Rules and regulations of Northern Hemlock and Hardwood Manufacturers Association, Oshkosh, Wisconsin, for Northern White Cedar.

v
20. Port Orford Cedar  
(Chamaecyparis lawsoniana)

a white cedar.

Description:
Spicy odor.
Heartwood very resistant to acids.
Heartwood very resistant to decay under adverse moisture conditions.
Quite light weight.
Average strength as beam; quite high strength as post; strongest of the commercial cedars.
Quite stiff.
Quite low hardness.
Resinous.
Fine and uniform texture; very close grain.

Uses:
Interior finish and trim.
Exterior finish and trim.
Siding.
Shingles.
Venetian blinds.
(Boats.)
General construction- lower grades.
Dock planks- lower grades.
(Grossties- lower grades.)
(Mine timbers- lower grades.)

References:
Wood Construction, p.129.
Voss and Henry, p.1029, no 11.
Hayward, pp. 341-51 especially 346.
Lumber Grade-Use Guide, not included.

Grading:
21. Western Larch
(Larix occidentalis)

Description:
Often logged, manufactured, graded, and sold with Douglas Fir as "Larch-Fir".
Quite heavy.
Quite strong as beam.
Very strong as post.
Quite stiff.
Quite low in shock resistance.
Resinous.
Takes natural finish well but paint poorly.
Splits easily; subject to ring shakes.
Average hardness; with Longleaf YP, hardest of the softwoods.
Fine, straight grain; conspicuous growth rings.
Average resistance to decay.

Uses:
Flooring.
Structural timbers.
Framing.
General construction.
Interior trim with natural finish.
Doors, sash, frames; other planing mill products.
(Boxes and crates—lower grades.)

References:
Wood Handbook, p.27.
Wood Construction, p.124.
Voss and Henry, p.1022, no il.
Hayward, pp.162, 384-8.
Lumber Grade-Use Guide, Pamphlet VII. (1940, 19pp., including Douglas Fir with Larch as "Larch-Fir").

Grading:
Standard Grading Rules, April 1, 1939, Western Pine Association, Portland, Oregon; 112pp., 68-70 Larch-Douglas Fir.
22. White Fir

\( \text{(Abies concolor, } \text{A. Abies grandis)} \)

Also called Western White Fir. Abies grandis, less important, is also called Lowland White Fir.

Description:
Generally similar to the eastern spruces.

Less color than any other commercial softwood.
Quite light weight.
Quite low strength.
Quite soft.
Average stiffness.
Non-resinous.
Very low resistance to decay under moisture conditions.
Quite low penetrability of preservatives.
Stays in place very well.
Average workability with hand tools.
Very easy to glue.
Average paintability.
Odorless.

Uses:
Small-house framing lumber.
Sheathing.
Subflooring.
Planing mill products; flooring.
General millwork.
(boxes.)
(Butter tubs.)

References:
Wood Construction, not described.
Vossaand Henry, p.1023.
Hayward, pp. 369-75.
Lumber Grade-Use Guide, Pamphlet V. (1940, 8pp.)

Grading:
Standard Grading Rules, April 1, 1939, Western Pine Association, Portland, Oregon; 112pp., White Fir p.65.
Balsam Fir
(Alter balsamea)
Also called Eastern White Fir. Mostly used locally, not much marketed commercially, and becoming extinct.
Description:
Nearly white, with little figure.
Very light weight.
Very low strength.
Very soft.
Very low resistance to moisture-caused decay.
Resinous.
Satiny.
Coarse grained.
Easily split.
Uses:
General light framing.
Sheathing.
Subflooring.
(Christmas trees.)

References:
Wood Construction, not described.
Voss and Henry, not included.
Hayward, pp.369-75.
Lumber Grade-Use Guide, not included.
24. Red Oak  
25. White Oak  
(Quercus sp., approx. 60)

Commercial White Oaks are: White Oak (Quercus alba), Chestnut Oak (Q. montana), Swamp Chestnut Oak (Q. prinus), Swamp White Oak (Q. bicolor), Post Oak (Q. stellata), Overcup Oak (Q. lyrata), Bur Oak (Q. macrocarpa), Chinquapin Oak (Q. muehlenbergii).

Commercial Red Oaks are: Red Oak (Q. borealis), Swamp Red Oak (Q. rubra pagodaefolia), Southern Red Oak (Q. rubra), Pin Oak (Q. palustris), Yellow or Black Oak (Q. velutina), Willow Oak (Q. phellos), Water Oak (Q. nigra), Scarlet Oak (Q. coccinea).

Description:  

<table>
<thead>
<tr>
<th>All Oaks</th>
<th>Red Oak</th>
<th>White Oak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very heavy.</td>
<td>Heartwood has quite low resistance to moisture-caused decay.</td>
<td>Heartwood has quite high resistance to moisture-caused decay.</td>
</tr>
<tr>
<td>Quite strong.</td>
<td>Very high permeability to liquids.</td>
<td>Very low permeability to liquids.</td>
</tr>
<tr>
<td>Quite stiff.</td>
<td>Medullary rays few and broad.</td>
<td>Medullary rays often conspicuous, accounting for the popularity of 1/4 sawed material.</td>
</tr>
<tr>
<td>Very high joint strength.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very high bendability.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very hard to work with hand tools.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very fine to work with machine tools.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takes excellent stain and natural finish.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very difficult to paint.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well marked annual rings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distinct stripe and flake when quartered.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Uses:  

Flooring, plain and quartered.  
Interior trim and molding.  
Exterior finish (white only).  
Other millwork, doors, windows, paneling.  
Plywood and veneers.  
Heavy construction.  
(Furniture.)  
(Implement handles.)  
(Tight cooperage, white only.)  
(Cross-ties.)  
(Piling.)
Related woods:
Live Oak (Q. virginiana), from the South Atlantic and Gulf Coasts, is sometimes bracketed with the white oaks but is twice as strong and hard as true white oak. It is hard to machine and fabricate and is used for knees and timbers in shipbuilding and for other purposes where its exceptional strength and hardness properties count.

References:
Wood Handbook, p.28.
Wood Construction, p.130.


Southern Lumberman: Southern Hardwoods Series No.16., June 1, 1941.

Grading:
Grades:
Qt. White Oak: FAS, #1Com.&Select, #2Com., Sound: Wormy, #3Coms.
Plain White Oak: FAS, #1Com.&Select, #2Com., #3Com., Sound: Wormy, Sill Stock.
Qt. Red Oak: FAS, #1Com.&Select, #2Com., Sound: Wormy, #3Coms.
Plain Red Oak: FAS, #1Com.&Select, #2Com., #3Com., Sound: Wormy, Clear Face Strips, Sound St. Edge, Step Plank, Bending Oak: FAS, #1Com.
Grades:
Qt. Oak: Clear, Sap Clear, Select.
Plain-sawed Oak: Clear, Select, #1Com., #2Com.
Red Gum (Liquidambar styraciflua)

Sapwood of Red Gum trees is marketed as Sap Gum and differs in properties only as noted below. In average trees there is more Sap Gum lumber than Red Gum; hence price of select Red Gum is higher than select Sap Gum because larger trees are required.

Description:

Both Red Gum and Sap Gum

Average weight.
Average strength as beam.
Quite low strength as post.
Quite soft.
Average workability with hand tools.
Fine, uniform texture.
Average resistance to moisture-caused decay.
Takes fine natural finish and stain.
Quite difficult to paint.

Red Gum

Dark reddish brown.
Available quartered with ribbon stripe.
Available with variegated figure.

Sap Gum

Very light pinkish white.
Available quartered.

Uses:

Veneers, plain, ribbon, figured.
Interior finish and trim. (Furniture.)
Flooring.
Beams.

Veneers.

Boxes and crates—low grades.

References:

Voss and Henry: Architectural Construction, p.1015 (not ill.)

Southern Lumberman: Southern Hardwoods Series No.14., May 1, 1941.
26. Red Gum – continued

Grading:

Grades:
Ribbon Stripe.
Qtd. Red Gum: FAS Figured, FAS Plain, #1 Com. & Select, #1 Com. & Select, #2 Com.
Plain Red Gum: FAS Figured, FAS, #1 Com. & Select, #2 Com.
Qtd. Sap Gum: FAS, #1 Com. & Select, #2 Com.
Plain Sap Gum: FAS, #1 Com. & Select, #2 Com., #3 Com.
### 27. Hard Maple  
(Sugar Maple-Acer saccharum)  
(Black Maple-Acer nigrum)

#### Description:
- **Hard Maple**
  - Very heavy.
  - Quite strong.
  - Very hard and wear resistant.
  - Quite high shock resistance.
  - Very high joint strength.
  - Quite high bendability.
  - Quite stiff.
  - Quite good machine tool workability.
  - Curly grain available.
  - Birdseye grain available.
  - Tendency toward mineral stain.

- **Soft Maple**
  - Quite heavy.
  - Average strength.
  - Average hardness.

---

### All Maple
- Light reddish brown heartwood.
- Whitish sapwood.
- Quite low resistance to moisture-caused decay.
- Diffuse porous. Not 1/4d. No obvious rays.

### Uses:
- **Flooring.** (Furniture.)
- Veneers and plywood.
- Cabinet work. (Tool handles.) (Work bench tops.) (Bowling pins.)
- Wall paneling. (Secondary furniture.)
- Cabinet work.
- Interior finish.
- Flooring.
- (Slack cooperage.) (Boxes and crates.)

### References:

- Southern Lumberman: Southern Hardwoods Series No.15., May 15, 1941 (Soft Maple).

27. Hard Maple
28. Soft Maple -continued

Grading:


Grades:
- Hard Maple: FAS, #1Com.&Select, #2Com., #3Com.
- Soft Maple: FAS, #1Com.&Select, #2Com., #3Com.; White FAS, White #1Com.; (Optional "Worm holes no defect"-WHND)


Grades:
- Birdseye Figured, Clear.
29. Yellow Birch  
(Betula lutea)  
30. Sweet Birch  
(Betula lenta)  

Yellow Birch, about 75% of all Birch, and Sweet Birch, about 15%, are mixed together and sold commercially as Birch. Grading is sometimes by color, as Red Birch (heartwood), White Birch (sapwood), or Unselected Birch (both).

Description:  
Both Birches  
Very heavy.  
Very strong as beam.  
Very stiff.  
Very tough.  
Very hard and wear resistant.  
Very high bendability.  
Very hard to work with hand tools.  
Average workability with machine tools.  
Fine uniform texture.  
Available wavy or curly grained.  
Easily veneered.  
Takes good polish.  
Takes fine stain and natural finish.  
Quite low resistance to moisture-caused decay.

<table>
<thead>
<tr>
<th>Yellow Birch</th>
<th>Sweet Birch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heartwood light reddish-brown.</td>
<td>Heartwood dark reddish-brown.</td>
</tr>
<tr>
<td>Sapwood nearly white.</td>
<td>Sapwood light brown.</td>
</tr>
<tr>
<td>Quite strong as post.</td>
<td>Very strong as post.</td>
</tr>
<tr>
<td>Average permeability of liquids.</td>
<td>Very high permeability of liquids.</td>
</tr>
</tbody>
</table>

Uses:  
Flooring, plain and selected for color.  
Interior finish and trim.  
Veneers and plywood.  
(Furniture.)  
Panel stock.

Related wood:  
Paper Birch (Betula papyrifera) is lighter, weaker, mostly used for turned products, and comprises 10% of all Birch produced. The other 17 U.S. Birch species are unimportant commercially.
29. Yellow Birch
30. Sweet Birch -continued

References:
Holtman: Wood Construction, p.133.
Voss and Henry: Architectural Construction, p.1013
(Yellow Birch only; no il.)
Hayward: Wood, Lumber and Timbers, pp.158, 199-204.
1936, p.6 (Yellow Birch only).

American Hardwood Flooring and Its Uses, Neubrech, W.L.,
1938, U.S.D.C. Trade Promotion Series No. 186; 35pp.,
G.P.O. (Birch- pp.12, 16, 19-20.)

Grading:
Rules for the Measurement and Inspection of Hardwood Lum-
ber, Cypress, Veneers, and Thin Lumber, N.H.L.A.,

Grades:
Birch lumber: FAS, #1Com.&Select, #2Com., #3Com. *
Northern Hard Maple, Beech, and Birch Floorings: Grading
Rules and Standard Specifications, 1935, Maple Flooring

Grades:
Birch Flooring: Red Clear, First Grade, Second Grade,
Third Grade.

*Red Birch: FAS, #1Com.&Select.
Sap Birch: FAS, #1Com.&Select.
31. Beech
(Fagus atropunicea)

Description:
Very heavy.
Quite strong.
Quite hard; very abrasion resistant.
Very high joint strength.
Very hard to work with hand tools.
Lathes and machines very well.
Quite high bendability.
Difficult to season.
Uniform texture and straight even grain.
Has obvious rays and many small flakes but is not 1/4 sawed
is not sufficiently more attractive.
Heartwood reddish brown.
Does not impart taste.
Quite low resistance to moisture-caused decay.

Uses:
Flooring, plain and selected for color.
Interior finish and trim.
(Furniture.)
(Food containers.)
(Tool handles.)
(Woodenware: bowls etc.)
(Cross ties and rough construction.)
(Boxes and crates- low grades.)

References:

American Hardwood Flooring and Its Uses, Neubrech, W.L.,
1938, U.S.D.C. Trade Promotion Series No.186; 35pp.,
G.P.O. (Beech- pp.12, 13, 16, 19-20.)

Southern Lumberman: Southern Hardwoods Series No.7.,
January 1, 1941.
31. Beech -continued

Grading:

Grades:
Beech Lumber: FAS, #16om.&Select, #2Com., #3Com., Log Run.


Grades:
Beech Flooring: Red Clear, First Grade, Second Grade, Third Grade.
32. **Black Gum**  
(*Nyssa sylvatica*)  
and **Tupelo Gum**  
(*Nyssa aquatica*)
sold together, and not interdistinguishable once cut. Occasionally sold separately, with harder material called Black Gum and softer material called Tupelo, without botanical justification. In general, properties are very similar and the Description below is based on the average.

**Description:**
Quite heavy.  
Average hardness; fairly good wear resistance.  
Average strength.  
Very low shock resistance.  
Hard to split.  
Tendency to warp and twist in seasoning.  
Apt to blue stain.  
Produces more sapwood than heartwood.  
Heartwood brownish gray.  
Sapwood grayish white.  
Medium textured wood with fine, interlocked grain.  
Lacks figure, except ribbon stripe when 1/4 sawed.  
Very low resistance to moisture-caused decay.  
Very high permeability by liquids.

**Uses:**  
Veneers and plywood. (Secondary furniture construction.)  
Flooring.  
Factory flooring, platform decking, dock planking (preserved).  
Interior finish, trim, molding.  
(Boxes and crates.)  
(Toys.)  
(Toilet seats.)  
(Cooperage.)

**References:**  

Tupelo and Black Gum, n.d., Southern Hardwood Producers Inc.  
Southern Hardwood Information Series No.4.; 8pp.  
Southern Lumberman: Southern Hardwoods Series No.9, February 15, 1941.

*NHLA makes no distinction between the two, 1940.*
32. Black Gum and Tupelo Gum -continued

Grading:

Grades:
Black Gum and/or Tupelo Lumber: FAS Qtd., FAS Plain,
#1 Com.&Select Qtd. (Black Gum only),
#1 Com.&Select Plain,
#2 Com.&Select Qtd. (Black Gum only),
#2 Com.&Select Plain,
#2 Com.Plain,
#3 Com.Plain.
Ribbon Stripe.
33. Yellow Poplar
(Liriodendron tulipifera)
also called Whitewood.

Description:
One of the largest hardwood trees in the world; produces wide lumber. Heartwood is greenish yellow-brown when fresh cut, changing to drab; sapwood is light yellowish. Occasional curl, mottle; usually lacks definite figure. Frequent mineral stain. Quite light weight. Very soft. Very low strength as beam. Quite low strength as post. Average stiffness. Stays in place quite well. Very easily worked by hand tools; quite high quality of machine tool workmanship. (Unique in this combination of properties.) Easily seasoned. Odorless. Quite easy to glue. Average ease of painting. Very low resistance of heartwood to moisture-caused decay.

Uses:
Planing mill products:
  Interior finish and trim
  Doors and sash
  Siding
Corewood.
  (Enameled and painted furniture.)
Panels, available knotty.
Veneers and plywood.
  (Boxes and crates.)

Related wood:
Magnolia (see Species Key No.44) is similar to and sometimes mixed and sold with Yellow Poplar.

References:

Southern Lumberman: Southern Hardwood Series No.5, December 1, 1940.
#33. Yellow Poplar -continued

Grading:


Grades:

Yellow Poplar lumber: FAS, Saps, Selects, Stained Saps,
#1Com., #2Com.(A&B), #3Com.(A&B).

Quartered Poplar lumber: FAS, #1Com., #2Com.(A&B),
#3Com.

Poplar siding: Clears, Selects, #1Com., #2Com.
Description:
Quite light weight.
Very soft.
Very low strength.
Quite low stiffness.
Average workability with hand tools.
Poor quality of work with machine tools.
Tendency to warp and twist; stays in place quite poorly.
Glues quite well.
Nails easily.
Odorless.
Uniform texture.
Heartwood and sapwood both grayish white to grayish brown; very little contrast.
Very low resistance to moisture-caused decay.

Uses:
(Boxes and crates -over 50%)
Veneers, veneered containers, plywood.)
(Agricultural implements.)
(Vehicle parts.)
(Woodenware.)
Some planing mill products.
(Excelsior, pulp, paper.)

References:

Southern Lumberman: Southern Hardwood Series No.12, April 1, 1941.

Grading:

Grades:
Cottonwood lumber: FAS, #1Com.&Select, #2Com, #3Com.(A&B).
35. Basswood
(Tilia glabra)
also called American Linden.

Description:
Heartwood creamy white and not clearly defined from the sapwood.
Very easily worked with hand tools; quite low quality of machine tool workability.
With Poplar, the hardwood least apt to warp and twist.
High shrinkage; stays in place average well.
Quite light weight.
Very soft and easily marred; wears poorly.
Very low strength.
Average stiffness.
Straight, even grain; lacks figure.
Very difficult to bend well.
Glues well.
Very low resistance to moisture-caused decay.

Uses:
(Boxes and crates - lower grades.)
Panel and plywood cores.
(Special wood products, novelties, toys.)
Interior trim - hidden parts.
Drawer bottoms.
Moldings.
Wood carving.
Drawing boards.
(Pulp.)

References:
Holtman: Wood Construction, p.139.

Grading:

Grades:
Basswood lumber: FAS, #1Com.&Select, #2Com., #3Com.(A&B).
36. White Ash  
   (Fraxinus americana)  
37. Black Ash  
   (Fraxinus nigra)  

Commercial White Ash, about 75% of all Ash, also includes:  
Green Ash (F. pennsylvanica lanceolata), and occasionally some Red Ash (F. pennsylvanica), Biltmore White Ash (F. biltmoreana), Blue Ash (F. quadrangulata). Of these, true White Ash (F. americana) itself is the toughest.  
Black Ash is also known as Brown Ash.  

Description:  

<table>
<thead>
<tr>
<th>White Ash</th>
<th>Black Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very heavy.</td>
<td>Average weight.</td>
</tr>
<tr>
<td>Very strong; strong for its weight; usually too cost-</td>
<td>Quite low strength as beam; very low strength as post.</td>
</tr>
<tr>
<td>ly for general construction purposes.</td>
<td></td>
</tr>
<tr>
<td>Quite tough.</td>
<td>Quite tough.</td>
</tr>
<tr>
<td>Quite stiff.</td>
<td>Quite stiff.</td>
</tr>
<tr>
<td>Very high joint strength.</td>
<td>Quite low joint strength.</td>
</tr>
<tr>
<td>Quite hard.</td>
<td>Average hardness.</td>
</tr>
<tr>
<td>Very high bendability.</td>
<td></td>
</tr>
<tr>
<td>Quite low resistance to moisture-caused decay.</td>
<td></td>
</tr>
<tr>
<td>Very high permeability by liquids.</td>
<td></td>
</tr>
<tr>
<td>Very hard to work by hand.</td>
<td>Quite good machine workability.</td>
</tr>
<tr>
<td>Quite good machine workability.</td>
<td>Quite good machine tool workability.</td>
</tr>
</tbody>
</table>

Prominent, rather coarse grain; occasionally available curly for veneer.  
Heartwood gray-brown, reddish. Heartwood dark gray-brown.  
Sapwood nearly white. Sapwood light grayish tan.  
Difficult to paint.  
Imparts no odor or taste.  

Uses: (material separated into Cabinet stock and Tough-Textured stock.)  
(Tool handles.) (Furniture.)  
Veneers and plywood. (Boxes and crates.)  
(Furniture.) (Refrigerators.)  
Interior finish. Interior finish.  
Panel stock. Panel stock.  
Kitchen cabinets. (Butter tubs.)  
(Auto bodies.) (Marine and sporting goods: oars, baseball bats, etc)  
(Butter tubs.)
36. White Ash
37. Black Ash

Related wood:
Oregon Ash (Fraxinus oregona) has strength properties midway between White Ash and Black Ash and is used locally in southwest Oregon.

References:
Holtman: Wood Construction, not included.
Southern Lumberman: Southern Hardwood Series No.1, October 1, 1940.

Grading:

Grades:
Ash lumber: FAS, #1Com.&Select, #2Com., Sound Wormy, #3Com.
Cabinet Ash: FAS, #1Com.&Select, Sound Wormy, #2Com., #3Com.(A&B).
38. Chestnut  
(Castanea dentata)

Description:
Heartwood very durable, and resistant to moisture-induced decay.
Average weight.
Quite low strength as beam.
Very low strength as post.
Very easy to work with hand tools.
Average workability with machine tools.
Easy to stain; very difficult to paint; may be sandblasted.
Stays in place quite well; with Walnut, the best hardwood in this property.
Very easy to glue.
Very low permeability by liquids.
Heartwood gray brown; sapwood light grayish tan.
Straight, open grain; large, distinct pores.
Frequently wormy.

Uses:
Planing mill products:
   Interior trim
   Molding
   Doors
Core stock for plywood and panels.
Paneling, available wormy.
(Exterior furniture.)
(Musical instruments.)
Piling.
(Poles, posts, cross ties.)

References:

Morbeck: Chestnut as a Corewood, 1932, 4p. USDA FPL, reprint-ed by Appalachian Hardwood Manufacturers, Inc., Cincinnati, O.

Grading:
Rules for the Measurement and Inspection of Hardwood Lum-
ber, Cypress, Veneers, and Thin Lumber, January 1940, 

Grades:
   Chestnut lumber: FAS, #1Com.&Select, Sound Wormy, #2Com., 
   #3Com.(A&B).
39. Soft Elm  
(Ulmus americana-American Elm)  
(Ulmus fulva-Slippery Elm)  
40. Rock Elm  
(Ulmus racemosa)

Rock Elm is also called Cork Elm.  
About 65% of all Elm produced is American Elm, 8% Slippery Elm, 7% other soft Elms, and 20% Rock Elm.  
In general, Soft Elm Description,below,averages the two main soft Elms.

**Description:**

<table>
<thead>
<tr>
<th>All Elms</th>
<th>Soft Elm</th>
<th>Rock Elm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not usually used for construction.</td>
<td>Quite heavy.</td>
<td>Very heavy.</td>
</tr>
<tr>
<td>Very high bendability.</td>
<td>Quite strong as beam.</td>
<td>Very strong as beam.</td>
</tr>
<tr>
<td>Average stiffness.</td>
<td>Average strength as post.</td>
<td>Quite strong as post.</td>
</tr>
<tr>
<td>Average resistance to moisture-caused decay.</td>
<td>Average hardness.</td>
<td>Quite hard.</td>
</tr>
<tr>
<td>Very difficulty to paint.</td>
<td>Available with bird pecks if desired.</td>
<td>Very tough.</td>
</tr>
<tr>
<td>Very high permeability of liquids.</td>
<td></td>
<td>Very high joint strength.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very durable when continually under water.</td>
</tr>
</tbody>
</table>

**Uses:**

- Heartwood light brown to gray.  
- Sapwood light grayish tan.  
- Very hard to work by hand.  
- Quite low machine tool workability.

**Uses:**  
(Furniture.)  
Interior finish.  
(Bentwood products.)  
(Vehicle parts.)  
(Boxes and crates.)  
(Slack cooperage.)

Dock and wharf construction.  
(Implement and handles.)
39. Soft Elm
40. Rock Elm  

Related wood:
Cedar Elm (Ulmus crassifolia) is a southern hard Elm of properties similar to northern Rock Elm.

References:
(Soft Elm only.)
Southern Lumberman: Southern Hardwood Series No.13, April 15, 1941. (Soft Elm and Cedar Elm only.)

Grading:

Grades:
Soft Elm lumber: FAS, #1Com.&Select, #2Com., #3Com.(A&B).
Rock Elm lumber: FAS, #1Com., #2Com., #3Com.(A&B).
Cabinet Rock Elm: FAS, #1Com., #2Com., #3Com.(A&B).
41. (True) Hickory
(Hicoria lasinosa - Bigleaf H.)
(Hicoria alba - Mockernut H.)
(Hicoria glabra - Pignut H.)
(Hicoria ovata - Shagbark H.)

Bigleaf Hickory is also called Bigleaf Shagbark Hickory.
Shagbark Hickory is also called Shellbark Hickory.
Pignut Hickory usually is slightly stronger than the other
species but is mixed and sold with the others. The Description
below will apply to any of the true Hickories.

Description:
Exceptional toughness and resistance to shock.
Very hard.
Exceptionally strong, as beam or post.
Bends very well.
Very hard to work with hand tools.
Very high quality of work with machine tools.
Very difficult to glue.
Very difficult to paint.
Quite low resistance to moisture-induced decay.
Straight, uniform grain; ring porous.
Heartwood brown, reddish; sapwood white to pinkish; cab-
inet grades classed by color as white and red (other
properties, except color, about equal).
Occasional mineral streaks.
Occasional worm holes and bird pecks; pecky or wormy fin-
ish available if wanted.

Uses:
(Tool handles.)
(Wagon parts: wheel rims, shafts, spokes, axles.)
Interior finish and paneling, plain or pecky, red or white.
Dowels.
(Furniture.)
(Skis.)
(Ladder rungs.)
(Gymnasium equipment.)
(Meat skewers.)

Related woods:
The Pecan Hickories (Bitternut H.-Hicoria cordiformis,
Nutmeg H.-Hicoria myristicaeformis, Water H.-Hicoria aqua-
tica, and True Pecan-Hicoria pecan) may be included occa-
sionally with the true Hickories, and are not distinguished
by the NHLA. They are slightly less strong and tough and
have much the same use, plus flooring (where they are com-
parable to Birch, Beech, and Maple).
41. (True) Hickory -continued

References:
Holtman: Wood Construction, (not described).
Hayward: Wood, Lumber and Timbers, pp.159, 259-68.

Southern Lumberman: Southern Hardwood Series No.3, November 1, 1940.

Grading:
Grades: (some Pecan Hickory may be included)
    Hickory lumber: FAS, #1Com.&Select, #2Com., #3Com.(A&B).
    Cabinet Hickory (all red, all white, or unselected):
        FAS, #1Com.&Select, #2Com., #3Com.(A&B).
Black Walnut
(Juglans nigra)

Description:
Exceptional color, grain, and figure.
Heartwood chocolate to purplish brown; sapwood light gray.
Irregular grain; distinct growth ring.
Occasional swirl, burl, crotch figure.
Available pin-knotty.
Takes excellent natural finish and polish.
Stays in place quite well (with Chestnut the best hardwood in this property).
Average ease of gluing.
Average workability with hand tools.
Quite high quality of machine tool work.
 Quite heavy.
Very strong, as beam or post.
Average hardness.
Quite low resistance to shock.
Very high joint strength.
Very high resistance to moisture-induced decay (with Chestnut the best hardwood in this property).

Uses:
(Furniture.)
Planing mill products:
Interior finish and trim
Doors
Molding
Paneling
Veneers and plywood.
Flooring.
Cabinets.
(Boats and ships.)
(Caskets.)
(Billard tables.)
(Pianos.)
(Gun stocks.)

Related wood:
Butternut (Juglans cinerea) or White Walnut is similar in structure to and substituted for Black Walnut. Butternut is lighter in color, lighter in weight, softer, apt to be more brittle. Its uses are as for Black Walnut except where its lack of characteristic chocolate color or its softness are limitations.
References:
Luxford and Trayer: Wood Handbook, p.34.

American Walnut: The Cabinet Wood of the Ages, n.d.,
American Walnut Manufacturers' Association, Chicago, Ill.; 45pp., il.
The Story of American Walnut, 1936, American Walnut manufacturers' Association, Chicago, Ill.; 36pp., il.
(History; comparative physical data of cabinet woods; unusual figures available in walnut, illustrated.)

Grading:
Grades:
Walnut lumber, unselected lengths: FAS (never separated),
Selects, #1Com., #2Com., #3Com.
Steamed Walnut: FAS, Selects, #1Com., #2Com., #3Com.
Walnut lumber, 6', 7' lengths: FAS, FAS one face.
43. **Sycamore**  
(Platanus occidentalis)

also called Buttonwood.

**Description:**
- Wavy grain, producing ripple.
- Very conspicuous rays when quarter-sawed, otherwise little figure.
- Many medium sized flakes when quarter-sawed.
- Average weight.
- Average hardness.
- Average stiffness.
- Difficult to split.
- Very apt to warp and twist.
- Average workability by both hand and machine.
- Takes natural finish and high polish well.
- Heartwood light brown to pinkish.
- Imparts no odor or taste.
- Very low resistance to moisture-induced decay.

**Uses:**
- Interior finish.
- Cabinet work.  
  (Packaging, toys, novelties.)
- Panels.
- Veneers and plywood.  
  (Furniture.)
- Drawer sides (self-lubricating properties claimed).  
  (Boxes and crates.)
- (Slack cooperage.)

**References:**
- Southern Lumberman: Southern Hardwood Series No.6, December 15, 1940.

**Grading:**

**Grades:**
- Sycamore lumber: FAS, #1Com.&Select, #2Com., Sound Wormy, #3Com.(A&B).
- Quartered Sycamore: -same grades.
44. Magnolia

(Magnolia acuminata - Cucumber M.)
(Magnolia grandiflora - Evergreen M.)

Cucumber Magnolia is the more important in quantity produced.
Both are similar in properties and the Description below
presents the average.

Description:
Generally similar to Yellow Poplar, but somewhat harder,
heavier, and more purplish in color.
Heartwood yellow brown with frequent greenish, purplish, and
variegated mineral streaks.
Sapwood nearly white.
Satiny; good for natural and blond finishes.
Easily seasoned, but quite apt to warp and twist.
Average weight.
Average strength.
Average hardness.
Average workability, both by hand and machine.
Average glueability.

Uses:
(Furniture, core stock.)
Planing mill products:
   Interior trim and finish
   Doors
   Siding
   Cabinet work.
   (Boxes and crates.)

Related wood:
In lower grades, a large amount of Magnolia is graded and
sold with Yellow Poplar (Species Key No. 33.)

References:
Holtman: Wood Construction, not included.
Voss and Henry: Architectural Construction, not listed.

Southern Lumberman: Southern Hardwood Series No. 2, October
15, 1940.

Grading:
Rules for the Measurement and Inspection of Hardwood Lumber,
Cypress, Veneers, and Thin Lumber, January 1940,
Grades:
   Magnolia lumber: FAS, #1 Com. & Select, #2 Com., #3 Com. (A&B).
45. Red Alder
(Alnus rubra)

Description:
Leading hardwood of the northwest U.S.. Similar to the Gums.
Quite light weight.
Quite low strength as beam.
Average strength as post.
Quite soft.
Quite low shock resistance.
Stays in place average well.
Quite easy to glue.
Heartwood light pinkish brown.
Subject to pith flecks.

Uses: (mostly locally)
(Furniture.)
Veneers and plywood.
Interior finish.
Veneers and plywood.

References:
Holtman: Wood Construction, Not included.
Voss and Henry: Architectural Construction, not included.

Grading:
Rules for the Measurement and Inspection of Hardwood Lum-
ber, Cypress, Veneers, and Thin Lumber, January 1940, 
Grades:
Alder lumber: FAS, #1Com.&Select, #2Com., Sound Wormy, 
#3Com.(A&B).
46. Black Cherry  
(Prunus serotina)

Description:
Heartwood reddish color; sapwood nearly white.
Uniform grain and texture.
Numerous scattered pores.
Takes natural finish and polish very well.
Occasional burl.
Subject to pith flecks and gum specks in low grades.
Moderate shrinkage.
Stays in place quite well.
Quite heavy.
Quite strong, as beam or post.
Average hardness.
Average stiffness.
Average toughness.
Very high joint strength.
Very hard to work with hand tools.
Very fine to work with machine tools.
Quite low resistance to moisture-induced decay.
Limited in range and supply.

Uses:
(Furniture.)
Paneling.
Interior trim.
Cabinet work.
(Turned products.)
(Engravers' blocks.)
(Piano actions.)

References:

Southern Lumberman: Southern Hardwood Series No.18, July 15, 1941 (with other 'miscellaneous' woods).

Grading:
Grades:
Cherry lumber: FAS, #1Com.&Select, #2Com., #3Com.(A&B).
ABBREVIATIONS

ASME  American Society of Mechanical Engineers
b.m.  board measure
DF    Douglas Fir
DFPA  Douglas Fir Plywood Association
FPL   Forest Products Laboratory
kips 1000 lbs.
n.d.  no date
NHLA  National Hardwood Lumber Association
NLMA  National Lumber Manufacturers' Association
USDA  United States Department of Agriculture
USDC  United States Department of Commerce
USDL  United States Department of Labor
YP    Yellow Pine