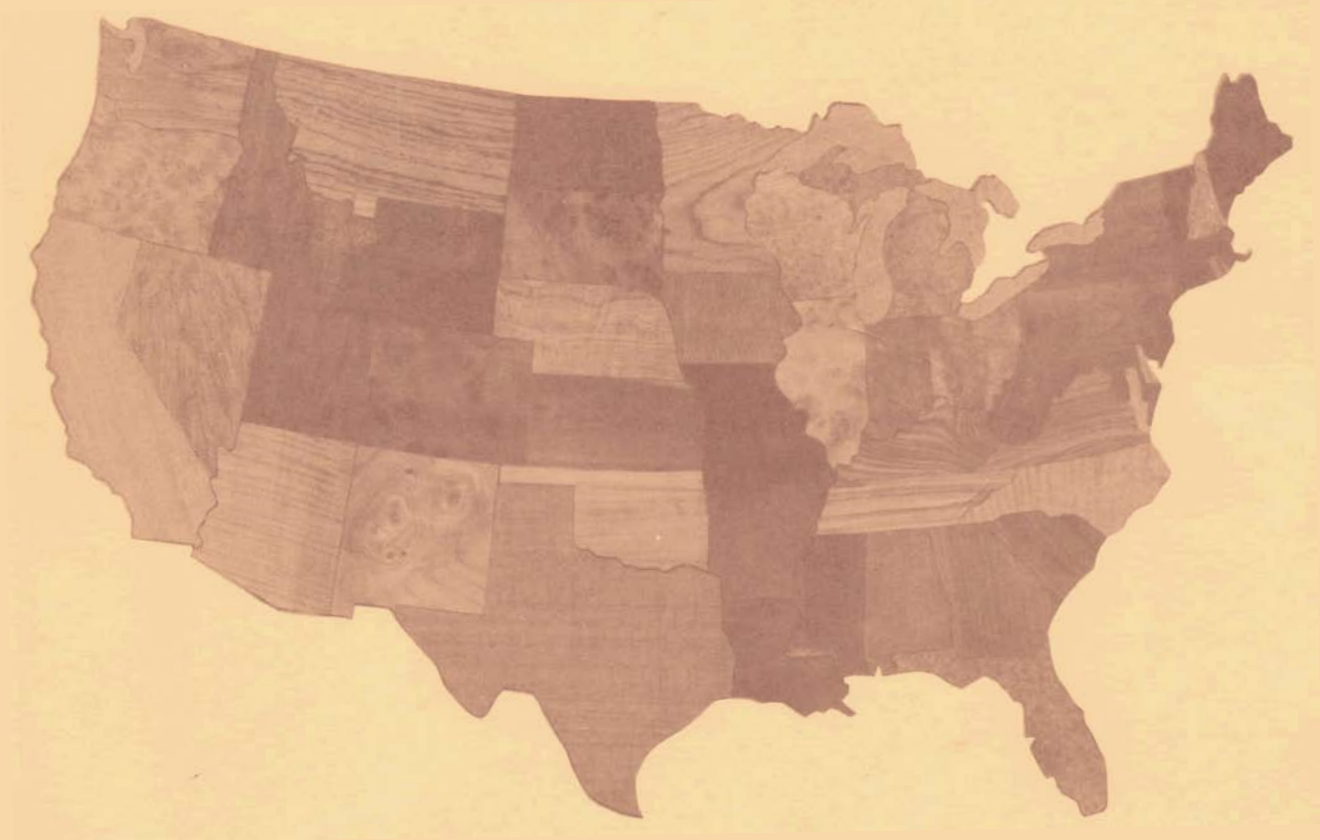
VENEER SPECIES THAT GROW IN THE UNITED STATES



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ABSTRACT

Describes properties of 156 U.S. tree species that affect their manufacture and use as veneer or products made from veneer. Each species is rated for use in the general categories of construction plywood, decorative face veneer, inner plies of decorative panels, or container veneer and plywood.

FORWORD

Condensing into one report all the pertinent information on U.S. wood species that might be used for veneer is an enormous and humbling task. Many people have some knowledge of individual species and the techniques for handling them, but this knowledge has never been assembled and unified in this manner for ready reference.

A number of people, both from industry and the Forest Service, have been of particular assistance in preparing this report. For instance, the hardwood information benefited greatly from the aid of John Putnam, Bill Groah, Bob Holowell, Len Ropella, Oscar Witt, E. A. Freeman, and Dutch Flock. Similarly, in considering softwood species, we received special suggestions and helpful review from Tom Batey, Marvin Bengelsdorf, and Jens Jorgensen. Another example of cooperation was the help of various manufacturers who were contacted to rate species on ease of debarking.

With so many people viewing the problem from a variety of viewpoints and experiences, it was inevitable that views occasionally conflicted. The resolution of these differences and responsibility for all the factual information in the report was, of course, in the author's hands.

CONTENTS

The detailed information in this publication has been summarized in briefer form for individuals that need material on only a few species. For this Summary publication, ask for the U.S. Forest Products Laboratory's "U.S. Veneer Species Information" and indicate the species of interest.

VENEER SPECIES THAT GROW IN THE UNITED STATES

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INTRODUCTION

This report is intended to cover tree species that grow large enough and in sufficient volume in the United States so that they could be considered for veneer. While the use of veneer and plywood is increasing, the timber available in such well-known veneer species as yellow birch and Douglas-fir has declined. As a result, it is becoming more important to know the potential for making useful veneer from all species that grow in the United States.

A number of species have been studied for use as veneer at the U.S. Forest Products Laboratory. In addition, other Government laboratories and universities have published information on veneer species. Still further information is available from the veneer industry. From such sources scattered information has been collected and condensed for this publication. When no published information was available on a species for veneer, the species has been evaluated on the basis of the known physical and mechanical properties of the wood.

It is hoped that this summary will be useful to timber growers, log buyers, personnel engaged in the manufacture of veneer, users of veneer products, and those considering research in the field of veneer cutting.

To make the information readily available for the user, it has been condensed into eight summary tables that are listed early in the report. For each species the factors covered include volume and log characteristics, physical and mechanical properties of wood, cutting and drying of veneer, and quality and uses of dry veneer.

Information that does not fit readily into the tables is presented in narrative form by individual species. These writeups include more information about characteristics of trees, logs, and wood, veneer cutting and drying, and the variety of end uses. Maps showing the growth range of most species discussed in this report are given in "Atlas of United States Trees: Volume 1. Conifers and Important Hardwoods," by Elbert L. Little, Jr., USDA Miscellaneous Publication 1146, 1970.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

USING SUMMARY TABLES

If the reader wants to know about a particular species, the summary tables offer the fastest route to general information. Tables 1 through 8 list species alphabetically by botanical name. Thus all the maples (Acer sp.), for instance, are listed together.

If this reader does not know the botanical name, he can go to table 9. There he will find a listing of the commercial name of veneer, along with the common species name, and the botanical name. Then it is easy to refer back to the appropriate species in tables 1 through 8.

Another way of getting the appropriate information quickly is by looking in table 8 at the rating given under relative suitability of individual species for specific uses. For example, if one is interested in species for construction plywood, from table 8 he could pick out those rated "A" in suitability for this purpose.

FILLING IN THE GAPS

In making out tables 1 through 8, it was apparent that information is lacking on some characteristics for many species. For example, the relative prevalence of stain in standing trees is known for some species but not for others. Similarly, the range of moisture content in the sapwood and heartwood of many species is not well documented. Even fewer data are published on the permeability of green and dry sapwood and heartwood of various species. Susceptibility to mold and bacteria, and the relation of this attack to permeability, are recorded for relatively few species. Oxidation stain has not been evaluated for many species.

For researchers, any broad studies of these factors would help to fill the gaps. The studies on stain, mold, and bacteria might be broken into laboratory work on relative susceptibility and field studies of prevalence in industrial use.

As further information is accumulated, it will be added in the tables to make them more complete.

SUMMARY TABLES

VOLUME AND LOG CHARACTERISTICS

Tables 1 and 2 give the estimated volume of the species and the characteristics or properties of the logs.

The column of estimated volume of timber is for trees 11 inches or larger in diameter at breast height and is estimated for each species or groups of similar species. Three groupings are used: A, over 25 billion board feet; B, from 5 to 25 billion board feet; and C, less than 5 billion board feet. It should be stressed that these figures for sawtimber volume include many trees that will not meet quality requirements currently deemed necessary for veneer. It is estimated that only about one-third of the sawtimber volume of preferred species is actually suitable for veneer. The proportion varies widely by species and type of veneer being produced. Additionally, many hardwood species only occur in limited areas or scattered in stands of other hardwoods.

Timber stand data were obtained primarily from the Forest Survey of the Forest Service, U.S. Department of Agriculture, Washington, D.C. The timber stand in the United States is constantly being reevaluated by the Forest Service and requests for the latest information should be addressed to the Forest Survey. The Forest Survey has volumes listed by diameter classes and could answer such questions as: What is the volume of timber of a certain species in trees 18 inches or larger in diameter breast high?

The next column lists the range of diameters of biologically mature timber for the species. These figures are for trees allowed to grow to their maximum sizes on good sites. In a few cases, the figures given in this column are much larger than the maximum diameter to which it is now or may ever be economically sound to grow timber. The figures in this column do differentiate species like lodgepole pine and aspen, which will never get large, from species like redwood and cottonwood that may reach very large diameters,

The next column gives the range of diameters of veneer logs found at typical veneer and plywood plants in the United States in 1971. This information on veneer log diameters obviously does not apply to all situations as log sizes vary widely within species and stands, depending on the site and age of the stand and previous cutting practice. In most cases, these diameters will be larger than typical woods-run logs of the species in 1971. For species commonly cut into face veneer, like walnut, maple, cherry, and white oak, the logs are generally the largest obtainable of good quality.

The next column similarly lists the width of sapwood on typical veneer logs in 1971. Like the preceding columns on log diameters, the figures on width of sapwood are estimates and will vary widely with the log source. The sapwood on slow-grown large trees, which are generally preferred for use as veneer, may be narrower than the sapwood on fast-growing, dominant, young trees growing on the best sites. In general, hardwood trees grown in the uplands have a narrower sapwood than trees of the same species grown in delta areas of the South.

The remaining log properties listed in tables 1 and 2 are given on an A, B, or C basis. An A rating indicates that for this particular property the species is well suited for use as veneer. A C rating indicates that, for this species, this particular property is undesirable for veneer. B ratings are intermediate between A and C ratings. Again due to the wide variability of log properties within a species, these ratings are not absolute but rather indicate comparisons between average trees of a species. For example, sugar maple has an A rating for freedom from resin or gum but a C rating for freedom from stain. The A rating for resin or gum indicates that sugar maple is relatively free of this characteristic compared to a species like black cherry. The C rating for stain indicates this is a fairly common characteristic of sugar maple and occurs more frequently than in many other hardwoods that grow in the United States.

A species that has mainly A ratings would be preferred for veneer to a species that has mainly C ratings. Similarly, a C rating should serve as a caution to watch for this property when growing timber, buying logs, or processing the logs into veneer. In most cases, a further description of log properties is given in the writeups of the individual species.

PHYSICAL AND MECHANICAL PROPERTIES OF WOOD

In table 3, the column on specific gravity of the wood gives a quick comparison between species. In general, the higher the specific gravity, the higher the strength properties such as hardness and stiffness and the greater the shrinkage.

The green moisture content is given to the closest 10 percent for both sapwood and heartwood. If the moisture content of the sapwood and heartwood is very different, it may pay to separate sapwood and heartwood veneer for drying. Very high moisture contents, such as over 100 percent, may indicate problems in cutting and drying veneer from this species.

Permeability is listed as P, permeable; M, moderately permeable; or R, refractory. Most of these ratings were taken from USDA Agriculture Handbook 40.[2]

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[2] MacLean, James, D. Preservative treatment of wood by pressure methods. USDA Agr. Handb. 40. Reprinted 1960.

Shrinkage is given under three subheads: Tangential, radial, and volumetric. Tangential shrinkage indicates the widthwise shrinkage of rotary-cut and flat-sliced veneer, while radial shrinkage gives an estimate of the widthwise shrinkage of quarter-sliced veneer. Since these figures are given from green to ovendry, they can be interpolated for other moisture conditions. In general, shrinkage is considered to be a straight-line relationship from a moisture content of 30 percent (green) to 0 percent. For example, if the tangential shrinkage of a species is listed as 9 percent and the veneer is actually dried to a final moisture content of 10 percent, the estimated shrinkage would be 20/30 of 9 percent or 6 percent. Caution should be used when making estimates from these shrinkage data as drying conditions may drastically alter the results.

The volumetric shrinkage, together with specific gravity, can be used to describe the wood on the basis of weight at any moisture content.

An approximate means of converting specific gravity based on green volume and ovendry weight and volumetric shrinkage green to dry in percent to pounds per cubic foot is:

$$\text{Weight in lbs. per cu. ft. at moisture content } \alpha = \frac{\text{Sp. gr.}(62.4)(1 + \alpha)}{1 - \text{Vol. sh.}\left(\frac{0.30 - \alpha}{0.30}\right)}$$

Sp. gr. is specific gravity based on green volume and ovendry weight, α is moisture content in decimals, and Vol. sh. is volumetric shrinkage green to dry. The formula applies for moisture content of 30 percent (0.30) or less.

If specific gravity only is known, the conversion can still be made using calculated volumetric shrinkage. In this case the equation is:

$$\text{Weight in lbs. per cu. ft. at moisture content } \alpha = \frac{\text{Sp. gr.}(62.4)(1 + \alpha)}{1 - 0.9(\text{Sp. gr.})(0.30 - \alpha)}$$

These two equations can be used to estimate weight in kilograms per cubic meter by using the constant 1,000 in place of 62.4 in the numerator.

The columns describing arrangement and size of vessels in hardwood veneer contribute to an understanding of the figure of this veneer. Small pores are under 100 microns in diameter; medium pores 100 to 150 microns; and large pores over 150 microns. The grain direction and color of the sapwood and heartwood are self-explanatory.

Seven mechanical properties--tension perpendicular to the grain, hardness, modulus of elasticity, modulus of rupture, compression parallel to the grain, compression perpendicular to the grain, and shear--are given in table 4. The figures for tension perpendicular are taken from green material while the others are for wood at 12 percent moisture content. Tension perpendicular is important during cutting when the wood is green while the other mechanical properties are most important for use of veneer in the dry conditions.

Most of the mechanical properties listed here came from the Wood Handbook.[3] In some cases, the information is from universities or from foreign laboratories. Mechanical property values are revised as new information is collected. For up-to-date values, it is suggested the reader check American Standards for Testing Materials D 255 or contact the Forest Products Laboratory, P.O. Box 5130, Madison, Wis. 53705.

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[3] U.S. Forest Products Laboratory. Wood Handbook. USDA Agr. Handb. 72. 1955.

The last column in table 4 lists well-known veneer species that are similar to some of the less well-known species being described.

All of the properties given in tables 1 through 4 are described in more detail in "Wood and Log Characteristics Affecting Veneer Production.[4]

CUTTING AND DRYING OF VENEER

Tables 5 and 6 discuss the quantity of logs that were studied at Madison, and how the veneer was cut.

The conditioning temperatures are those suggested for rotary cutting veneer about 1/8 inch thick. The recommended temperatures take into account the tendency of the species to develop splits at the ends of the bolts during heating. The recommended temperature for slicing will often be 10° to 20° F. higher than for peeling because splitting is less of a problem when heating flitches for slicing. Additional comments on heating may be given in the supplement for each species.

The last columns in tables 5 and 6 are rated on an A, B, and C scale. As in table 1, A indicates that the specific property is basically favorable for use as veneer and C indicates that the particular property may be a problem in utilizing the species for veneer. For example, an A rating for log splitting due to heating indicates the species is little affected by heating while a C rating indicates that log end splits are a major problem with this species.

Ease of bark removal is based on fall-cut wood debarked by machine. Logs cut in spring are easier to debark than those cut in winter. Frozen logs may be nearly impossible to debark without also damaging the outer wood. Storage under water or a water spray often makes debarking easier. Heated logs can generally be debarked more easily than unheated logs.

The A, B, and C ratings for drying times are comparative. The time required to dry veneer varies widely with species and with the type of dryer being used. For this reason, rather than give specific times for a specific dryer, drying times are given in comparison with other species--yellow birch for hardwood veneer and Douglas-fir for softwood veneer.

Yellow birch was selected as "typical" for hardwood veneer because this is a well-known veneer species and one on which we had much drying data. Besides, the sapwood and heartwood of yellow birch take about the same time to dry. Our data show that no other hardwoods dry much faster than yellow birch. In contrast, several hardwood species require considerably longer drying time than yellow birch. So drying time ratings for hardwoods are either B or C.

For softwoods, the comparison is based on the drying of sapwood or heartwood of Douglas-fir. The sapwood of Douglas-fir takes significantly longer drying time than the heartwood.

The quality and recovery of veneer from all species is sensitive to the setting of the knife and pressure bar. However, acceptable veneer can be cut from some species with a wider range of settings than can be tolerated by other species. An A rating for sensitivity to settings of the knife and pressure bar indicates the species tolerates a wide latitude in machine setting; a C rating indicates the species cuts well only within a narrow range of machine settings.

Under defects in drying, an A rating means a species is relatively free of the characteristics listed, while a C rating means the veneer from the species is subject to this particular drying defect.

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[4] Lutz, John F. Wood and log characteristics affecting veneer production. USDA Forest Serv. Res. Pap. FPL 150. 1971. Forest Prod. Lab., Madison, Wis.

QUALITY AND USE OF DRY VENEER

Most information in tables 7 and 8 is again based on the A, B, and C scale, and expresses relative ratings. In particular, information in the columns headed "Relative freedom from veneer characteristics originating in log storage and processing" involves a highly variable set of data. The reason, of course, is that all these characteristics are at least to a degree under the control of the processor.

An A rating would indicate that the wood is resistant to development of a particular characteristic even under a wide range of processing conditions. A C rating indicates that the wood is highly susceptible to this particular characteristic and should indicate caution in processing to keep this specific characteristic to a minimum.

The column "Clear veneer" in table 8 indicates the tendency of veneer logs of various species to produce clear wood.

The last five columns of table 8--"Relative suitability for"--in a sense summarize all the data. An A rating indicates the species is well suited for the indicated product. A B rating indicates the species is moderately well suited for this product, and a C rating indicates the species is generally not suited for the particular end product. In making these classifications, the following broad criteria were considered,

End use	Typical specific uses	
Construction plywood	Building construction as subfloor, wall sheathing, roof sheathing, concrete forms, and overlaid panels	High stiffness and strength, moderate weight, readily glued
Decorative face veneer	Prefinished decorative wall panels, furniture, flush doors, kitchen cabinets, case goods	Attractive figure and color, moderately hard, readily glued
Inner plies for decorative panels	Inner plies for prefinished wall panels, furniture, flush doors, kitchen cabinets, case goods	Low weight, low shrinkage, straight grain, fine uniform grain, easily glued
Container veneer and plywood	Wirebound boxes, bushel baskets, paper-overlaid veneer, cleated panel boxes, plywood-sheathed crates	High in stiffness, shock resistance, and resistance to splitting, light color, free from odor and taste, moderate in weight

Veneer with properties other than those listed can be used for the indicated products, provided some compensation is made for the less desirable qualities.

For example, construction plywood is made from some species that are relatively low in stiffness. This is generally compensated for by using thicker panels than would be satisfactory when using a species high in stiffness and strength. Another practical method is to change the construction design to a shorter span with plywood made from the less strong species.

Decorative face veneer can be made from any species that has an attractive appearance.

Denser hardwoods like the oaks and yellow birch are sometimes used as inner plies of decorative panels. This can be done provided care is used to make balanced panels, by selecting straight-grained veneer and carefully controlling the moisture content of the individual plies at the time the glue sets. Use of relatively thin veneer and careful gluing conditions are also important when using dense wood for inner plies.

Almost all species can be used for containers.

Table 1.--Volume, diameter, width of sapwood, and log form

Botanical name	Common name	Estimated volume (11 inches in diameter at breast height or larger in 1968)[1]	Estimated diameters of-- Mature timber	Estimated diameters of-- Typical veneer logs	Estimated width of sapwood of veneer logs	Log form[2] Eccentricity	Log form[2] Crook (sweep)	Log form[2] Taper
			In.	In.	In.			
		UNITED STATES HARDWOODS						
Acacia koa	Koa	C	36-60	12-20	1 - 2	B	B-C	B
Acer macrophyllum	Bigleaf maple	C	18-30	12-20	3 - 5	B	B	A
A. nigrum	Black maple	A (Black and sugar maple)	30-36	12-22	3 - 5	A	A	A
A. rubrum	Red maple	B (Red and silver maple)	18-30	12-24	3 - 5	B	C	B
A. saccharinum	Silver maple	B (Red and silver maple)	24-35	14-24	3 - 5	B	B	B
A. saccharum	Sugar maple	A (Black and sugar maple)	30-40	12-24	4 - 8	A	A	A
A. negundo	Boxelder	--	20-28	12-20	2 - 5	C	C	B
Aesculus glabra	Ohio buckeye	C	20-24	12-14	--	B	B	B
A. octandra	Yellow buckeye	C	24-30	12-16	--	B	B	B
Alnus nepalensis	Nepal alder	C	20-28	15-20	2 - 3	B	B	B
A. rubra	Red alder	B	16-18	12-14	3 - 4	A	B	A
Arbutus menziesii	Pacific madrone	C	20-24	12-16	.5-1.5	B	C	B
Betula alleghaniensis	Yellow birch	B (Yellow and sweet birch)	20-24	12-24	3 - 5	A	A	A
B. lenta	Sweet birch	B (Yellow and sweet birch)	20-24	12-18	2 - 3	A	A	A
B. nigra	River birch	C	20-24	12-16	2.5-4	B	C	B
B. papyrifera	Paper birch	C	14-18	10-14	4 - 6	B	B	B
B. papyrifera var. *humilis*	Alaskan paper birch	C	10-12	8-10	2 - 4	A	A	A
B. populifolia	Gray birch	C	10-12	8-10	--	A	C	B
Carya aquatica	Water hickory	A (All hickory and pecan)	24-30	16-20	1.5-2.5	A	A-B	B
C. cordiformis	Bitternut hickory	A (All hickory and pecan)	20-24	14-16	1.5-2.0	A	A	B
C. glabra	Pignut hickory	A (All hickory and pecan)	20-24	14-24	2 - 8	A	B	B
C. illinoensis	Pecan	A (All hickory and pecan)	30-44	18-36	3 - 7	A	A	B
C. laciniosa	Shellbark hickory	A (All hickory and pecan)	20-24	14-18	2 - 4	A	A	B
C. myristicaeformis	Nutmeg hickory	A (All hickory and pecan)	20-24	14-16	--	A	A	A
C. ovata	Shagbark hickory	A (All hickory and pecan)	24-30	16-20	1.5-3	A	A	A
C. tomentosa	Mockernut hickory	A (All hickory and pecan)	20-24	14-16	2.5-3.5	A	A	A
Cecropia peltata	Yagrumo hembra	C	18-24	10-14	5 - 7	B	B	B
Celtis laevigata	Sugarberry	C	18-24	12-20	3 - 8	B-C	B-C	B
C. occidentalis	Hackberry	C	16-20	12-20	3 - 8	B-C	B-C	B
Diospyros virginiana	Common persimmon	C	12-20	10-14	3 - 6	B	B	B
Eucalyptus robusta	Eucalyptus	C	36-48	20-30	1 - 2	B	A	B
Fagus grandifolia	American beech	B	24-36	14-24	2 - 6	A	A	A

(Sheet 1 of 5)

Table 1.--Volume, diameter, width of sapwood, and log form--continued

Botanical name	Common name	Estimated volume (11 inches in diameter at breast height or larger in 1968)[1]	Estimated diameters of--: Mature timber	Estimated diameters of--: Typical veneer logs	Estimated width of sapwood of veneer logs	Log form[2]: Eccentricity	Log form[2]: Crook (sweep)	Log form[2]: Taper
			In.	In.	In.			
		UNITED STATES HARDWOODS--continued						
Fraxinus americana	White ash	B (All eastern ashes)	24-30	12-20	3 - 8	A	A	B
F. latifolia	Oregon ash	C	24-30	12-18	3 - 6	A	A	A
F. nigra	Black ash	B (All eastern ashes)	16-20	12-16	1 - 2	A	A	A
F. pennsylvanica	Green ash	B (All eastern ashes)	24-30	12-18	3 - 6	B	B	C
F. profunda	Pumpkin ash	B (All eastern ashes)	24-30	12-18	3 - 6	B	B	C
F. quadrangulata	Blue ash	B (All eastern ashes)	20-24	12-16	3 - 6	B	B	B
F. uhdei	Shamel ash	C	24-30	12-14	4 - 5	B	A	B
Gleditsia triacanthos	Honeylocust	C	24-36	16-24	1.5-2.5	B	A	B
Grevillea robusta	Silk-oak	C	24-36	20-24	1 - 2	B	B	B
Ilex opaca	American holly	C	18-22	10-14	3 - 5	A	B	A
Juglans cinerea	Butternut	C	20-24	12-20	1 - 3	C	C	B
J. nigra	Black walnut	C	30-44	12-24	1 - 3	A	A	A
Liquidambar styraciflua	Sweetgum	A	30-36	14-30	5 - 8	A	A	A
Liriodendron tulipifera	Yellow-poplar	A	28-40	16-24	2 - 6	A	A	A
Lithocarpus densiflorus	Tanoak	C	24-30	16-20	6 - 7	B	B	B
Magnolia acuminata	Cucumbertree	C	24-36	16-20	1.5-3	A	A	A
M. grandiflora	Southern magnolia	C	24-36	16-20	1.5-3	A	A	A
M. virginiana	Sweetbay	C	20-28	14-18	1.5-5	B	B	B
Metrosideros polymorpha	Ohia	B	24-40	18-24	1 - 2	B	B	C
Nyssa aquatica	Water tupelo	A (Tupelo and blackgum)	30-36	18-22	3 - 6	A	A	C
N. sylvatica	Blackgum	A (Tupelo and blackgum)	28-32	14-20	2 - 4	B	B	B
N. sylvatica var. *biflora*	Swamp tupelo	A (Tupelo and blackgum)	28-36	18-22	3 - 5	A	A	C
Platanus occidentalis	American sycamore	B	32-44	20-36	2 - 6	B	B	B
Populus balsamifera	Balsam poplar (Balm of Gilead)	A (All cottonwood and aspen)	28-32	18-22	1.5-4	A	B	A
P. deltoides	Eastern cottonwood	A (All cottonwood and aspen)	34-48	20-40	2 - 6	A	A	A
P. grandidentata	Bigtooth aspen	A (All cottonwood and aspen)	11-14	10-14	2 - 4	A	B	A
P. heterophylla	Swamp cottonwood	A (All cottonwood and aspen)	34-38	18-36	2 - 4	B	C	B
P. tremuloides	Quaking aspen	A (All cottonwood and aspen)	11-14	10-14	2 - 4	A	B	A
P. trichocarpa	Black cottonwood	A (All cottonwood and aspen)	28-36	18-36	1.5-4	A	B	A

Table 1.--Volume, diameter, width of sapwood, and log form--continued

Botanical name	Common name	Estimated volume (11 inches in diameter at breast height or larger in 1968)[1]	Estimated diameters of-- Mature timber	Estimated diameters of-- Typical veneer logs	Estimated width of sapwood of veneer logs	Log form[2] Eccentricity	Log form[2] Crook (sweep)	Log form[2] Taper
			In.	In.	In.			
		UNITED STATES HARDWOODS--continued						
Prunus serotina	Black cherry	B	20-28	14-20	1 - 1.5	A	A-B	A
Quercus alba	White oak	A (All eastern oaks)	26-40	16-30	1.5-2	A	A	B
Q. bicolor	Swamp white oak	A (All eastern oaks)	30-36	16-20	1.5-2	A	A	B
Q. coccinea	Scarlet oak	A (All eastern oaks)	18-24	14-18	1.5-2	A	A	B
Q. durandii	Durand oak	A (All eastern oaks)	20-30	16-24	--	A	A	B
Q. falcata	Southern red oak	A (All eastern oaks)	24-30	15-24	1.5-2.5	A	A	B
Q. falcata var. *pagodaefolia*	Cherrybark oak	A (All eastern oaks)	30-36	16-28	1.5-2.5	A	A	B
Q. garryana	Oregon white oak	C	24-30	16-20	1 - 2	C	C	C
Q. kelloggii	California black oak	C	18-30	12-18	1 - 2	B	B	B
Q. laurifolia	Laurel oak	A (All eastern oaks)	20-28	14-20	1.5-2.5	B	B	B-C
Q. lyrata	Overcup oak	A (All eastern oaks)	26-32	16-24	1.5-2.5	B	B-C	B-C
Q. macrocarpa	Bur oak	A (All eastern oaks)	24-36	16-30	1.5-2.5	A	A	B
Q. michauxii	Swamp chestnut oak	A (All eastern oaks)	24-36	18-28	1.5-2.5	A	A	B
Q. muehlenbergii	Chinkapin oak	A (All eastern oaks)	20-30	14-22	1 - 2	A	B	B
Q. nigra	Water oak	A (All eastern oaks)	20-30	14-22	2 - 3	A	B	B-C
Q. nuttallii	Nuttall oak	A (All eastern oaks)	24-30	14-24	1.5-2.5	A	A	B
Q. palustris	Pin oak	A (All eastern oaks)	24-30	14-22	2 - 3	A	A	B
Q. phellos	Willow oak	A (All eastern oaks)	24-32	16-24	2 - 3	A	A-B	B-C
Q. prinus	Chestnut oak	A (All eastern oaks)	18-30	14-18	1 - 2	B	B	B
Q. rubra	Northern red oak	A (All eastern oaks)	24-30	12-24	1.5-2.5	A	A	B
Q. shumardii	Shumard oak	A (All eastern oaks)	28-36	16-28	1.5-2.5	A	A	B
Q. stellata	Post oak	A (All eastern oaks)	16-24	14-20	1 - 2	B	B-C	B
Q. stellata var. *mississippiensis*	Delta post oak	A (All eastern oaks)	24-32	16-26	1.5-2.5	A	A	B
Q. velutina	Black oak	A (All eastern oaks)	20-30	12-22	1 - 3	B	B	B
Q. virginiana	Live oak	C	30-40	12-18	1.5-2	C	B-C	C
Robinia pseudoacacia	Black locust	C	12-24	10-12	.5-1	C	C	B
Salix nigra	Black willow	C	20-28	16-20	2 - 3	B	B	B
Sassafras albidum	Sassafras	C	12-30	12-16	1 - 1.5	B	B	B
Tectona grandis	Teak	C	30-40	12-24	1 - 2	B	B	B

Table 1.--Volume, diameter, width of sapwood, and log form--continued

Botanical name	Common name	Estimated volume (11 inches in diameter at breast height or larger in 1968)[1]	Estimated diameters of--		Estimated width of sapwood of veneer logs	Log form[2]		
			Mature timber	Typical veneer logs		Eccentricity	Crook (sweep)	Taper
			In.	In.	In.			
		UNITED STATES HARDWOODS--continued						
Tilia americana	American basswood	C	28-38	12-20	3 - 4	A	B	B
T. heterophylla	White basswood	C	24-28	14-18	3 - 4	A	A	B
Ulmus alata	Winged elm	B (All elms)	14-18	12-14	1.5-2	A	B	B
U. americana	American elm	B (All elms)	30-36	12-24	1.5-3	A	A-B	B
U. crassifolia	Cedar elm	B (All elms)	14-26	12-18	1.5-2	C	C	B-C
U. rubra	Slippery elm	B (All elms)	16-24	12-20	1.0-1.5	A	B	B
U. thomasii	Rock elm	B (All elms)	18-20	12-16	.75-1.5	A	A	B
Umbellularia californica	California laurel	C	20-24	14-18	2	C	C	B
		UNITED STATES SOFTWOODS						
Abies amabilis	Pacific silver fir	B	24-40	18-30	2 - 3	A	A	A
A. balsamea	Balsam fir	C	14-18	10-12	--	A	A	B
A. concolor	White fir	A	36-48	18-30	2 - 5	A	A	B
A. grandis	Grand fir	B	24-40	24-30	--	A	A	A
A. lasiocarpa	Subalpine fir	B	18-24	12	--	A	A	C
A. magnifica	California red fir	B	30-40	18-24	4 - 7	A	B	A
A. magnifica var. *shastensis*	Shasta red fir	B	30-40	18-24	4 - 5	A	B	A
A. procera	Noble fir	C	36-60	24-36	--	A	A	A
Chamaecyparis lawsoniana	Port-Orford-cedar	C	40-50	24-36	1 - 2	A	A	B
C. nootkatensis	Alaska-cedar	C	24-36	18-24	1	A-B	A	C
C. thyoides	Atlantic white-cedar	C	10-14	10-12	1	A	A	B
Juniperus deppeana	Alligator juniper	C	8-12	8-10	1.5-2.5	A	A	B
J. occidentalis	Western juniper	C	8-12	8-10	1.5-2.5	A	A	B
J. scopulorum	Rocky Mountain juniper	C	8-12	8-10	1.5-2.5	A	A	B
J. virginiana	Eastern redcedar	C	12-30	12-18	1 - 2	A	A	B
Larix laricina	Tamarack	C	14-24	10-16	1 - 1.5	B	A	B
L. occidentalis	Western larch	A	18-36	16-24	1	A	A	A-B
Libocedrus decurrens	Incense-cedar	B	36-48	24-36	--	A	A	B
Picea engelmannii	Engelmann spruce	A	18-30	16-22	1 - 2	A	A	A
P. glauca	White spruce	C	12-24	12-18	--	B	A	B
P. mariana	Black spruce	C	12	6-12	--	A	A	B
P. pungens	Blue spruce	C	12-24	12-18	--	B	A	C
P. rubens	Red spruce	C	12-24	12-18	--	A		B
P. sitchensis	Sitka spruce	A	36-60	24-36	--	A	A	B

Table 1.--Volume, diameter, width of sapwood, and log form--continued

Botanical name	Common name	Estimated volume (11 inches in diameter at breast height or larger in 1968)[1]	Estimated diameters of--		Estimated width of sapwood of veneer logs	Log form[2]		
			Mature timber	Typical veneer logs		Eccentricity	Crook (sweep)	Taper
			In.	In.	In.			
UNITED STATES SOFTWOODS--continued								
Pinus albicaulis	Whitebark pine	C	12-24	10-14	--	B	B	C
P. attenuata	Knobcone pine	C	12-24	10-15	4 - 5	B	C	B
P. banksiana	Jack pine	C	12-15	10-12	4 - 5	A	B	B
P. clausa	Sand pine	C	12	10-12	--	B	B	B
P. contorta	Lodgepole pine	A	12-24	10-14	1 - 2	B	B	B
P. echinata	Shortleaf pine	A	24-36	12-16	--	A	A	A
P. elliottii	Slash pine	B	18-24	12-16	--	A	A	A
P. flexilis	Limber pine	C	15-24	10-15	--	B	B	C
P. glabra	Spruce pine	C	18-24	12-16	--	B	C	B
P. jeffreyi	Jeffrey pine	C	24-36	16-24	3 - 6	A	A	A
P. lambertiana	Sugar pine	B	36-100	24-48	2 - 4	A	B	A
P. monticola	Western white pine	B	30-40	12-30	1 - 3	A	B	A
P. palustris	Longleaf pine	B	24-30	12-16	--	A	A	A
P. ponderosa	Ponderosa pine	A	36-48	14-36	3 - 6	A	A	A
P. pungens	Table-Mountain pine	C	12-18	10-14	--	B	B	B
P. resinosa	Red pine	C	24-36	12-14	--	A	A	A
P. rigida	Pitch pine	C	12-24	12-14	--	B	C	B
P. sabiniana	Digger pine	C	12-24	10-14	--	B	C	C
P. serotina	Pond pine	C	18-24	12-16	--	B	C	B
P. strobus	Eastern white pine	B	36-40	12-16	2 - 3	A	B	A
P. taeda	Loblolly pine	A	24-30	12-18	4 - 6	B	C	A
P. virginiana	Virginia pine	C	12-15	10-12	--	B	B	B
Pseudotsuga menziesii	Douglas-fir coast	A	36-100	24-48	1 - 3	A	A	A
P. menziesii	Douglas-fir interior west	A	18-36	14-30	1 - 2	A	A	A
P. menziesii var. *glauca*	Douglas-fir interior north	A	18-24	14-20	1 - 2	A	A	A
P. menziesii var. *glauca*	Douglas-fir interior south	B	18-24	14-20	1 - 2	A	A	A
Sequoia gigantea	Big tree	C	120-180	60+	1 - 2	A	A	B
S. sempervirens	Redwood	B	60-120	24-60	1 - 2	B	A	B
Taxodium distichum	Baldcypress	B	36-60	12-16	2	A-B	A	C
T. distichum var. *nutans*	Pondcypress	B	24-36	12-14	2	A-B	A	C
Taxus brevifolia	Pacific yew	C	12-15	10-12	--	B	B	C
Thuja occidentalis	Northern white-cedar	C	12-36	10-14	1	B	B	B
T. plicata	Western redcedar	A	48-96	24-48	1	B	B	B
Tsuga canadensis	Eastern hemlock	B	24-36	12-20	1	B	B	C
T. heterophylla	Western hemlock	A	24-48	18-36	1	A	A	A
T. mertensiana	Mountain hemlock	B	20-30	10-20	1	B	B	B

[1] A, more than 25 billion bd. ft.; B, 5 to 25 billion bd. ft.; and C, less than 5 billion bd. ft.

[2] A rating, species property very suitable for veneer; B rating, intermediate; and C rating, less desirable for veneer.

Table 2.--Other log properties

Botanical name	Common name	Relative freedom of logs from--[1]											
		End splits	Shake	Decay	Knots	Seams	Reaction wood	Resin or gum	Insect attack	Bird peck	Bark pockets	Wet wood	Stain	Hard deposits
UNITED STATES HARDWOODS														
Acacia koa	Koa	B	B	B	B	B	A	B	B	A	A	A	A	A
Acer macrophyllum	Bigleaf maple	B	A	B	B	B	B	A	A	A	A	B	C	B
A. nigrum	Black maple	B	B	B	B	B	B	A	A	A	A	A	C	B
A. rubrum	Red maple	B	B	B	B	B	B	A	B-C	A	B	A	C	B
A. saccharinum	Silver maple	B	A	B	B	B	B	A	B	A	A	B	C	B
A. saccharum	Sugar maple	A	A	B	B	B	B	A	B	A	B	A	C	B
A. negundo	Boxelder	B	A	C	B	B	C	A	B	B	A	B	C	B
Aesculus glabra	Ohio buckeye	--	--	B	B	--	--	A	A	--	A	A	--	A
A. octandra	Yellow buckeye	--	--	B	B	--	--	A	A	--	A	A	--	A
Alnus nepalensis	Nepal alder	B	A	B	B	A	B	A	A	A	A	A	B	A
A. rubra	Red alder	A	A	B	B	A	B	A	B	A	A	A	A	A
Arbutus menziesii	Pacific madrone	C	B	A	B	A	B	A	A	A	A	A	A	A
Betula alleghaniensis	Yellow birch	B	B	B-C	B	B	A	A	B	A	A	A	B	A
B. lenta	Sweet birch	B	A	B	B	B	A	A	B	A	A	A	B	A
B. nigra	River birch	B	A	B	B	B	B	A	B	A	A	B	B	A
B. papyrifera	Paper birch	B	B	C	B	B	B	A	B	A	B	A	C	A
B. papyrifera var. *humilis*	Alaskan paper birch	B	A	C	C	B	B	A	A	A	A	A	B	A
B. populifolia	Gray birch	--	--	B	C	B	B	A	--	--	--	B	--	A
Carya aquatica	Water hickory	C	C	B	B	A	C	A	B	B	B	B	C	C
C. cordiformis	Bitternut hickory	C	C	B	B	A	C	A	C	C	C	B	C	C
C. glabra	Pignut hickory	C	C	A	B	A	C	A	C	C	C	B	C	C
C. illinoensis	Pecan	C	B	B	A	A	C	A	B	B	B	B	B	C
C. laciniosa	Shellbark hickory	C	C	B	B	A	C	A	C	C	C	B	C	C
C. myristicaeformis	Nutmeg hickory	C	C	B	B	A	C	A	C	C	C	B	C	C
C. ovata	Shagbark hickory	C	C	B	B	A	C	A	C	C	C	B	C	C
C. tomentosa	Mockernut hickory	C	C	B	B	A	C	A	C	C	C	B	C	C
Cecropia peltata	Yagrumo hembra	A	A	B	B	A	C	A	A	A	A	A	B	A
Celtis laevigata	Sugarberry	A-B	B	C	A	B	B-C	A	A	A	B	A	C	A
C. occidentalis	Hackberry	A	B	C	A	B	B-C	A	A	A	B	A	C	A
Diospyros virginiana	Common persimmon	C	B	B	B	A	A	A	B	A	A	A	B	A
Eucalyptus robusta	Eucalyptus	C	B	B	B	A	B	A	A	A	A	A	B	A
Fagus grandifolia	American beech	C	C	C	B	B	A	A	A	A	A	A	B	A
Fraxinus americana	White ash	C	A	B	B	B	A	A	B-C	B	B	A	B	A
F. latifolia	Oregon ash	B	--	--	A	B	--	A	B	A	--	--	--	A
F. nigra	Black ash	B	A	B	B	B	A	A	A	A	B	A	B	A
F. pennsylvanica	Green ash	B	A	B	A	B	B	A	B	A	B	--	B	A
F. profunda	Pumpkin ash	B	A	B	A	B	B	A	B	A	B	--	B	A
F. quadrangulata	Blue ash	B	A	B	A	--	--	A	B	A	B	--	--	A
F. uhdei	Shamel ash	B	A	A	B	A	A	A	B	A	A	A	A	A
Gleditsia triacanthos	Honeylocust	C	C	A	B	B	B	A	A	A	B	--	B	A
Grevillea robusta	Silk-oak	B	A	A	A	A	A	Waxy	A	A	A	A	A	A
Ilex opaca	American holly	B	A	B	B	B	--	A	B	B	B	--	B	A
Juglans cinerea	Butternut	B	A	B-C	B-C	B	C	A	B-C	B-C	B-C	A	B	A
J. nigra	Black walnut	A	A	A	B	A	B	A	B	A	A	A	B	A
Liquidambar styraciflua	Sweetgum	A	A-B	B	A	A-B	A	B	B	B	A-B	--	B	A
Liriodendron tulipifera	Yellow-poplar	A	A	B	A	B	A	A	B	B	A	B	C	A
Lithocarpus densiflorus	Tanoak	C	B	B	B	A	B	A	B	A	A	A	B	A
Magnolia acuminata	Cucumbertree	A	A	A	A	A	A	A	A	A	A	A	C	A
M. grandiflora	Southern magnolia	A	A	A	B	A-B	A	A	A	B	A-B	A	C	A
M. virginiana	Sweetbay	A	A	B	A	A	A	A	A	B	A	A	C	A
Metrosideros polymorpha	Ohia	B	A	A	B	A	A	A	A	A	A	A	A	B-C
Nyssa aquatica	Water tupelo	A	B	B	A	A	B	B	A	B	B	A	B	A
N. sylvatica	Blackgum	A	A	B	A-B	A	B	B	A	B	B	A	B	A
N. sylvatica var. *biflora*	Swamp tupelo	A	B	B	A	A	B	B	A	B	B	A	B	A
Platanus occidentalis	American sycamore	B	B	B	A-B	B	B	A	B	B	B	B	A	A

Table 2.--Other log properties--continued

Botanical name	Common name	Relative freedom of logs from--[1]												
		End splits	Shake	Decay	Knots	Seams	Reaction wood	Resin or gum	Insect attack	Bird peck	Bark pockets	Wet wood	Stain	Hard deposits
UNITED STATES HARDWOODS--continued														
Populus balsamifera	Balsam poplar (Balm of Gilead)	B	A	B	A	A	C	A	B	A	A	C	B	A
P. deltoides	Eastern cottonwood	B	B-C	B	A-B	B	C	A	B	A	B	C	B	A
P. grandidentata	Bigtooth aspen	A	A	C	B-C	A	C	A	B	B	A	C	C	A
P. heterophylla	Swamp cottonwood	B	B-C	B	B	A	C	A	B	A	A	C	B	A
P. tremuloides	Quaking aspen	A	A	C	B-C	A	C	A	B	B	A	C	C	A
P. trichocarpa	Black cottonwood	B	B	B	B	A	C	A	B	A	B	C	B	A
Prunus serotina	Black cherry	B	A	A	B	B	A	C	C	B	C	A	B	A
Quercus alba	White oak	B	A	A	B	B	A	A	B	A	A	A	B	A
Q. bicolor	Swamp white oak	B	B	B	B	B	B	A	A	B	A	A	B	A
Q. coccinea	Scarlet oak	C	B	B	B-C	B	A	A	C	B-C	C	B	C	A
Q. durandii	Durand oak	B	B	B	B	A	B	A	B	B	A	--	B	A
Q. falcata	Southern red oak	B	A	B	B	B	A	A	B	B	B	--	B	A
Q. falcata var. *pagodaefolia*	Cherrybark oak	B	A	A	A-B	A	A	A	B	A-B	A-B	B	B	A
Q. garryana	Oregon white oak	--	--	--	C	B	--	A	B	--	B	--	B	A
Q. kelloggii	California black oak	C	C	C	C	B	B	A	B	B	B	--	B	A
Q. laurifolia	Laurel oak	C	B	B	B	B	B	A	C	C	C	--	C	A
Q. lyrata	Overcup oak	C	B	B	B	B-C	B	A	C	B	C	--	C	A
Q. macrocarpa	Bur oak	B	A	A	B	B	A	A	B	B	B	--	B	A
Q. michauxii	Swamp chestnut oak	B	A-B	A-B	A-B	A-B	B	A	A	B	A	--	A-B	A
Q. muehlenbergii	Chinkapin oak	A	A	A	B	B	A	A	A	A	B	A	B	A
Q. nigra	Water oak	B-C	B	B	B	B	A	A	B-C	B	B	--	C	A
Q. nuttallii	Nuttall oak	B-C	A	B	B	A-B	A	A	B	B	B	--	B	A
Q. palustris	Pin oak	C	A	B	C	B	A	A	C	B	B	B	B	A
Q. phellos	Willow oak	B-C	B	B	B-C	B	A	A	B-C	B	B	--	B-C	A
Q. prinus	Chestnut oak	B	B	B	B	B	A	A	B	A	C	B	C	A
Q. rubra	Northern red oak	B-C	A	A-B	A-B	B	A	A	B	A	B	B	B-C	A
Q. shumardii	Shumard oak	B-C	A	B	A-B	A-B	A	A	A	A-B	A	--	B	A
Q. stellata	Post oak	B	B	B	C	B	B	A	C	B	B	--	C	A
Q. stellata var. *mississippiensis*	Delta post oak	B	B	B	B	A-B	A	A	A	A-B	A	--	B	A
Q. velutina	Black oak	B	C	B	C	B	B	A	B	B	B	B	C	A
Q. virginiana	Live oak	--	A	A	B	B	--	A	B	A	B	--	B	A
Robinia pseudoacacia	Black locust	B	B	B	C	B	B	A	C	B	B	A	C	A
Salix nigra	Black willow	C	B	B	A-B	B	C	A	A	B	A	C	C	A
Sassafras albidum	Sassafras	B	A	C	A	B	--	B	B	A	B	A	--	A
Tectona grandis	Teak	B	A	A	B	A	A	Waxy	A	A	A	A	A	B
Tilia americana	American basswood	A	A	B	B	B	B	A	B	B	B	A	A-B	A
T. heterophylla	White basswood	A	A	B	A	A	B	A	B	A	A	A	A-B	A
Ulmus alata	Winged elm	A	B	B	B	B	--	A	B-C	B	--	B	--	A
U. americana	American elm	A	B	B	B	B	B-C	A	B	B	B	C	B-C	A
U. crassifolia	Cedar elm	A	B	C	B-C	B	--	A	--	B	C	B	--	A
U. rubra	Slippery elm	A	B	B	A-B	B	C	A	B	B	A	C	B	A
U. thomasii	Rock elm	A	B	B	A	B	B	A	B	B	A	B	B	A
Umbellularia californica	California laurel	B	B	B	C	A	C	A	B	A	A	A	C	A
UNITED STATES SOFTWOODS														
Abies amabilis	Pacific silver fir	B	B	B	C	A	A	A	B	C	C	C	A	A
A. balsamea	Balsam fir	--	--	C	C	B	A	A	B	--	--	C	--	A
A. concolor	White fir	B	B	B	C	B	A	A	B	B	B	C	A	A
A. grandis	Grand fir	--	--	B	B	--	A	A	--	--	--	B	A	A
A. lasiocarpa	Subalpine fir	--	--	B	C	--	B	A	B	--	--	B	--	A
A. magnifica	California red fir	B	B	B	B	A	B	A	B	--	B	B	A	A
A. magnifica var. *shastensis*	Shasta red fir	B	B	B	B	A	B	A	B	--	--	B	A	A
A. procera	Noble fir	B	B	B	B	A	A	A	B	--	B	B	A	A
Chamaecyparis lawsoniana	Port-Orford-cedar	A	A	A	A	A	B	A	A	A	A	A	B	A
C. nootkatensis	Alaska cedar	--	--	A	B	--	B	A	A	--	B	A	B	A
C. thyoides	Atlantic white-cedar	--	--	A	B	--	--	A	A	--	--	A	--	A
Juniperus deppeana	Alligator juniper	B	A	B	C	C	B	A	B	B	C	A	A	A
J. occidentalis	Western juniper	B	A	C	C	C	B	A	C	B	C	A	A	A
J. scopulorum	Rocky Mountain juniper	B	A	B	C	C	B	A	B	B	C	A	A	A
J. virginiana	Eastern redcedar	B	A	A	C	B	A	A	A	A	B	A	A	A

Table 2.--Otherlog properties--continued

Botanical name	Common name	Relative freedom of logs from--[1]												
		End splits	Shake	Decay	Knots	Seams	Reaction wood	Resin or gum	Insect attack	Bird peck	Bark pockets	Wet wood	Stain	Hard deposits
						UNITED STATES SOFTWOODS--continued								
Larix laricina	Tamarack	B	B	B	B	A	B	B	C	A	A	A	A	A
L. occidentalis	Western larch	B	C	B	B	A	A	B	B	A	A	A	A	A
Libocedrus decurrens	Incense-cedar	--	--	B-C	C	--	B	A	B	--	--	A	--	A
Picea engelmannii	Engelmann spruce	--	--	B	C	--	B	B	C	--	--	A	A	A
P. glauca	White spruce	B	--	B	C	B	B	B	B	--	B	A	A	A
P. mariana	Black spruce	B	A	B	C	B	B	B	A	--	--	--	A	A
P. pungens	Blue spruce	--	--	--	C	--	B	B	--	--	--	--	--	A
P. rubens	Red spruce	B	A	B	C	C	B	B	B	--	--	--	A	A
P. sitchensis	Sitka spruce	--	A	B	B	--	B	B	B	--	--	--	A	A
Pinus albicaulis	Whitebark pine	--	--	--	C	--	--	B	--	--	--	--	--	A
P. attenuata	Knobcone pine	--	--	--	C	--	--	B	--	--	--	--	--	A
P. banksiana	Jack pine	A	A	B	C	A	B	B	B	--	--	--	--	A
P. clausa	Sand pine	A	A	A	B	A	C	B	A	--	--	--	A	A
P. contorta	Lodgepole pine	A	A	A	C	A	B	B	B	A	B	B	A	A
P. echinata	Shortleaf pine	A	A	A	A	A	B	B	B	A	B	--	A	A
P. elliottii	Slash pine	A	A	B	A	A	B	C	B	A	B	--	A	A
P. flexilis	Limber pine	--	--	--	C	--	--	B	--	--	--	--	--	A
P. glabra	Spruce pine	A	A	A	B	A	B	B	A	A	B	--	B	A
P. jeffreyi	Jeffrey pine	A	A	B	B	A	A	B	A	A	B	--	A	A
P. lambertiana	Sugar pine	--	--	A	A	A	A	B	B	A	B	A	A	A
P. monticola	Western white pine	A	A	B	B	B	B	B	B	A	B	B	A	A
P. palustris	Longleaf pine	A	A	A	A	A	B	C	A	A	B	--	A	A
P. ponderosa	Ponderosa pine	A	A	B	B	A	A	B	A	A	B	--	A	A
P. pungens	Table-Mountain pine	A	A	B	C	A	B	B	--	--	--	--	A	A
P. resinosa	Red pine	A	A	B	B	A	B	B	A	A	B	A	A	A
P. rigida	Pitch pine	A	A	A	C	A	B	B	A	A	B	A	--	A
P. sabiniana	Digger pine	--	--	--	C	--	C	C	--	--	--	A	--	A
P. serotina	Pond pine	A	A	B	C	A	C	C	B	A	B	A	B	A
P. strobus	Eastern white pine	A	A	A	B	A	B	B	B	A	B	B	A	A
P. taeda	Loblolly pine	A	A	A	B	A	C	B	A	A	B	A	A	A
P. virginiana	Virginia pine	A	A	B	C	A	B	B	B	A	B	A	A	A
Pseudotsuga menziesii	Douglas-fir coast	B	B	B	A-B	A	A-B	B	A	A	B	A	A	A
P. menziesii	Douglas-fir interior west	B	B	B	B	A	A-B	B	A	A	B	A	A	A
P. menziesii var. *glauca*	Douglas-fir interior north	B	B	B	B	A	A-B	B	A	A	B	A	A	A
P. menziesii var. *glauca*	Douglas-fir interior south	B	B	B	B	A	A-B	B	A	A	B	A	A	A
Sequoia gigantea	Big tree	B	--	A	A-B	A	B	A	A	A	A	B	A	A
S. sempervirens	Redwood	B	A	A	A-B	A	B	A	A	A	A	B-C	A	A
Taxodium distichum	Baldcypress	B	B	B	A	B	A	A	A	A	A	A	A	A
T. distichum var. *nutans*	Pondcypress	B	--	B	B	A	B	A	A	A	A	A	A	A
Taxus brevifolia	Pacific yew	--	--	B	C	--	--	A	--	--	B	A	--	A
Thuja occidentalis	Northern white-cedar	--	C	B	C	--	--	A	A	A	--	A	--	A
T. plicata	Western redcedar	--	B	B	B	--	A	A	A	A	A	B	--	A
Tsuga canadensis	Eastern hemlock	B	C	B	C	B	B	A	A	A	B	B-C	A	A
T. heterophylla	Western hemlock	B	B	B	B	A	B	A	B	B	B	B-C	B	A
T. mertensiana	Mountain hemlock	B	B	B	C	A	B	A	B	B	B	B	B	A

[1] A rating, species property very suitable for veneer; B rating, intermediate; and C rating, less desirable for veneer.

Table 3.--Physical properties of the wood

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content		Permeability[1]		Shrinkage green to ovendry			Vessels (pores)		Grain	Color of sapwood and heartwood
			Sapwood	Heartwood	Sapwood	Heartwood	Tangential	Radial	Volumetric	Arrangement	Size (texture)		
			Pct.	Pct.			Pct.	Pct.	Pct.				
UNITED STATES HARDWOODS													
Acacia koa	Koa	0.53	--	60 to 100	--	--	6.2	5.5	--	Diffuse porous	Medium	Straight to very irregular	Sapwood is narrow and yellow-white. Golden brown heartwood may have shades of red. Veneer from old trees may have black streaks.
Acer macrophyllum	Bigleaf maple	.44	--	--	P	M	7.1	3.7	11.6	...do...	Small to medium	Straight; occasionally curly or wavy grained	Sapwood reddish-white. Heartwood pink-brown.
A. nigrum	Black maple	.52	--	--	P	--	9.3	4.8	14.0	...do...	Small	.....do.....	White sapwood may be tinged red-brown. Uniform light red-brown heartwood.
A. rubrum	Red maple	.49	--	--	P	M	8.2	4.0	13.1	...do...	...do...	.....do.....	Do.
A. saccharinum	Silver maple	.44	100	60	P	M	7.2	3.0	12.0	...do...	...do...	.....do.....	Do.
A. saccharum	Sugar maple	.56	70	70	P	M	9.9	4.8	14.9	Diffuse	...do...	.....do.....	Do.
A. negundo	Boxelder	.41	--	--	--	--	7.4	3.9	11.1	...do...	...do...	.....do.....	Green-yellow sapwood sometimes with red streaks. Heartwood yellowish-bronze.
Aesculus glabra	Ohio buckeye	--	--	--	--	--	--	--	--	...do...	...do...	Straight	White sapwood merging gradually to creamy white to pale yellow heartwood. Frequent gray streaks.
A. octandra	Yellow buckeye	.33	140	140	--	--	8.1	3.6	12.5	...do...	...do...	.....do.....	Do.
Alnus nepalensis	Nepal alder	.34	90 to 190	--	--	--	6.8	4.0	10.8	Diffuse porous	Medium	.....do.....	Sapwood nearly white. Heartwood pink-white. Both become light tan with a roseate cast during drying.
A. rubra	Red alder	.37	100	--	P	P	7.3	4.4	12.6	...do...	...do...	.....do.....	Sapwood white turning

Table 3.--Physical properties of the wood--continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content: Sapwood	Green moisture content: Heartwood	Permeability[1]: Sapwood	Permeability[1]: Heartwood	Shrinkage green to ovendry: Tangential	Shrinkage green to ovendry: Radial	Shrinkage green to ovendry: Volumetric	Vessels (pores): Arrangement	Vessels (pores): Size (texture)	Grain	Color of sapwood and heartwood
			Pct.	Pct.			Pct.	Pct.	Pct.				
UNITED STATES HARDWOODS--continued													
Arbutus menziesii	Pacific madrone	.58	140 to 170	120	--	--	12.4	5.6	18.1	...do...	...do....	Straight; occasionally irregular	Sapwood white often with pink tinge. Heartwood light pink to red-brown and gray-green.
Betula alleghaniensis	Yellow birch	.55	70	70	P	M	9.5	7.3	16.7	...do...	...do....	Straight to curly	Sapwood white to pale yellow. Heartwood light to dark brown or reddish-brown.
B. lenta	Sweet birch	.60	70	80	P	M	9.0	6.3	15.6	...do...	...do....	.....do.....	Do.
B. nigra	River birch	.49	--	--	P	P	9.2	4.7	13.9	...do...	...do....	.....do.....	Do.
B. papyrifera	Paper birch	.48	70	90	M	M	8.6	6.3	16.2	...do...	...do....	.....do.....	Do.
B. papyrifera var. *humilis*	Alaskan paper birch	.49	60	60	--	--	9.9	6.5	16.7	...do...	Small	Straight	Sapwood nearly white, may brown slightly during drying at high temperatures. Heartwood is light reddish-brown.
B. populifolia	Gray birch	.45	--	--	--	--	9.5	5.2	14.7	...do...	Medium	Straight to curly	Sapwood white to pale yellow. Heartwood light to dark brown or reddish-brown.
Carya aquatica	Water hickory	.61	60 to 100	80 to 90	P	--	--	--	13.6	Semi-ring porous	Large	Straight	Sapwood white to light pink-tan. Heartwood reddish-brown with darker streaks.
C. cordiformis	Bitternut hickory	.60	50	80	P	--	--	--	13.6	...do...	...do....	.....do.....	Do.
C. glabra	Pignut hickory	.66	50	70	P	--	11.5	7.2	17.9	Ring porous	...do....	.....do.....	Do.
C. illinoensis	Pecan	.60	60	70	P	--	8.9	4.9	13.6	Semi-ring porous	...do....	.....do.....	Do.
C. laciniosa	Shellbark hickory	0.62	--	--	P	--	12.6	7.6	19.2	Ring porous	Large	Straight	Sapwood white to light pink-tan. Heartwood reddish-brown with darker streaks.
C. myristicaeformis	Nutmeg hickory	.56	--	--	P	--	--	--	13.6	Semi-ring porous	...do....	.....do.....	Do.
C. ovata	Shagbark hickory	.64	50	70	P	--	10.5	7.0	16.7	Ring porous	...do....	.....do.....	Do.

C. tomentosa	Mockernut hickory	.64	50	80	P	M	11.0	7.7	17.9	...do...	...do...	.....do.....	Do.
Cecropia peltata	Yagrumo hembra	.26	110 to 180	--	--	--	7.5	1.7	--	Diffuse porous	Medium	.....do.....	All the wood appears to be sapwood. It is white when first cut and dries to a creamy white color.
Celtis laevigata	Sugarberry	.47	--	--	--	--	7.3	5.0	12.7	Ring porous	Large	Straight; sometimes inter-locked	Sapwood pale yellow to greenish-gray. Heartwood same as sapwood but darker.
C. occidentalis	Hackberry	.49	70	60	--	R	8.9	4.8	16.9	...do...	...do...	.....do.....	Do.
Diospyros virginiana	Common persimmon	.64	60	60	--	--	11.2	7.9	19.1	Semi-ring porous	Medium to large	Straight to inter-locked	Sapwood creamy white darkening to gray-brown. Heartwood dark brown with black stripes.
Eucalyptus robusta	Eucalyptus	.60	70	90 to 100	--	--	10.7	6.1	--	Diffuse porous	Medium	Interlocked	Sapwood cream to light brown. Heartwood is reddish-pink.
Fagus grandifolia	American beech	.56	70	60	P	P-R	11.9	5.5	16.3	Diffuse	Small	Straight to inter-locked	Sapwood white tinged with red. Heartwood light red-brown.
Fraxinus americana	White ash	.55	40	50	--	P	7.8	4.9	13.4	Ring porous	Large	Straight	White to pale yellow sapwood. The heartwood is very light brown.
F. latifolia	Oregon ash	.50	--	50	--	--	8.1	4.1	13.2	...do...	...do...	.....do.....	Similar to white ash but the heartwood sometimes has a reddish tinge.
F. nigra	Black ash	.45	--	90	--	--	7.8	5.0	15.2	...do...	...do...	.....do.....	Similar to white ash but the heartwood is a darker warm brown.
F. pennsylvanica	Green ash	.53	60	--	--	P	7.1	4.6	12.5	...do...	...do...	.....do.....	White to pale yellow sapwood, the heartwood is very light brown.
F. profunda	Pumpkin ash	.48	--	--	--	--	6.3	3.7	12.0	...do...	...do...	.....do.....	Do.
F. quadrangulata	Blue ash	.53	--	--	--	--	6.5	3.9	11.7	...do...	...do...	.....do.....	Do.
F. uhdei	Shamel ash	.47	50	--	--	--	7.4	3.5	10.2	...do...	...do...	.....do.....	Sapwood is nearly white and merges gradually into the light-tan heartwood.
Gleditsia triacanthos	Honeylocust	.60	--	--	--	--	6.6	4.2	10.8	...do...	...do...	.....do.....	Cream colored sapwood and warm light red-brown heartwood.
Grevillea robusta	Silk-oak	.51	--	100 to 130	--	--	7.7	2.7	--	Diffuse porous	Medium	.....do.....	Sapwood is white. The heartwood is light pink and turns to light pink-tan on exposure to sunlight.

Table 3.--Physical properties of the wood--continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content: Sapwood	Green moisture content: Heartwood	Permeability[1]: Sapwood	Permeability[1]: Heartwood	Shrinkage green to ovendry: Tangential	Shrinkage green to ovendry: Radial	Shrinkage green to ovendry: Volumetric	Vessels (pores): Arrangement	Vessels (pores): Size (texture)	Grain	Color of sapwood and heartwood
			Pct.	Pct.			Pct.	Pct.	Pct.				
UNITED STATES HARDWOODS--continued													
Ilex opaca	American holly	.50	80	80	P	P	9.9	4.8	16.9	...do...	Small	.....do.....	White sapwood and ivory-white heartwood turning brown with exposure.
Juglans cinerea	Butternut	.36	100	100	--	--	6.4	3.4	10.6	Semi-diffuse porous	Medium	Straight	Sapwood white to light gray-brown. Heartwood a buttery-tan with occasional dark streaks.
J. nigra	Black walnut	.51	70	90	--	--	7.8	5.5	12.8	Semi-ring porous	...do....	Straight to irregular	Light pale brown sapwood darkened by steaming. Heartwood light gray-brown to dark purplish-brown.
Liquidambar styraciflua	Sweetgum	0.46	140	80 to 120	P	R	10.2	5.3	15.0	Diffuse porous	Small	Frequently interlocked	Sapwood is pinkish-white. Heartwood is reddish-brown, often with irregular dark streaks.
Liriodendron tulipifera	Yellow-poplar	.40	110	80	P	R	8.2	4.6	12.3	...do...	...do....	Straight	Sapwood white. Heartwood light yellow-green. Occasional dark green or purple streaks.
Lithocarpus densiflorus	Tanoak	.58	80	100	P	--	13.0	6.0	14.9	...do...	Medium	.....do.....	Sapwood light tan. Heartwood light red-brown.
Magnolia acuminata	Cucumbertree	.44	--	--	--	--	8.8	5.2	13.6	...do...	Small	.....do.....	Sapwood white. Heartwood light yellow-green. Occasional dark green or purple streaks.
M. grandiflora	Southern magnolia	.46	100	80	--	--	6.6	5.4	12.3	...do...	...do....	.....do.....	Reported dark streaks more common than in yellow-poplar.
M. virginiana	Sweetbay	.42	--	--	--	--	8.3	4.7	13.0	...do...	...do....	.....do.....	Sapwood white. Heartwood light yellow-green. Occasional dark green or purple streaks.

Metrosideros polymorpha	Ohia	.70	--	60 to 70	--	--	12.1	6.9	19.1	...do...	...do...	Straight to mildly irregular	Light yellow-brown sapwood. The heartwood is dark brown with a reddish cast.
Nyssa aquatica	Water tupelo	.46	140	150	P	P	7.6	4.2	12.5	...do...	...do...	Usually interlocked	White sapwood. Pale brown-gray heartwood.
N. sylvatica	Blackgum	.46	120	90	P	P	8.7	5.1	13.9	...do...	...do...	...do...	White sapwood. Pale brown-gray heartwood. Heartwood may be darker than water tupelo.
N. sylvatica var. *biflora*	Swamp tupelo	.45	150	120	P	--	7.0	--	--	...do...	...do...	...do...	Do.
Platanus occidentalis	American sycamore	.46	130	110	P	R	8.4	5.0	14.2	...do...	...do...	Interlocked	Sapwood pale reddish-brown. Heartwood is deeper red-brown but not sharply defined from the sapwood.
Populus balsamifera	Balsam poplar (Balm of Gilead)	.30	--	--	--	M	7.1	3.0	10.5	...do...	...do...	Usually straight	Sapwood white gradually merging into gray-white to light brown heartwood.
P. deltoides	Eastern cottonwood	.37	--	--	--	M	9.2	3.9	14.1	...do...	...do...	...do...	Do.
P. grandidentata	Bigtooth aspen	.35	90	--	--	M	7.9	3.3	11.8	...do...	...do...	...do...	Sapwood white to cream merging into cream to light gray-brown heartwood.
Populus heterophylla	Swamp cottonwood	--	--	--	--	M	--	--	--	...do...	...do...	...do...	Sapwood white gradually merging into gray-white to light gray-brown heartwood.
P. tremuloides	Quaking aspen	.35	110	100	--	M	6.7	3.5	11.5	...do...	...do...	...do...	Sapwood white to cream merging into cream to light gray-brown heartwood.
P. trichocarpa	Black cottonwood	.31	150	160	P	M	8.6	3.6	12.4	...do...	...do...	...do...	Sapwood white gradually merging into gray-white to light gray-brown heartwood.
Prunus serotina	Black cherry	.47	--	60	--	--	7.1	3.7	11.5	...do...	...do...	...do...	Sapwood nearly white. Heartwood light to dark red-brown, darkens with exposure.
Quercus alba	White oak	0.60	80	60	P	R	10.5	5.6	15.8	Ring porous	Large	Straight	Sapwood generally white. Heartwood of the white oak group is light or pale gray-brown occasionally, has a reddish tinge. Heartwood of the red oak group usually has a pink tinge but may resemble heartwood of white oaks.

Table 3. – Physical properties of the wood – continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content		Permeability		Shrinkage green to ovendry			Vessels (pores)		Grain	Color of sapwood and heartwood
			Sapwood	Heartwood	Sapwood	Heartwood	Tangential	Radial	Volumetric	Arrangement	Size (texture)		
			Pct.	Pct.			Pct.	Pct.	Pct.				
UNITED STATES HARDWOODS--continued													
Q. lyrata	Swamp white oak	.64	--	--	P	R	--	--	17.7	...do...	...do...	...do...	Do.
Q. rubra	Scarlet oak	.60	--	--	P	P	10.8	4.4	13.8	...do...	...do...	...do...	Do.
Q. durandii	Durand oak	--	--	--	--	--	--	--	--	...do...	...do...	...do...	Do.
Q. falcata	Southern red oak	.52	80	80	P	P	11.3	4.7	16.3	...do...	...do...	...do...	Do.
Q. falcata var. *pagodaefolia*	Cherrybark oak	.61	--	--	P	P	10.6	5.5	16.1	...do...	...do...	...do...	Do.
Q. garryana	Oregon white oak	.64	--	--	P	R	9.2	4.2	13.4	...do...	...do...	...do...	Do.
Q. kelloggii	California black oak	.51	80	80	P	P	6.6	3.6	12.1	...do...	...do...	...do...	Do.
Q. laurifolia	Laurel oak	.56	--	--	P	--	9.9	4.0	19.0	...do...	...do...	...do...	Do.
Q. lyrata	Overcup oak	.57	90 to 110	80 to 120	P	R	12.7	5.3	18.0	...do...	...do...	...do...	Do.
Q. macrocarpa	Bur oak	.58	--	--	P	R	8.8	4.4	12.7	...do...	...do...	...do...	Do.
Q. michauxii	Swamp chestnut oak	.60	--	--	P	R	10.8	5.2	16.4	...do...	...do...	...do...	Do.
Q. muehlenbergii	Chinkapin oak	--	--	--	P	R	--	--	--	...do...	...do...	...do...	Do.
Q. nigra	Water oak	.56	80	80	--	--	9.8	4.4	16.4	...do...	...do...	...do...	Do.
Q. nuttallii	Nuttall oak	--	--	--	P	P	--	--	--	...do...	...do...	...do...	Do.
Q. palustris	Pin oak	.58	--	--	P	P	9.5	4.3	14.5	...do...	...do...	...do...	Do.
Q. phellos	Willow oak	.56	70	80	--	--	9.6	5.0	18.9	...do...	...do...	...do...	Do.
Q. prinus	Chestnut oak	.57	--	70	P	M	10.8	5.3	16.7	...do...	...do...	...do...	Do.
Q. rubra	Northern red oak	.56	70	80	P	P	8.6	4.0	13.5	...do...	...do...	...do...	Do.
Q. shumardii	Shumard oak	--	--	--	P	P	--	--	--	...do...	...do...	...do...	Do.
Q. stellata	Post oak	.60	--	--	P	R	9.8	5.4	16.2	...do...	...do...	...do...	Do.
Q. stellata var. *mississippiensis*	Delta post oak	.60	--	--	--	--	--	--	--	...do...	...do...	...do...	Do.
Q. velutina	Black oak	.56	--	--	P	P	11.1	4.4	14.2	...do...	...do...	...do...	Do.
Q. virginiana	Live oak	.81	50	50	P	R	9.5	6.6	14.7	Diffuse porous	Small	Irregular	Sapwood white to gray-brown. Heartwood dull brown to gray-brown.
Robinia pseudoacacia	Black locust	.66	40	40	--	R	7.2	4.6	10.2	Ring porous	Large	Straight	Narrow sapwood white to cream. Heartwood golden brown with greenish tinge.
Salix nigra	Black willow	.34	140	160	--	M	8.7	3.3	14.4	Nearly diffuse porous	Small	Straight to interlocked	Sapwood whitish. Heartwood pale brown to gray-brown.

Sassafras albidum	Sassafras	.42	--	--	--	--	6.2	4.0	10.3	Ring porous	Large	Straight	Sapwood light yellow. Heartwood dull gray-brown to orange-brown.
Tectona grandis	Teak	.59	--	90 to 110	--	--	6.6	2.4	--	Ring to semi-dif-fuse porous	...do...	.....do.....	Sapwood white to pale yellow-brown. Heartwood yellow-brown to rich brown frequently with irregular dark streaks.
Tilia americana	American basswood	.32	130	80	--	P	9.3	6.6	15.8	Diffuse porous	Small	.....do.....	Sapwood creamy white merging gradually to pale brown heartwood.
T. heterophylla	White basswood	--	--	--	--	--	--	--	--	...do...	...do...	.....do.....	Do.
Ulmus alata	Winged elm	0.60	--	--	--	--	11.6	5.3	16.9	Ring porous	Small	Straight; sometimes inter-locked	Sapwood gray-white. Heartwood light gray-brown, often tinged with red.
U. americana	American elm	.46	90	100	P	M	9.5	4.2	14.6	...do...	Large	.....do.....	Do.
U. crassifolia	Cedar elm	.59	60	70	--	--	10.2	4.7	14.9	...do...	Variable (small)	.....do.....	Do.
U. rubra	Slippery elm	.48	--	--	--	P	8.9	4.9	13.8	...do...	Large	.....do.....	Sapwood gray-white. Heartwood light red-brown to dark red-brown or chocolate brown. May have yellow streaks.
U. thomasii	Rock elm	.57	60	40	--	R	8.1	4.8	14.1	...do...	Small	.....do.....	Sapwood gray-white. Heartwood light gray-brown, often tinged with red.
Umbellularia californica	California laurel	.51	70	70	--	--	8.5	2.9	11.9	Diffuse porous	...do.....	Straight to inter-locked	Sapwood white to light brown. Heartwood golden brown. Sometimes yellowish-green, often with darker streaks.

Table 3.--Physical properties of wood--continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content: Sapwood	Green moisture content: Heartwood	Permeability[1]: Sapwood	Permeability[1]: Heartwood	Shrinkage green to ovendry: Tangential	Shrinkage green to ovendry: Radial	Shrinkage green to ovendry: Volumetric	Contrast in density from springwood to summerwood	Grain	Color of sapwood and heartwood
			Pct.	Pct.			Pct.	Pct.	Pct.			
UNITED STATES SOFTWOODS												
Abies amabilis	Pacific silver fir	.40	130 to 200	40 to 50	M	M	10.0	4.5	14.1	Transition gradual, latewood distinct	Straight	Heartwood and sapwood indistinguishable, white springwood, narrow summerwood with a slight reddish-brown tinge.
A. balsamea	Balsam fir	.34	Mixed 120		--	R	7.1	2.5	9.0	do	do	Heartwood and sapwood indistinguishable, nearly white. Heartwood may be gray.
A. concolor	White fir	.37	175 to 200	25 to 190	M-R	R	7.0	3.2	9.4	do	do	Heartwood and sapwood indistinguishable, white springwood, narrow summerwood with a light reddish-brown tinge.
A. grandis	Grand fir	.35	140	90	M	R	7.2	3.2	10.6	do	do	Do.
A. lasiocarpa	Subalpine fir	.31	Mixed	50	--	R	7.1	2.5	9.0	do	do	Do.
A. magnifica	California red fir	.36	Mixed 35 to 230		M	M-R	6.9	3.8	11.8	do	do	Do.
A. magnifica var. *shastensis*	Shasta red fir	.36	Mixed 35 to 190		M	R	--	--	--	do	do	Do.
A. procera	Noble fir	.37	60 to 130	40 to 50	M	R	8.3	4.5	12.5	do	do	Do.
Chamaecyparis lawsoniana	Port-Orford-cedar	.40	100	50	P	M	6.9	4.6	10.1	Usually fine, uniform texture, faint growth ring	do	Thin light-colored sapwood merges into the light yellow or pale brown heartwood.
C. nootkatensis	Alaska-cedar	.42	170	30	--	R	6.0	2.8	9.2	Fine uniform texture, faint growth ring	do	Narrow sapwood, white to yellow merging into bright clear yellow heartwood.
C. thyoides	Atlantic white-cedar	.31	--	40	--	--	5.2	2.8	8.4	More or less gradual	do	Thin sapwood, light in color, light brown heartwood with a pink tinge.

Juniperus deppeana	Alligator juniper	0.50	100 to 150	35 to 30	—	—	3.6	2.7	7.8	Gradual to abrupt latewood distinct	Straight	White sapwood and light red-brown heartwood.
J. occidentalis	Western juniper	.51	110 to 150	25 to 30	—	—	—	—	—	do.	do.	Do.
J. scopulorum	Rocky Mountain juniper	.51	110 to 150	25 to 30	—	—	—	—	—	do.	do.	Do.
J. virginiana	Eastern redcedar	.44	—	30	—	—	4.7	3.1	7.8	do.	do.	Thin white sapwood and bright purplish-red to dull red heartwood.
Larix laricina	Tamarack	.49	135 to 175	45 to 65	—	R	7.4	3.7	13.6	Conspicuous abrupt changes spring- wood to summer- wood.	Straight to spiral	Whitish sapwood and yellowish-brown heartwood.
L. occidentalis	Western larch	.48	120 to 130	40 to 70	P	R	8.1	4.2	13.2	do.	Straight	Whitish sapwood and russet or reddish-brown heartwood.
Libocedrus decurrens	Incense-cedar	.35	210	40	—	—	5.2	3.3	7.6	Gradual transi- tion, faint growth ring	do.	Thin whitish sapwood, heartwood reddish-brown to dull brown, sometimes with a purplish tinge.
Picea engelmannii	Engelmann spruce	.33	140 to 170	40 to 50	R	R	6.6	3.4	10.4	do.	do.	Nearly white sapwood, heartwood nearly white with an occasional slight tinge of red.
P. glauca	White spruce	.37	140 to 200	30 to 50	R	R	8.2	4.7	13.7	do.	do.	Nearly white to pale yellowish-brown lustrous. Heart- wood not distinct.
P. mariana	Black spruce	.38	130	40	R	R	6.8	4.1	11.3	do.	Usually straight	Do.
P. pungens	Blue spruce	—	—	—	R	R	—	—	—	do.	Straight	Nearly white with occasional reddish tinge.

Table 3.--Physical properties of the wood--continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content: Sapwood	Green moisture content: Heartwood	Permeability[1]: Sapwood	Permeability[1]: Heartwood	Shrinkage green to ovendry: Tangential	Shrinkage green to ovendry: Radial	Shrinkage green to ovendry: Volumetric	Contrast in density from springwood to summerwood	Grain	Color of sapwood and heartwood
			Pct.	Pct.			Pct.	Pct.	Pct.			
UNITED STATES SOFTWOODS--continued												
P. rubens	Red spruce	.38	110	30	R	R	7.8	3.8	11.8	ditto	Usually straight	Nearly white to pale yellowish-brown lustrous. Heartwood not distinct.
P. sitchensis	Sitka spruce	.37	140	40	M	M-R	7.5	4.3	11.5	Gradual transition, distinct growth ring	ditto	Sapwood creamy white to light yellow. Heartwood light pinkish-yellow to pale brown with purplish cast, darkening on exposure to silver-brown.
Pinus albicaulis	Whitebark pine	.37	Mixed:	50	P	M-R	--	--	--	Gradual transition	ditto	Nearly white sapwood. Heartwood cream to light brown.
P. attenuata	Knobcone pine	--	--	--	P	M-R	--	--	--	Abrupt transition	ditto	White sapwood. Heartwood pale yellow-brown.
P. banksiana	Jack pine	.39	105	--	P	M	6.5	3.4	10.4	ditto	ditto	Sapwood nearly white. Heartwood light orange to light brown.
P. clausa	Sand pine	.36	Mixed:	45	P	M-R	7.3	3.9	10.0	ditto	ditto	Sapwood white to yellow. Heartwood light orange to reddish-brown.
P. contorta	Lodgepole pine	.38	150 to 175	35 to 80	P	R	6.7	4.5	11.5	More or less abrupt	ditto	Sapwood nearly white to pale yellow. Heartwood light yellow to pale yellowish-brown.
P. echinata	Shortleaf pine	.46	70 to 180	25 to 50	P	M	7.7	4.4	12.3	Abrupt transition	ditto	Sapwood nearly white to yellowish orange-white or pale yellow. Heartwoods shades of yellow and orange to reddish-brown or light brown.
P. elliottii	Slash pine	.56	Mixed:	66	P	M-R	7.8	5.5	12.2	ditto	ditto	Do.
P. flexilis	Limber pine	.37	Mixed:	68	P	M-R	5.1	2.4	8.2	Gradual transition	ditto	Sapwood pale yellow. Heartwood cream to light brown.

P. glabra	Spruce pine	0.41	--	--	P	M-R	--	--	--	--	Abrupt transition	Usually straight	Sapwood white. Heartwood light brown.
P. jeffreyi	Jeffrey pine	.37	100	--	--	--	6.7	4.4	9.9	More or less abrupt	....do....	Sapwood nearly white to pale yellowish. Heartwood yellowish to light reddish or orange-brown.
P. lambertiana	Sugar pine	.35	140 to 220	100	P	M	5.6	2.9	7.9	Gradual transition	....do....	Sapwood nearly white to pale yellowish-white. Heartwood light brown to pale reddish-brown.
P. monticola	Western white pine	.36	150 to 200	50 to 60	P	M	5.3	2.6	11.8	....do....	Straight	Sapwood nearly white to pale yellowish-white. Heartwood cream colored to light brown or reddish-brown turning darker on exposure.
P. palustris	Longleaf pine	.54	70 to 130	25 to 50	P	M	7.5	5.1	12.2	Abrupt transition	Usually straight	Sapwood nearly white to yellowish or orange-white or pale yellow. Heartwood shades of yellow and orange to reddish-brown or light brown.
P. ponderosa	Ponderosa pine	.38	120 to 150	30 to 40	P	P-M	6.3	3.9	9.6	More or less abrupt	....do....	Sapwood nearly white to pale yellowish. Heartwood yellowish to light reddish or orange-brown.
P. pungens	Table-Mountain pine	.49	Mixed	75	P	M-R	6.8	3.4	10.9	Abrupt transition	....do....	Sapwood nearly white. Heartwood light brown.
P. resinosa	Red pine	.44	40 to 150	35	P	M	7.2	4.6	11.5	More or less abrupt	....do....	Sapwood nearly white to yellowish. Heartwood light red to orange-brown or reddish-brown.
Pinus rigida	Pitch pine	.45	Mixed	30	P	R	7.1	4.0	10.9	Abrupt transition	....do....	Sapwood nearly white to yellowish or orange-white to pale yellow. Heartwood shades of yellow and orange to reddish-brown or light brown.
P. sabiniana	Digger pine	--	--	--	P	--	--	--	--	More or less abrupt	....do....	Sapwood nearly white. Heartwood dark yellow-brown often tinged with red.

Table 3.--Physical properties of the wood--continued

Botanical name	Common name	Specific gravity (green volume and ovendry weight)	Green moisture content		Permeability[1]		Shrinkage green to ovendry			Contrast in density from springwood to summerwood	Grain	Color of sapwood and heartwood
			Sapwood	Heartwood	Sapwood	Heartwood	Tangential	Radial	Volumetric			
			Pct.	Pct.			Pct.	Pct.	Pct.			
UNITED STATES SOFTWOODS--continued												
P. serotina	Pond pine	.50	60	--	P	M-R	7.1	5.1	11.2	Abrupt transition	...do...	Sapwood nearly white to yellowish or orange-white or pale yellow. Heartwood shades of yellow and orange to reddish-brown or light brown.
P. strobus	Eastern white pine	.34	150 to 210	Mixed 70	P	M	6.0	2.3	8.2	Gradual transition	...do...	Sapwood nearly white to pale yellowish-white. Heartwood cream colored to light brown or reddish-brown turning darker on exposure.
P. taeda	Loblolly pine	.47	80 to 140	30 to 40	P	M	7.4	4.8	12.3	Abrupt transition	...do...	Sapwood nearly white to yellowish or orange-white of pale yellow. Heartwood shades of yellow and orange to reddish-brown or light brown.
P. virginiana	Virginia pine	.45	--	--	P	M-R	--	--	--	...do...	...do...	Sapwood nearly white. Heartwood light orange colored.
Pseudotsuga menziesii	Douglas-fir coast	.45	120	40	M	M-R	7.8	5.0	11.8	...do...	...do...	Sapwood whitish to pale yellowish or reddish-white. Heartwood yellowish or pale reddish-yellow to orange-red or deep red.
P. menziesii	Douglas-fir interior west	.46	110	30	R	R	--	--	--	...do...	...do...	Do.
P. menziesii var. *glauca*	Douglas-fir interior north	.45	150	30	--	R	--	--	--	...do...	...do...	Do.
P. menziesii var. *glauca*	Douglas-fir interior south	.43	110	30	--	--	--	--	--	...do...	...do...	Do.
Sequoia gigantea	Big tree	--	--	--	--	M	--	--	--	Usually abrupt	Usually straight	Sapwood nearly white. Narrow heartwood clear light red to deep reddish-brown.

S. sempervirens	Redwood	0.38	135 to 240	70 to 245	P	P-M	4.4	2.6	6.8	....do....	....do....	Do.
Taxodium distichum	Baldcypress	.42	170	120	--	M	6.2	3.8	10.5	More or less abrupt	....do....	Sapwood pale yellowish-white, merging into heartwood. Heartwood very variable in color ranging from yellowish to light or dark brown, reddish-brown, or almost black.
T. distichum var. *nutans*	Pondcypress	--	--	--	--	M	--	--	--	....do....	....do....	Do.
Taxus brevifolia	Pacific yew	.60	--	45	--	R	5.4	4.0	9.7	Very gradual transition, latewood dense	Straight to irregular and spiral	Thin light yellow sapwood, bright orange to rose-red heartwood.
Thuja occidentalis	Northern white-cedar	.29	Mixed	55	R	R	4.7	2.1	7.0	More or less gradual transition	Usually straight	Sapwood nearly white. Narrow heartwood uniformly straw brown.
T. plicata	Western redcedar	.37	250	60	R	R	5.0	2.4	7.7	More or less abrupt, latewood is narrow	Straight	Sapwood nearly white. Narrow heartwood reddish or pinkish-brown to dull brown.
Tsuga canadensis	Eastern hemlock	.38	180 to 270	40 to 180	M-R	R	6.8	3.0	9.7	Transition gradual to abrupt	Uneven spiral grained	Sapwood buff to light brown, latewood with a roseate or reddish-brown tinge. Heartwood not distinct.
T. heterophylla	Western hemlock	.38	80 to 230	40 to 220	P	M	7.9	4.3	11.9	Transition more or less gradual	Usually straight	Wood whitish to light yellowish-brown. Latewood with a roseate, purplish or reddish-brown tinge.
T. mertensiana	Mountain hemlock	.43	--	60	--	--	7.4	4.4	11.4	....do....	....do....	Do.

[1] P, permeable; M, moderately permeable; and R, refractory.

Table 4.--Mechanical properties of the wood

Botanical name	Common name	Tension perpendicular to grain (green)	12 percent moisture content: Hardness (side)	Modulus of elasticity	Modulus of rupture	Compression parallel to the grain--maximum crushing strength	Compression perpendicular to the grain--fiber stress at proportional limit	Shear parallel to grain--maximum shearing strength	Similar to well-known veneer species
		P.s.i.	Lb.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	
UNITED STATES HARDWOODS									
Acacia koa	Koa	--	850	1,570	13,300	7,300	--	--	
Acer macrophyllum	Bigleaf maple	600	850	1,450	10,700	5,950	750	1,730	
A. nigrum	Black maple	720	1,180	1,620	13,300	6,680	1,020	1,820	
A. rubrum	Red maple	--	950	1,640	13,400	6,540	1,000	1,850	
A. saccharinum	Silver maple	560	700	1,140	8,900	5,220	740	1,480	
A. saccharum	Sugar maple	--	1,450	1,830	15,800	7,830	1,470	2,330	
A. negundo	Boxelder	--	--	--	--	--	--	--	
Aesculus glabra	Ohio buckeye	--	--	--	--	--	--	--	Basswood
A. octandra	Yellow buckeye	--	--	1,170	7,490	4,170	360	960	Do.
Alnus nepalensis	Nepal alder	--	510	1,020	8,500	--	--	--	Red alder
A. rubra	Red alder	390	590	1,380	9,800	5,820	440	1,080	Yellow-poplar
Arbutus menziesii	Pacific madrone	--	--	1,230	10,450	6,880	1,310	1,810	Black cherry
Betula alleghaniensis	Yellow birch	430	1,260	2,010	16,600	8,170	970	1,880	
B. lenta	Sweet birch	430	1,470	2,170	16,900	8,540	1,080	2,240	
B. nigra	River birch	--	--	--	--	--	--	--	
B. papyrifera	Paper birch	380	910	1,590	12,300	5,690	600	1,210	
B. papyrifera var. *humilis*	Alaskan paper birch	200	840	1,900	13,800	7,510	830	1,420	Paper birch
B. populifolia	Gray birch	--	760	1,150	9,800	4,870	750	1,340	
Carya aquatica	Water hickory	--	--	2,020	17,800	8,600	1,550	--	
C. cordiformis	Bitternut hickory	--	1,580	1,790	17,100	9,040	1,680	1,960	
C. glabra	Pignut hickory	--	2,140	2,260	20,100	9,190	1,980	2,150	
C. illinoensis	Pecan	680	1,820	1,730	13,700	7,850	1,720	2,080	
C. laciniosa	Shellbark hickory	--	--	1,890	18,100	8,000	1,800	2,110	
C. myristicaeformis	Nutmeg hickory	--	1,810	1,700	16,600	6,910	1,570	1,850	
C. ovata	Shagbark hickory	--	1,880	2,160	20,200	9,210	1,760	2,430	
C. tomentosa	Mockernut hickory	--	1,970	2,220	19,200	8,940	1,730	1,740	
Cecropia peltata	Yagrumo hembra	--	320	1,090	6,490	3,490	270	--	
Celtis laevigata	Sugarberry	--	960	1,140	9,900	5,620	1,000	1,280	American elm
C. occidentalis	Hackberry	630	880	1,190	11,000	5,440	890	1,590	Do.
Diospyros virginiana	Common persimmon	1,200	2,300	2,010	17,660	9,170	1,990	2,160	
Eucalyptus robusta	Eucalyptus	--	1,330	2,200	15,600	8,200	--	--	
Fagus grandifolia	American beech	720	1,300	1,720	14,900	7,300	1,010	2,010	

Table 4.--Mechanical properties of the wood--continued

Botanical name	Common name	Tension perpendicular to grain (green)	12 percent moisture content: Hardness (side)	Modulus of elasticity	Modulus of rupture	Compression parallel to the grain--maximum crushing strength	Compression perpendicular to the grain--fiber stress at proportional limit	Shear parallel to grain--maximum shearing strength	Similar to well-known veneer species
		P.s.i.	Lb.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	
				UNITED STATES HARDWOODS--continued					
Fraxinus americana	White ash	590	1,320	1,770	15,400	7,410	1,160	1,950	
F. latifolia	Oregon ash	590	1,160	1,360	12,700	6,040	1,250	1,790	White ash
F. nigra	Black ash	490	850	1,600	12,600	5,970	760	1,570	
F. pennsylvanica	Green ash	590	1,200	1,660	14,100	7,080	1,310	1,910	Do.
F. profunda	Pumpkin ash	770	990	1,260	11,060	5,690	1,460	1,720	
F. quadrangulata	Blue ash	--	1,290	1,400	13,790	6,980	1,420	2,030	
F. uhdei	Shamel ash	--	860	1,660	12,800	--	--	--	Black ash
Gleditsia triacanthos	honeylocust	930	1,580	1,630	14,700	7,500	1,840	2,250	
Grevillea robusta	Silk-oak	--	930	--	--	--	--	--	
Ilex opaca	American holly	680	1,020	1,110	10,260	5,540	920	1,710	
Juglans cinerea	Butternut	430	490	1,180	8,100	5,110	460	1,170	
J. nigra	Black walnut	570	1,010	1,680	14,600	7,580	1,010	1,370	
Liquidambar styraciflua	Sweetgum	540	850	1,640	12,500	6,320	620	1,600	
Liriodendron tulipifera	Yellow-poplar	510	540	1,580	10,100	5,540	500	1,190	
Lithocarpus densiflorus	Tanoak	--	--	--	--	--	--	--	
Magnolia acuminata	Cucumbertree	440	700	1,820	12,300	6,310	570	1,340	Yellow-poplar
M. grandiflora	Southern magnolia	610	1,020	1,400	11,200	5,460	860	1,530	Do.
M. virginiana	Sweetbay	--	--	1,640	10,920	5,680	560	1,680	Do.
Metrosideros polymorpha	Ohia	950	2,090	2,370	18,300	8,900	1,400	2,360	
Nyssa aquatica	Water tupelo	600	880	1,260	9,600	5,920	870	1,590	
N. sylvatica	Blackgum	570	810	1,200	9,600	5,520	930	1,340	
N. sylvatica var. *biflora*	Swamp tupelo	--	--	--	--	--	--	--	
Platanus occidentalis	American sycamore	630	770	1,420	10,000	5,380	700	1,470	
Populus balsamifera	Balsam poplar (Balm of Gilead)	160	300	1,100	6,800	4,020	370	790	
P. deltoides	Eastern cottonwood	410	430	1,370	8,500	4,910	380	930	
P. grandidentata	Bigtooth aspen	310	420	1,430	9,100	5,300	560	1,080	Quaking aspen
P. heterophylla	Swamp cottonwood	--	--	--	--	--	--	--	
P. tremuloides	Quaking aspen	230	350	1,180	8,400	4,250	370	850	
P. trichocarpa	Black cottonwood	270	360	1,270	8,500	4,500	300	1,040	
Prunus serotina	Black cherry	570	950	1,490	12,300	7,110	690	1,700	

Table 4.--Mechanical properties of the wood--continued

Botanical name	Common name	Tension perpendicular to grain (green)	Hardness (side)	Modulus of elasticity	Modulus of rupture	Compression parallel to the grain--maximum crushing strength	Compression perpendicular to the grain--maximum crushing fiber stress at proportional limit	Shear parallel to grain--maximum shearing atrength	Similar to well-known veneer species
		12 percent moisture content							
		P.s.i.	Lb.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	
		UNITED STATES HARDWOODS--continued							
Quercus alba	White oak	770	1,360	1,780	15,200	7,440	1,070	2,000	
Q. bicolor	Swamp white oak	860	1,620	2,050	17,700	8,600	1,190	2,000	
Q. coccinea	Scarlet oak	700	1,400	1,910	17,400	8,330	1,120	1,890	
Q. durandii	Durand oak	--	--	--	--	--	--	--	
Q. falcata	Southern red oak	480	1,060	1,490	10,900	6,090	870	1,390	
Q. falcata var. *pagodaefolia*	Cherrybark oak	800	1,480	2,280	18,100	8,740	1,250	2,000	
Q. garryana	Oregon white oak	940	1,660	1,100	10,320	6,530	1,710	2,020	
Q. kelloggii	California black oak	700	1,100	990	8,700	5,640	1,160	1,470	
Q. laurifolia	Laurel oak	770	1,210	1,690	12,600	6,980	1,060	1,830	
Q. lyrata	Overcup oak	730	1,190	1,420	12,600	6,200	810	2,000	
Q. macrocarpa	Bur oak	800	1,370	1,030	10,300	6,060	1,200	1,820	
Q. michauxii	Swamp chestnut oak	670	1,240	1,770	13,900	7,270	1,110	1,990	
Q. muehlenbergii	Chinkapin oak	730	1,190	1,420	12,600	--	--	--	
Q. nigra	Water oak	820	1,190	2,020	15,400	6,770	1,020	2,020	
Q. nuttallii	Nuttall oak	--	--	--	--	--	--	--	
Q. palustris	Pin oak	800	1,510	1,730	14,000	6,820	1,020	2,080	
Q. phellos	Willow oak	760	1,460	1,900	14,500	7,040	1,130	1,650	
Q. prinus	Chestnut oak	690	1,130	1,590	13,300	6,830	840	1,490	
Q. rubra	Northern red oak	750	1,290	1,820	14,300	6,760	1,010	1,780	
Q. shumardii	Shumard oak	--	--	--	--	--	--	--	
Q. stellata	Post oak	790	1,360	1,510	13,200	6,600	1,430	1,840	
Q. stellata var. *mississippiensis*	Delta post oak	--	--	--	--	--	--	--	
Q. velutina	Black oak	--	1,210	1,640	13,900	6,520	930	1,910	
Q. virginiana	Live oak	1,040	2,680	1,970	18,400	8,900	2,840	2,660	
Robinia pseudoacacia	Black locust	770	1,700	2,050	19,400	10,180	1,830	2,480	
Salix nigra	Black willow	430	450	1,010	7,830	4,100	430	1,250	
Sassafras albidum	Sassafras	520	630	1,120	9,030	4,760	850	1,240	Black ash
Tectona grandis	Teak	960	1,130	1,820	13,900	7,900	1,410	1,320	
Tilia americana	American basswood	280	410	1,460	8,700	4,730	370	990	
T. heterophylla	White basswood	--	--	--	--	--	--	--	American basswood
Ulmus alata	Winged elm	850	1,540	1,650	14,800	6,780	1,020	2,370	Rock elm
U. americana	American elm	590	830	1,340	11,800	5,520	690	1,510	
U. crassifolia	Cedar elm	690	1,320	1,480	13,500	6,020	950	2,240	Do.
U. rubra	Slippery elm	640	860	1,490	13,000	6,360	820	1,630	
U. thomasii	Rock elm	--	1,320	1,540	14,800	7,050	1,520	1,920	
Umbellularia californica	California laurel	780	1,270	940	8,000	5,640	1,130	1,860	

Table 4.--Mechanical properties of the wood--continued

Botanical name	Common name	Tension perpendicular to grain (green)	12 percent moisture content: Hardness (side)	Modulus of elasticity	Modulus of rupture	Compression parallel to the grain--maximum crushing strength	Compression perpendicular to the grain--fiber stress at proportional limit	Shear parallel to grain--maximum shearing strength	Similar to well-known veneer species
		P.s.i.	Lb.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	
				UNITED STATES SOFTWOODS					
Abies amabilis	Pacific silver fir	240	430	1,720	10,600	6,530	450	1,180	
A. balsamea	Balsam fir	180	400	1,230	7,600	4,530	300	710	
A. concolor	White fir	300	480	1,490	9,800	5,810	530	1,100	
A. grandis	Grand fir	240	490	1,570	8,800	5,290	500	910	
A. lasiocarpa	Subalpine fir	--	400	900	7,100	4,330	490	1,020	
A. magnifica	California red fir	380	500	1,490	10,400	5,470	610	1,050	
A. magnifica var. *shastensis*	Shasta red fir	--	--	--	--	--	--	--	
A. procera	Noble fir	230	410	1,720	10,700	6,100	520	1,050	
Chamaecyparis lawsoniana	Port-Orford-cedar	180	560	1,730	11,300	6,470	620	1,080	
C. nootkatensis	Alaska-cedar	330	580	1,420	11,100	6,310	620	1,130	
C. thyoides	Atlantic white-cedar	180	350	930	6,800	4,700	410	800	
Juniperus deppeana	Alligator juniper	--	1,160	650	6,700	4,120	1,380	1,042	
J. occidentalis	Western juniper	--	--	--	--	--	--	--	
J. scopulorum	Rocky Mountain juniper	--	--	720	8,310	5,340	890	1,065	
J. virginiana	Eastern redcedar	330	900	880	8,800	6,020	920	--	
Larix laricina	Tamarack	260	590	1,640	11,600	7,160	800	1,280	
L. occidentalis	Western larch	330	830	1,870	13,100	7,640	930	1,360	
Libocedrus decurrens	Incense-cedar	280	470	1,040	8,000	5,200	590	880	
Picea engelmannii	Engelmann spruce	240	390	1,300	9,300	4,480	410	1,200	
P. glauca	White spruce	220	480	1,340	9,800	5,470	460	1,080	
P. mariana	Black spruce	100	520	1,530	10,300	5,320	530	1,030	
P. pungens	Blue spruce	--	--	--	--	--	--	--	
P. rubens	Red spruce	220	490	1,520	10,200	5,890	470	1,080	
P. sitchensis	Sitka spruce	250	510	1,570	10,200	5,610	580	1,150	

Table 4.--Mechanical properties of the wood--continued

Botanical name	Common name	Tension perpendicular to grain (green)	12 percent moisture content: Hardness (side)	Modulus of elasticity	Modulus of rupture	Compression parallel to the grain--maximum crushing strength	Compression perpendicular to the grain--fiber stress at proportional limit	Shear parallel to grain--maximum shearing strength	Similar to well-known veneer species
		P.s.i.	Lb.	1,000 p.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	
				UNITED STATES SOFTWOODS--continued					
Pinus albicaulis	Whitebark pine	--	--	--	--	--	--	--	
P. attenuata	Knobcone pine	--	--	--	--	--	--	--	
P. banksiana	Jack pine	360	570	1,350	9,900	5,660	580	1,170	
P. clausa	Sand pine	380	730	1,410	11,600	6,920	1,030	1,100	
P. contorta	Lodgepole pine	220	480	1,340	9,400	5,370	610	880	
P. echinata	Shortleaf pine	320	690	1,760	12,800	7,070	810	1,310	
P. elliottii	Slash pine	400	1,010	2,060	15,900	9,100	1,020	1,730	
P. flexilis	Limber pine	270	430	1,170	9,100	5,290	580	800	
P. glabra	Spruce pine	--	660	1,230	10,400	5,650	730	1,490	
P. jeffreyi	Jeffrey pine	260	500	1,240	9,300	5,530	790	1,210	
P. lambertiana	Sugar pine	270	380	1,200	8,000	4,770	480	1,050	
P. monticola	Western white pine	260	370	1,510	9,500	5,620	440	850	
P. palustris	Longleaf pine	330	870	1,990	14,700	8,440	960	1,500	
P. ponderosa	Ponderosa pine	310	460	1,290	9,400	5,320	580	1,130	
P. pungens	Table-Mountain pine	320	660	1,550	11,600	6,830	980	1,200	
P. resinosa	Red pine	300	560	1,630	11,000	6,070	600	1,210	
P. rigida	Pitch pine	280	620	1,430	10,800	5,940	1,010	1,360	
P. sabiniana	Digger pine	--	--	--	--	--	--	--	
P. serotina	Pond pine	280	740	1,750	11,600	7,540	1,120	1,380	
P. strobus	Eastern white pine	250	380	1,240	8,600	4,800	440	900	
P. taeda	Loblolly pine	260	690	1,800	12,800	7,080	800	1,370	
P. virginiana	Virginia pine	400	740	1,520	13,000	6,710	910	1,350	
Pseudotsuga menziesii	Douglas-fir coast	300	710	1,950	12,400	7,240	800	1,130	
P. menziesii	Douglas-fir interior west	290	660	1,820	12,600	7,440	760	1,290	
P. menziesii var. *glauca*	Douglas-fir interior north	340	600	1,790	13,100	6,900	770	1,400	
P. menziesii var. *glauca*	Douglas-fir interior south	250	510	1,490	11,900	6,220	740	1,510	
Sequoia gigantea	Big tree	--	--	---	--	--	--	--	
S. sempervirens	Redwood	260	480	1,340	10,000	6,150	700	940	
Taxodium distichum	Baldcypress	300	510	1,440	10,600	6,360	730	1,000	
T. distichum var. *nutans*	Pondcypress	--	--	--	--	--	--	--	
Taxus brevifolia	Pacific yew	450	1,600	1,350	15,200	8,100	2,110	2,230	
Thuja occidentalis	Northern white-cedar	240	320	800	6,500	3,960	310	850	
T. plicata	Western redcedar	230	350	1,120	7,700	5,020	490	860	
Tsuga canadensis	Eastern hemlock	230	500	1,200	8,900	5,410	650	1,060	
T. heterophylla	Western hemlock	290	540	1,640	11,300	7,110	550	1,250	
T. mertensiana	Mountain hemlock	330	740	1,320	11,200	6,840	1,030	1,230	

Table 5.--Cuttingof veneer

Botanical name	Common name	Source of information			Number of logs cut at Laboratory	How veneer was cut				Ease of bark removal by machine[1]
		Veener cutting research	Industrial use	Basic log and wood properties		Rotary	Flat sliced	Quarter-sliced	Rift sliced	
				UNITED STATES HARDWOODS						
Acacia koa	Koa	X	X		1		X			--
Acer macrophyllum	Bigleaf maple	X	X		2	X				B
A. nigrum	Black maple		X							B
A. rubrum	Red maple		X							B
A. saccharinum	Silver maple		X							B
A. saccharum	Sugar maple	X	X		6	X				B
A. negundo	Boxelder			X						B
Aesculus glabra	Ohio buckeye			X						A
A. octandra	Yellow buckeye			X						A
Alnus nepalensis	Nepal alder	X			6	X	X	X	X	A
A. rubra	Red alder	X	X		8	X	X			B
Arbutus menziesii	Pacific madrone	X	X		4	X	X	X		C
Betula alleghaniensis	Yellow birch	X	X		100	X	X	X		B
B. lenta	Sweet birch		X							B
B. nigra	River birch			X						B
B. papyrifera	Paper birch		X							B
B. papyrifera var. *humilis*	Alaskan paper birch			X						B
B. populifolia	Gray birch			X						B
Carya aquatica	Water hickory	X	X		6	X				C
C. cordiformis	Bitternut hickory		X							C
C. glabra	Pignut hickory	X	X		5	X	X	X		C
C. illinoensis	Pecan	X	X		15	X				C
C. laciniosa	Shellbark hickory		X	X						C
C. myristicaeformis	Nutmeg hickory		X							C
C. ovata	Shagbark hickory	X	X		5	X				C
C. tomentosa	Mockernut hickory	X	X		3	X				C
Cecropia peltata	Yagrumo hembra	X			2	X				B
Celtis laevigata	Sugarberry		X	X						A
C. occidentalis	Hackberry		X	X						A
Diospyros virginiana	Common persimmon		X	X						--
Eucalyptus robusta	Eucalyptus	X			2			X	X	B
Fagus grandifolia	American beech	X	X		10	X				A
Fraxinus americana	White ash	X	X		1		X			B
F. latifolia	Oregon ash			X						B
F. nigra	Black ash		X							B
F. pennsylvanica	Green ash		X							B
F. profunda	Pumpkin ash			X						B
F. quadrangulata	Blue ash			X						B
F. uhdei	Shamel ash	X			1	X	X	X		B
Gleditsia triacanthos	Honeylocust	X		X	1		X	X		C
Grevillea robusta	Silk-oak	X	X		1	X	X	X		B
Ilex opaca	American holly			X						B
Juglans cinerea	Butternut		X							B
J. nigra	Black walnut	X			7		X			B
Liquidambar styraciflua	Sweetgum	X	X		10	X				A
Liriodendron tulipifera	Yellow-poplar	X	X		30	X	X	X		A
Lithocarpus densiflorus	Tanoak	X	X		8	X	X	X		A

Table 5.--Cutting of veneer--continued

Botanical name	Common name	Source of information			Number of logs cut at Laboratory	How veneer was cut				Ease of bark removal by machine
		Veneer cutting research	Industrial use	Basic log and wood properties		Rotary	Flat sliced	Quarter-sliced	Rift sliced	
				UNITED STATES HARDWOODS--continued						
Magnolia acuminata	Cucumbertree		X	X						A
M. grandiflora	Southern magnolia		X	X						A
M. virginiana	Sweetbay			X						A
Metrosideros polymorpha	Ohia	X	X		3			X	X	B
Nyssa aquatica	Water tupelo	X			8	X				A
N. sylvatica	Blackgum		X	X						A
N. sylvatica var. *biflora*	Swamp tupelo	X			7	X				A
Platanus occidentalis	American sycamore		X	X						A
Populus balsamifera	Balsam poplar		X							B
P. deltoides	Eastern cottonwood		X							B
P. grandidentata	Bigtooth aspen	X			7	X	X			A
P. heterophylla	Swamp cottonwood		X							B
P. tremuloides	Quaking aspen	X			9	X	X			A
P. trichocarpa	Black cottonwood	X	X		6	X				B
Prunus serotina	Black cherry	X	X		2	X				B
Quercus alba	White oak	X	X		2	X		X		B
Q. bicolor	Swamp white oak		X	X						B
Q. coccinea	Scarlet oak		X	X						B
Q. durandii	Durand oak			X						B
Q. falcata	Southern red oak		X	X						B
Q. falcata var. *pagodaefolia*	Cherrybark oak		X	X						B
Q. garryana	Oregon white oak			X						B
Q. kelloggii	California black oak	X	X		6	X				B
Q. laurifolia	Laurel oak	X		X	1	X				B
Q. lyrata	Overcup oak	X	X		4	X	X	X	X	B
Q. macrocarpa	Bur oak			X						B
Q. michauxii	Swamp chestnut oak			X						B
Q. muehlenbergii	Chinkapin oak			X						B
Q. nigra	Water oak	X	X		15	X				B
Q. nuttallii	Nuttall oak			X						B
Q. palustris	Pin oak			X						B
Q. phellos	Willow oak		X							B
Q. prinus	Chestnut oak	X			8	X	X	X	X	B
Q. rubra	Northern red oak	X	X		17	X	X			B
Q. shumardii	Shumard oak			X						B
Q. stellata	Post oak			X						B
Q. stellata var. *mississippiensis*	Delta post oak			X						B
Q. velutina	Black oak		X	X						B
Q. virginiana	Live oak			X						B
Robinia pseudoacacia	Black locust	X		X	1		X			C
Salix nigra	Black willow	X			5	X				C
Sassafras albidum	Sassafras			X						B
Tectona grandis	Teak	X	X		2	X	X	X		B
Tilia americana	American basswood		X							C
T. heterophylla	White basswood		X							C

Table 5.--Cuttingof veneer--continued

Botanical name	Common name	Source of information			Number of logs cut at Laboratory	How veneer was cut				Ease of bark removal by machine[1]
		Veener cutting research	Industrial use	Basic log and wood properties		Rotary	Flat sliced	Quarter-sliced	Rift sliced	
		UNITED STATES HARDWOODS--continued								
Ulmus alata	Winged elm			X						B
U. americana	American elm		X							B
U. crassifolia	Cedar elm			X						B
U. rubra	Slippery elm		X							B
U. thomasii	Rock elm			X						B
Umbellularia californica	California laurel	X	X		2	X				--
		UNITED STATES SOFTWOODS								
Abies amabilis	Pacific silver fir	X	X		8	X				A
A. balsamea	Balsam fir			X						A
A. concolor	White fir	X	X		8	X	X	X	X	A
A. grandis	Grand fir		X	X						A
A. lasiocarpa	Subalpine fir			X						A
A. magnifica	California red fir	X	X		2	X				A
A. magnifica var. *shastensis*	Shasta red fir	X	X		2	X				A
A. procera	Noble fir		X	X						A
Chamaecyparis lawsoniana	Port-Orford-cedar	X	X		2					C
C. nootkatensis	Alaska-cedar			X						C
C. thyoides	Atlantic white-cedar			X						B
Juniperus deppeana	Alligator juniper	X			1	X				C
J. occidentalis	Western juniper	X			2	X				C
J. scopulorum	Rocky Mountain juniper			X						C
J. virginiana	Eastern redcedar		X							B
Larix laricina	Tamarack	X			5	X				B
L. occidentalis	Western larch	X	X		9	X	X	X		C
Libocedrus decurrens	Incense-cedar			X						C
Picea engelmannii	Engelmann spruce	X	X		2	X				A
P. glauca	White spruce		X							A
P. mariana	Black spruce		X							A
P. pungens	Blue spruce			X						A
P. rubens	Red spruce		X							A
P. sitchensis	Sitka spruce	X	X		5	X				A
Pinus albicaulis	Whitebark pine			X						A
P. attenuata	Knobcone pine			X						A
P. banksiana	Jack pine			X						A
P. clausa	Sand pine			X						A
P. contorta	Lodgepole pine	X			4	X	X			A
P. echinata	Shortleaf pine	X	X		6	X				A
P. elliottii	Slash pine	X	X		2	X				A
P. flexilis	Limber pine			X						A
P. glabra	Spruce pine			X						A
P. jeffreyi	Jeffrey pine		X	X						A
P. lambertiana	Sugar pine		X	X						A
P. monticola	Western white pine	X	X		1					A
P. palustris	Longleaf pine	X	X		2	X	X			A
P. ponderosa	Ponderosa pine	X	X		23	X	X	X		A
P. pungens	Table-Mountain pine			X						A
P. resinosa	Red pine	X	X		1	X	X			A
P. rigida	Pitch pine			X						A
P. sabiniana	Digger pine			X						A

Table 5.--Cutting of veneer--continued

Botanical name	Common name	Source of information			Number of logs cut at Laboratory	How veneer was cut				Ease of bark removal by machine[1]
		Veneer cutting research	Industrial use	Basic log and wood properties		Rotary	Flat sliced	Quarter-sliced	Rift sliced	
		UNITED STATES SOFTWOODS--continued								
P. serotina	Pond pine		X	X						A
P. strobus	Eastern white pine	X	X		3	X	X			A
P. taeda	Loblolly pine	X	X		10	X	X	X		A
P. virginiana	Virginia pine			X						A
Pseudotsuga menziesii	Douglas-fir coast	X	X		33	X	X	X		A
P. menziesii	Douglas-fir interior west		X							A
P. menziesii var. *glauca*	Douglas-fir interior north		X							A
P. menziesii var. *glauca*	Douglas-fir interior south		X							A
Sequoia gigantea	Big tree			X						C
S. sempervirens	Redwood	X	X		5	X	X	X	X	C
Taxodium distichum	Baldcypress		X							C
T. distichum var. *nutans*	Pondcypress		X							C
Taxus brevifolia	Pacific yew		X	X						--
Thuja occidentalis	Northern white-cedar			X						B
T. plicata	Western redcedar	X	X		1		X	X		C
Tsuga canadensis	Eastern hemlock		X	X						B
T. heterophylla	Western hemlock	X	X		4	X	X			B
T. mertensiana	Mountain hemlock			X						B

[1] A, species relatively easy to debark; B, intermediate; and C, difficult to debark.

Table 6.--log heating, veneer cutting and drying [1]

Botanical name	Common name	Suggested conditioning temperature: Rotary	Suggested conditioning temperature: Sliced	Aggravation of log splitting due to heating	Sensitivity to setting of-- Knife	Sensitivity to setting of-- Pressure bar	Drying time: Sapwood	Drying time: Heartwood	Defects in drying: Buckle	Defects in drying: Splits	Defects in drying: Collapse
		°F.	°F.								
UNITED STATES HARDWOODS											
Acacia koa	Koa	140-160	160-180	B	A	B	B	B	B	B	A
Acer macrophyllum	Bigleaf maple	80-120	120-140	B	A	A	B	B	B	B	A
A. nigrum	Black maple	160-180	170-190	B	B	B	B	B	B	B	B
A. rubrum	Red maple	100-140	130-150	B	A	A	C	C	A	A	A
A. saccharinum	Silver maple	80-120	120-140	B	A	A	C	C	B	B	A
A. saccharum	Sugar maple	160-190	170-190	A-B	C	C	B	B	A-B	B	A-B
A. negundo	Boxelder	80-120	120-140	--	--	--	--	--	--	--	--
Aesculus glabra	Ohio buckeye	40- 70	40- 70	A	--	--	--	--	--	--	--
A. octandra	Yellow buckeye	40- 70	40- 70	A	--	--	--	--	--	--	--
Alnus nepalensis	Nepal alder	100-140	140-160	A	A	A	B	B	A	A	A
A. rubra	Red alder	80-140	120-160	B	A	A	B	B	A	A	A
Arbutus menziesii	Pacific madrone	150-160	180-190	B	B	B	C	C	B	B	A
Betula alleghaniensis	Yellow birch	140-160	160-180	B	B	B	B	B	B	A	A-B
B. lenta	Sweet birch	140-160	160-180	B	B	B	B	B	B	A	A-B
B. nigra	River birch	120-140	140-160	B	B	B	--	--	A	A	A
B. papyrifera	Paper birch	120-140	140-160	B	B	B	B	B	A	B	A
B. papyrifera var. *humilis*	Alaskan paper birch	140-160	160-180	B	A	A	B	B	B	B	A
B. populifolia	Gray birch	120-140	140-160	--	--	--	--	--	--	--	--
Carya aquatica	Water hickory	160-180	190-200	C	C	B	C	C	B	B	A
C. cordiformis	Bitternut hickory	160-180	190-200	C	B	B	B	C	B	B	A
C. glabra	Pignut hickory	160-180	190-200	C	B	B	B	C	C	B	A
C. illinoensis	Pecan	160-180	170-180	C	B	B	B	C	C	B	A
C. laciniosa	Shellbark hickory	160-180	190-200	C	B	B	B	C	B	B	A
C. myristicaeformis	Nutmeg hickory	160-180	190-200	C	B	B	B	C	B	B	A
C. ovata	Shagbark hickory	160-180	190-200	C	B	B	B	C	B	B	A
C. tomentosa	Mockernut hickory	160-180	190-200	C	B	B	B	C	B	B	A
Cecropia peltata	Yagrumo hembra	50- 80	70- 80	A	B	A	B	--	B	B	B
Celtis laevigata	Sugarberry	120-140	140-160	--	--	--	--	--	--	--	--
C. occidentalis	Hackberry	120-140	140-160	A	A	A	B	B	A	A	A
Diospyros virginiana	Common persimmon	150-200	190-200	C	C	C	B	B	B	B	B
Eucalyptus robusta	Eucalyptus	140-160	180-200	C	B	B	C	C	B	B	B
Fagus grandifolia	American beech	160-180	180-190	B	B	B	B	B	B	A	A-B
Fraxinus americana	White ash	140-160	160-180	B	B	B	B	B	B	B	A
F. latifolia	Oregon ash	140-160	160-180	--	--	--	--	--	--	--	--
F. nigra	Black ash	120-140	140-160	B	B	B	B	B	B	A	A
F. pennsylvanica	Green ash	140-160	160-180	--	--	--	--	--	--	--	--
F. profunda	Pumpkin ash	140-160	160-180	--	--	--	--	--	--	--	--
F. quadrangulata	Blue ash	140-160	160-180	--	--	--	--	--	--	--	--
F. uhdei	Shamel ash	140-160	170-180	B	A	B	B	B	B	B	A
Gleditsia triacanthos	Honeylocust	140-160	180-190	B	B	B	B	B	A	B	A
Grevillea robusta	Silk-oak	150-160	170-180	B	A	A	C	C	A	A	A
Ilex opaca	American holly	150-160	170-180	--	--	--	--	--	--	--	--

Table 6.--Log heating, veneer cutting and drying[1]-continued

Botanical name	Common name	Suggested conditioning temperature: Rotary	Suggested conditioning temperature: Sliced	Aggravation of log splitting due to heating	Sensitivity to setting of--: Knife	Sensitivity to setting of--: Pressure bar	Drying time: Sapwood	Drying time: Heartwood	Defects in drying: Buckle	Defects in drying: Splits	Defects in drying: Collapse
		°F.	°F.								
				UNITED STATES HARDWOODS--continued							
Juglans cinerea	Butternut	70- 90	100-120	A	C	C	B	B	C	B	A
J. nigra	Black walnut	180 then 150	180 then 150	B	B	B	B	B	B	A	A
Liquidambar styraciflua	Sweetgum	120-140	140-160	A	A	B	C	C	A	B	B
Liriodendron tulipifera	Yellow-poplar	70-120	120-140	A	A	A	B	B	A	A	A
Lithocarpus densiflorus	Tanoak	150-160	180-190	C	B	B	C	C	B	C	C
Magnolia acuminata	Cucumbertree	70-120	120-140	A	A	A	--	--	A	A	A
M. grandiflora	Southern magnolia	70-120	120-140	A	A	A	--	--	A	A	A
M. virginiana	Sweetbay	70-120	120-140	A	A	A	--	--	A	A	A
Metrosideros polymorpha	Ohia	170-180	200-210	B	B	C	B	B	B	B	A
Nyssa aquatica	Water tupelo	120-140	150-160	A	A	A	C	C	B	A	B
N. sylvatica	Blackgum	120-140	150-160	A	A	A	C	C	B	A	B
N. sylvatica var. *biflora*	Swamp tupelo	120-140	150-160	A	A	A	C	C	B	A	B
Platanus occidentalis	American sycamore	120-140	150-160	B	A	A	C	C	C-B	B	B
Populus balsamifera	Balsam poplar	40- 70	40- 70	A	B	B	C	C	C	B	C
P. deltoides	Eastern cottonwood	40- 70	40- 70	A	B	B	C	C	C	B	C
P. grandidentata	Bigtooth aspen	40- 70	40- 70	A	B	A	C	C	B	A	B
P. heterophylla	Swamp cottonwood	40- 70	40- 70	A	B	B	C	C	C	B	C
P. tremuloides	Quaking aspen	40- 70	40- 70	A	B	A	C	C	B	A	B
P. trichocarpa	Black cottonwood	40- 70	40- 70	A	B	B	C	C	C	B	C
Prunus serotina	Black cherry	120-140	150-170	B	B	B	B	B	B	A	A
Quercus alba	White oak	140-160	180-200	C	B	B	C	C	A	B	B
Q. bicolor	Swamp white oak	140-160	180-200	C	B	B	C	C	A	B	B
Q. coccinea	Scarlet oak	140-160	180-200	C	B	B	C	C	A	B	--
Q. durandii	Durand oak	140-160	180-200	C	B	B	C	C	A	B	--
Q. falcata	Southern red oak	140-160	180-200	C	B	B	C	C	A	B	B
Q. falcata var. *pagodaefolia*	Cherrybark oak	140-160	180-200	C	B	B	C	C	A	B	B
Q. garryana	Oregon white oak	140-160	180-200	C	--	--	--	--	--	--	--
Q. kelloggii	California black oak	140-160	160-180	C	B	B	C	C	B	B	A
Q. laurifolia	Laurel oak	140-160	180-200	C	B	C	C	C	B	C	C
Q. lyrata	Overcup oak	140-160	180-200	C	B	B	C	C	B	C	C
Q. macrocarpa	Bur oak	140-160	180-200	C	B	B	C	C	--	--	--
Q. michauxii	Swamp chestnut oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. muehlenbergii	Chinkapin oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. nigra	Water oak	140-160	180-200	C	B	B	C	C	A	C	C
Q. nuttallii	Nuttall oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. palustris	Pin oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. phellos	Willow oak	140-160	180-200	C	B	B	C	C	A	C	C
Q. prinus	Chestnut oak	140-160	180-200	C	B	B	C	C	A	B	A
Q. rubra	Northern red oak	140-160	180-200	C	B	B	C	C	B	B	B
Q. shumardii	Shumard oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. stellata	Post oak	140-160	180-200	C	B	B	C	C	--	--	--
Q. stellata var. *mississippiensis*	Delta post oak	140-160	180-200	C	B	B	--	--	--	--	--
Q. velutina	Black oak	140-160	180-200	C	B	B	C	C	A	B	A
Q. virginiana	Live oak	160-170	200-210	C	B	B	--	C	--	C	--

Table 6.--Log heating, veneer cutting and drying[1]--continued

Botanical name	Common name	Suggested conditioning temperature: Rotary (°F.)	Suggested conditioning temperature: Sliced (°F.)	Aggravation of log splitting due to heating	Sensitivity to setting of--: Knife	Sensitivity to setting of--: Pressure bar	Drying time: Sapwood	Drying time: Heartwood	Defects in drying: Buckle	Defects in drying: Splits	Defects in drying: Collapse
			UNITED STATES HARDWOODS--continued								
Robinia pseudoacacia	Black locust	160-180	180-190	B	B	B	--	--	B	B	A
Salix nigra	Black willow	40- 70	40- 70	B	B	B	C	C	B	B	A
Sassafras albidum	Sassafras	100-120	120-150	--	--	--	--	--	--	--	--
Tectona grandis	Teak	190-200	200-210	B	A	B	C	C	A	A	A
Tilia americana	American basswood	40- 70	40- 70	A	C	B	B	B	A	A	A
T. heterophylla	White basswood	40- 70	40- 70	A	C	B	C	C	A	A	A
Ulmus alata	Winged elm	160-170	190-200	B	B	B	C	C	--	--	--
U. americana	American elm	120-140	150-170	B	B	B	C	C	C	B	A
U. crassifolia	Cedar elm	160-170	190-200	B	B	B	C	C	--	--	--
U. rubra	Slippery elm	120-140	180 then 150	B	B	B	C	C	C	B	A
U. thomasii	Rock elm	160-170	190-200	B	B	B	C	C	C	B	A
Umbellularia californica	California laurel	150-160	190-200	B	B	B	C	C	C	B	A
			UNITED STATES SOFTWOODS								
Abies amabilis	Pacific silver fir	70-150	130-160	B	B	B	B	B-C	B	B	A
A. balsamea	Balsam fir	70-130	120-150	B	B	B	B	C	B	B	A
A. concolor	White fir	70-150	130-160	B	B	B-C	C	C	B	B	A
A. grandis	Grand fir	70-150	130-160	B	B	B-C	B	C	B	B	A
A. lasiocarpa	Subalpine fir	70-130	120-150	B	B	B	B	C	B	B	A
A. magnifica	California red fir	70-150	130-160	B	B	B-C	B	C	B	B	A
A. magnifica var. *shastensis*	Shasta red fir	70-150	130-160	B	B	B-C	B	C	B	B	A
A. procera	Noble fir	70-150	130-160	B	B	B-C	B	B-C	B	B	A
Chamaecyparis lawsoniana	Port-Orford-cedar	120-160	140-160	B	A	B	B	B	A	A	A
C. nootkatensis	Alaska-cedar	120-140	140-160	B	A	B	B	B	A	A	A
C. thyoides	Atlantic white-cedar	60-100	100-130	A	A	B	B	B	A	A	A
Juniperus deppeana	Alligator juniper	140-160	160-180	B	C	B	B	A	B	C	A
J. occidentalis	Western juniper	140-160	160-180	B	C	B	B	A	B	C	A
J. scopulorum	Rocky Mountain juniper	140-160	160-180	B	C	B	B	A	B	C	A
J. virginiana	Eastern redcedar	140-160	160-180	B	C	B	B	A	B	B	A
Larix laricina	Tamarack	140-160	150-160	B	B	B	B	C	B	B	A
L. occidentalis	Western larch	140-150	160-180	B	B	B	B	C	A	B	A
Libocedrus decurrens	Incense-cedar	70-120	70-120	A	B	B	--	C	A	A	--
Picea engelmannii	Engelmann spruce	70-120	120-140	A	C	B	B	B	B	B	A
P. glauca	White spruce	70-120	120-140	A	C	B	B	B	B	B-C	A
P. mariana	Black spruce	70-120	120-140	A	C	B	B	B	B	B-C	A
P. pungens	Blue spruce	70-120	120-140	A	C	B	B	B	B	B	A
P. rubens	Red spruce	70-120	120-140	A	C	B	B	B	B	B-C	A
P. sitchensis	Sitka spruce	70-120	120-140	A	C	B	B	B	B	B	A

Table 6.--Log heating, veneer cutting and drying[1]--continued

Botanical name	Common name	Suggested conditioning temperature: Rotary (°F.)	Suggested conditioning temperature: Sliced (°F.)	Aggravation of log splitting due to heating	Sensitivity to setting of--: Knife	Sensitivity to setting of--: Pressure bar	Drying time: Sapwood	Drying time: Heartwood	Defects in drying: Buckle	Defects in drying: Splits	Defects in drying: Collapse
				UNITED STATES SOFTWOODS--continued							
Pinus albicaulis	Whitebark pine	60-120	120-140	A	C	B	B	B	B	B	A
P. attenuata	Knobcone pine	60-140	140-180	A	B	B	B	--	B	B	A
P. banksiana	Jack pine	70-120	120-140	A	B	B	--	--	--	--	--
P. clausa	Sand pine	120-160	140-180	A	B	B	B	B	B	B	A
P. contorta	Lodgepole pine	60-140	140-180	A	A	A	B	C	B	B	A
P. echinata	Shortleaf pine	120-160	160-180	A	B	B	B	B	B	B	A
P. elliottii	Slash pine	120-160	160-180	A	B	B	B	B	B	B	A
P. flexilis	Limber pine	60-120	120-140	A	C	B	B	C	B	B	A
P. glabra	Spruce pine	120-140	140-160	A	B	B	B	B	B	B	A
P. jeffreyi	Jeffrey pine	60-140	140-180	A	A	A	B	B	A	B	A
P. lambertiana	Sugar pine	60-120	120-140	A	B	B	B	C	A	B	A
P. monticola	Western white pine	60-120	120-140	A	B	B	B	C	A	B	A
P. palustris	Longleaf pine	120-160	160-180	A	B	B	B	B	B	B	A
P. ponderosa	Ponderosa pine	60-140	140-180	A	A	A	B	B	A	B	A
P. pungens	Table-Mountain pine	120-160	160-180	A	B	B	B	B	B	B	A
P. resinosa	Red pine	70-120	120-140	A	B	B	B	B	B	B	A
P. rigida	Pitch pine	120-160	160-180	A	B	B	B	B	B	B	A
P. sabiniana	Digger pine	60-140	140-180	A	B	B	B	B	B	B	A
P. serotina	Pond pine	120-160	160-180	A	B	C	B	B	B	B	A
P. strobus	Eastern white pine	70-120	120-140	A	B	B	B	B	B	B	A
P. taeda	Loblolly pine	120-160	160-180	A	B	B	B	B	B-C	B-C	A
P. virginiana	Virginia pine	120-160	160-180	A	B	B	B	B	B	B	A
Pseudotsuga menziesii	Douglas-fir coast	60-140	140-180	A	B	B	B	B	A	B	A
P. menziesii	Douglas-fir interior west	60-140	140-180	A	B	B	B	B	A	B	A
P. menziesii var. *glauca*	Douglas-fir interior north	60-140	140-180	A	B	B	B	B	A	B	A
P. menziesii var. *glauca*	Douglas-fir interior south	60-140	140-180	A	B	B	B	B	A	B	A
Sequoia gigantea	Big tree	70-160	160-180	B	B	C	C	C	A	C	A
S. sempervirens	Redwood	70-160	160-180	B	B	C	C	C	A	C	A
Taxodium distichum	Baldcypress	60-120	120-140	A	B	C	C	C	A	B	A
T. distichum var. *nutans*	Pondcypress	60-120	120-140	A	B	C	C	C	A	B	A
Taxus brevifolia	Pacific yew	160-180	180-200	--	B	B	--	B	C	B	A
Thuja occidentalis	Northern white-cedar	120-140	140-160	B	C	C	--	C	A	B	B
T. plicata	Western redcedar	140-160	160-180	B	C	C	B	C	A	B	B
Tsuga canadensis	Eastern hemlock	120-160	160-180	B	B	C	B	C	B	B	A
T. heterophylla	Western hemlock	120-160	160-180	B	B	C	B	C	B	B	A
T. mertensiana	Mountain hemlock	120-160	160-180	B	B	C	B	C	B	B	A

[1] A, species property very suitable for veneer; B, intermediate; and C, less desirable for veneer.

Table 7.--Veneer characteristics originating in log storage and proceeding[1]

Botanical name	Common name	Relative freedom from veneer characteristics originating in log storage and in processing								
		Sap stains	Mold	Iron stain	Oxidative stain	Bacteria		Surface irregularities		
						Odor	Extreme permeability	Fuzzy	Shelling	Rough
UNITED STATES HARDWOODS										
Acacia koa	Koa	A	A	B	B	--	--	A	A	B
Acer macrophyllum	Bigleaf maple	A	B	B	C	A	A	A	A	B
A. nigrum	Black maple	A	B	B	C	A	A	A	A	B
A. rubrum	Red maple	A	B	B	C	A	A	A	A	B
A. saccharinum	Silver maple	A	B	B	C	A	A	A	A	B
A. saccharum	Sugar maple	C	B	B	C	A	A	B	A	B
A. negundo	Boxelder	A	B	B	C	--	--	--	--	--
Aesculus glabra	Ohio buckeye	--	--	--	C	--	--	--	--	--
A. octandra	Yellow buckeye	--	--	--	C	--	--	--	--	--
Alnus nepalensis	Nepal alder	B	B	B	C	B	B	B	A	A
A. rubra	Red alder	A	B	B	C	A	A	B	A	A
Arbutus menziesii	Pacific madrone	A	B	B	B	A	A	A	A	A
Betula alleghaniensis	Yellow birch	A	B	B	B	A	A	A	B	A
B. lenta	Sweet birch	A	B	B	B	A	A	A	A	B
B. nigra	River birch	A	B	B	C	--	--	A	A	B
B. papyrifera	Paper birch	A	B	B	C	B	A	A	B	B
B. papyrifera var. *humilis*	Alaskan paper birch	B	B	A	B	--	--	B	A	B
B. populifolia	Gray birch	A	B	B	C	--	--	--	--	--
Carya aquatica	Water hickory	B	B	B	A	A	A	A	A	C
C. cordiformis	Bitternut	B	B	B	A	A	A	A	A	C
C. glabra	Pignut hickory	B	A	B	B	A	A	A	A	C
C. illinoensis	Pecan	B	A	B	B	A	A	A	A	C
C. laciniosa	Shellbark hickory	B	B	B	A	A	A	A	A	C
C. myristicaeformis	Nutmeg hickory	B	B	B	A	A	A	A	A	C
C. ovata	Shagbark hickory	B	B	B	A	A	A	A	A	C
C. tomentosa	Mockernut hickory	B	B	B	A	A	A	A	A	C
Cecropia peltata	Yagrumo hembra	C	B	B	B	B	B	B	A	A
Celtis laevigata	Sugarberry	C	C	C	C	--	--	--	--	--
C. occidentalis	Hackberry	C	C	B	C	A	A	B	B	B
Diospyros virginiana	Common persimmon	A	A	A	C	A	A	A	A	B
Eucalyptus robusta	Eucalyptus	B	B	C	C	A	A	A	A	B
Fagus grandifolia	American beech	A	B	B	B	A	A	A	A	B

Table 7.--Veneer characteristics originating in log storage and processing[1]--continued

Botanical name	Common name	Relative freedom from veneer characteristics originating in log storage and in processing								
		Sap stains	Mold	Iron stain	Oxidative stain	Bacteria		Surface irregularities		
						Odor	Extreme permeability	Fuzzy	Shelling	Rough
UNITED STATES HARDWOODS--continued										
Fraxinus americana	White ash	B	B	B	C	A	A	A	A	B
F. latifolia	Oregon ash	B	B	B	--	--	--	A	A	B
F. nigra	Black ash	B	B	B	A	A	A	A	A	B
F. pennsylvanica	Green ash	B	B	B	--	--	--	A	A	B
F. profunda	Pumpkin ash	B	B	B	--	--	--	A	A	B
F. quadrangulata	Blue ash	B	B	B	--	--	--	A	A	B
F. uhdei	Shamel ash	B	B	A	A	A	A	A	A	A
Gleditsia triacanthos	Honeylocust	A	B	B	A	A	A	A	A	B
Grevillea robusta	Silk-oak	A	A	B	A	A	A	A	A	A
Ilex opaca	American holly	C	--	--	--	--	--	A	A	A
Juglans cinerea	Butternut	A	B	B	B	A	A	C	A	A
J. nigra	Black walnut	A	B	C	B	A	A	B	A	A
Liquidambar styraciflua	Sweetgum	C	C	B	B	B	A	A	B	A
Liriodendron tulipifera	Yellow-poplar	C	C	A	B	C	B	B	A	A
Lithocarpus densiflorus	Tanoak	A	A	C	C	A	A	A	A	C
Magnolia acuminata	Cucumbertree	B	C	A	C	C	B	A	A	A
M. grandiflora	Southern magnolia	B	C	A	C	C	B	A	A	A
M. virginiana	Sweetbay	B	C	A	C	C	B	A	A	A
Metrosideros polymorpha	Ohia	A	A	B	B	A	A	A	A	B
Nyssa aquatica	Water tupelo	B	B	A	C	--	--	A	A	A
N. sylvatica	Black tupelo	B	B	A	C	--	--	A	A	A
N. sylvatica var. *biflora*	Swamp tupelo	B	B	A	C	--	--	A	A	B
Platanus occidentalis	American sycamore	B	B	A	A	A	A	A	A	B
Populus balsamifera	Balsam poplar	B	C	A	B	C	--	C	A	B
P. deltoides	Eastern cottonwood	B	C	A	B	C	B	C	A	B
P. grandidentata	Bigtooth aspen	B	C	A	B	C	--	C	A	B
P. heterophylla	Swamp cottonwood	B	C	A	B	C	--	C	A	B
P. tremuloides	Quaking aspen	B	C	A	B	C	--	C	A	B
P. trichocarpa	Black cottonwood	B	C	A	B	C	B	C	A	B
Prunus serotina	Black cherry	A	A	C	B	A	A	A	A	A
Quercus alba	White oak	A	A	C	C	A	A	A	A	B-C
Q. bicolor	Swamp white oak	A	A	C	C	A	A	A	A	B-C
Q. coccinea	Scarlet oak	A	A	C	C	A	A	A	A	B-C
Q. durandii	Durand oak	A	A	C	C	A	A	A	A	B-C
Q. falcata	Southern red oak	A	A	C	C	A	A	A	A	B-C
Q. falcata var. *pagodaefolia*	Cherrybark oak	A	A	C	C	A	A	A	A	B-C
Q. garryana	Oregon white oak	A	A	C	C	A	A	A	A	B-C
Q. kelloggii	California black oak	A	A	C	C	A	A	A	A	B-C

Table 7.--Veneer characteristics originating in log storage and processing[1]--continued

Botanical name	Common name	Relative freedom from veneer characteristics originating in log storage and in processing								
		Sap stains	Mold	Iron stain	Oxidative stain	Bacteria		Surface irregularities		
						Odor	Extreme permeability	Fuzzy	Shelling	Rough
UNITED STATES HARDWOODS--continued										
Quercus laurifolia	Laurel oak	A	A	C	C	A	A	A	A	B-C
Q. lyrata	Overcup oak	A	A	C	C	A	A	A	A	B-C
Q. macrocarpa	Bur oak	A	A	C	C	A	A	A	A	B-C
Q. michauxii	Swamp chestnut oak	A	A	C	C	A	A	A	A	B-C
Q. muehlenbergii	Chinkapin oak	A	A	C	C	A	A	A	A	B-C
Q. nigra	Water oak	A	A	C	C	A	A	A	A	B-C
Q. nuttallii	Nuttall oak	A	A	C	C	A	A	A	A	B-C
Q. palustris	Pin oak	A	A	C	C	A	A	A	A	B-C
Q. phellos	Willow oak	A	A	C	C	A	A	A	A	B-C
Q. prinus	Chestnut oak	A	A	C	C	A	A	A	A	B-C
Q. rubra	Northern red oak	A	A	C	C	A	A	A	A	B-C
Q. shumardii	Shumard oak	A	A	C	C	A	A	A	A	B-C
Q. stellata	Post oak	A	A	C	C	A	A	A	A	B-C
Q. stellata var. *mississippiensis*	Delta post oak	A	A	C	C	A	A	A	A	B-C
Q. velutina	Black oak	A	A	C	C	A	A	A	A	B-C
Q. virginiana	Live oak	A	A	C	C	A	A	A	A	B-C
Robinia pseudoacacia	Black locust	A	A	C	B	A	A	A	A	B
Salix nigra	Black willow	C	C	B	C	B	B	C	A	B
Sassafras albidum	Sassafras	B	B	C	--	--	--	--	--	--
Tectona grandis	Teak	A	A	B	A	A	A	A	A	B
Tilia americana	American basswood	B	B	A	C	A	A	C	A	A
T. heterophylla	White basswood	B	B	A	C	A	A	C	A	A
Ulmus alata	Winged elm	B	A	A	B	B	A	--	--	--
U. americana	American elm	A	A	A	B	B	A	B	B	B
U. crassifolia	Cedar elm	B	A	A	B	B	A	--	--	--
U. rubra	Slippery elm	A	A	A	B	B	A	B	B	B
U. thomasii	Rock elm	A	A	A	B	B	A	B	B	B
Umbellularia californica	California laurel	B	--	B	C	A	A	A	A	B
UNITED STATES SOFTWOODS										
Abies amabilis	Pacific silver fir	A	A	A	A	B	B	B	B	B
A. balsamea	Balsam fir	A	A	A	A	B	B	B	B	B
A. concolor	White fir	A	A	A	A	B	B	B	B	B
A. grandis	Grand fir	A	A	A	A	B	B	B	B	B
A. lasiocarpa	Subalpine fir	A	A	A	A	B	B	B	B	B
A. magnifica	California red fir	A	A	A	A	B	B	B	B	B
A. magnifica var. *shastensis*	Shasta red fir	A	A	A	A	B	B	B	B	B
A. procera	Noble fir	A	A	A	B	B	B	B	B	B
Chamaecyparis lawsoniana	Port-Orford-cedar	A	A	B	B	A	A	A	A	A
C. nootkatensis	Alaska-cedar	A	A	B	B	A	A	A	A	A
C. thyoides	Atlantic white-cedar	C	A	B	B	A	A	B	A	B

Table 7.--Veneer characteristics originating in log storage and processing[1]--continued

Botanical name	Common name	Relative freedom from veneer characteristics originating in log storage and in processing								
		Sap stains	Mold	Iron stain	Oxidative stain	Bacteria: Odor	Bacteria: Extreme permeability	Surface irregularities: Fuzzy	Surface irregularities: Shelling	Surface irregularities: Rough
UNITED STATES SOFTWOODS--continued										
Juniperus deppeana	Alligator juniper	A	A	B	A	A	A	A	A	B
J. occidentalis	Western juniper	A	A	B	A	A	A	A	A	B
J. scopulorum	Rocky Mountain juniper	A	A	B	A	A	A	A	A	B
J. virginiana	Eastern redcedar	A	A	B	A	A	A	A	A	B
Larix laricina	Tamarack	A	A	B	A	A	A	B	B	B
L. occidentalis	Western larch	A	A	B	A	A	A	A	B	B
Libocedrus decurrens	Incense-cedar	A	A	C	B	A	A	B	B	B
Picea engelmannii	Engelmann spruce	B	B	A	A	A	A	C	B	B
P. glauca	White spruce	B	B	A	A	A	A	C	B	B
P. mariana	Black spruce	B	B	A	A	A	A	C	B	B
P. pungens	Blue spruce	B	B	A	A	A	A	C	B	B
P. rubens	Red spruce	B	B	A	A	A	A	C	B	B
P. sitchensis	Sitka spruce	B	B	A	A	A	A	C	B	B
Pinus albicaulis	Whitebark pine	B-C	B	A	B	B	B	C	B	B
P. attenuata	Knobcone pine	B	B	A	B	B	B	B	B	B
P. banksiana	Jack pine	B	B	A	B	B	B	--	--	--
P. clausa	Sand pine	C	C	A	A	B	C	A	B	B
P. contorta	Lodgepole pine	B	B	A	B	B	B	B	A	A
P. echinata	Shortleaf pine	C	C	A	A	B	C	A	B	B
P. elliottii	Slash pine	C	C	A	A	B	C	A	B	B
P. flexilis	Limber pine	B	B	A	B	B	B	C	B	B
P. glabra	Spruce pine	C	C	A	A	B	C	A	B	B
P. jeffreyi	Jeffrey pine	C	B	A	C	B	C	A	A	B
P. lambertiana	Sugar pine	B	B	A	C	B	C	B	B	B
P. monticola	Western white pine	B	B	A	C	B	C	B	B	B
P. palustris	Longleaf pine	C	C	A	A	B	C	A	B	B
P. ponderosa	Ponderosa pine	C	B	A	C	B	C	A	A	B
P. pungens	Table-Mountain pine	C	C	A	A	B	C	A	B	B
P. resinosa	Red pine	B	B	A	A	B	B	B	B	B
P. rigida	Pitch pine	C	C	A	A	B	C	A	B	B
P. sabiniana	Digger pine	C	B	A	B	B	C	A	B	B
P. serotina	Pond pine	C	C	A	A	B	C	A	B	B
P. strobus	Eastern white pine	B	B	A	B	B	B	B	B	B
P. taeda	Loblolly pine	C	C	A	A	B	C	A	B	B
P. virginiana	Virginia pine	C	C	A	A	B	C	A	B	B
Pseudotsuga menziesii	Douglas-fir coast	A	A	B	A	A	A	A	B	B
P. menziesii	Douglas-fir interior west	A	A	B	A	A	A	A	B	B
P. menziesii var. *glauca*	Douglas-fir interior north	A	A	B	A	A	A	A	B	B
P. menziesii var. *glauca*	Douglas-fir interior south	A	A	B	A	A	A	A	B	B
Sequoia gigantea	Big tree	A	A	C	B	A	A	B	C	B
S. sempervirens	Redwood	A	A	C	B	A	A	B	C	B

Table 7 .--Veneer characteristics originating in log storage and processing[1]--continued

Botanical name	Common name	Relative freedom from veneer characteristics originating in log storage and in processing								
		Sap stains	Mold	Iron stain	Oxidative stain	Bacteria		Surface irregularities		
						Odor	Extreme permeability	Fuzzy	Shelling	Rough
UNITED STATES SOFTWOODS--continued										
Taxodium distichum	Baldcypress	B	B	B	B	B	B	B	C	B
T. distichum var. *nutans*	Pondcypress	B	B	B	B	B	B	B	C	B
Taxus brevifolia	Pacific yew	--	--	--	--	A	A	A	A	B
Thuja occidentalis	Northern white-cedar	A	A	B	--	A	A	B	C	B
T. plicata	Western redcedar	A	A	C	--	A	A	B	C	B
Tsuga canadensis	Eastern hemlock	B	B	B	B	B	B	B	C	B
T. heterophylla	Western hemlock	B	B	B	B	B	B	B	C	B
T. mertensiana	Mountain hemlock	B	B	B	B	B	B	B	C	B

[1] A, good--species resists development of undesirable characteristics under a wide range of operating conditions; B, species intermediate in resistance; and C, poor--species susceptible to this undesirable development.

Table 8.--Clear veneer, figure in veneer, and suitability for different uses

Botanical name	Common name	Clear veneer[1]	Figure of veneer		Relative suitability for--[2]				
			Rotary- and flat-sliced	Quarter- and rift-sliced	Construction plywood	Decorative face veneer	Inner plies of decorative panels	Container veneer and plywood	Other
				UNITED STATES HARDWOODS					
Acacia koa	Koa	A	Irregular grain, dark streaks	Curly, wavy grain, fiddleback dark streaks	B-C	A	B	B-C	
Acer macrophyllum	Bigleaf maple	B	Faint growth ring, occasional burls, blister, curly, and quilted	Most plain, occasionally curly and wavy	C	A	B	A	
A. nigrum	Black maple	A	Faint growth ring, occasionally curly, wavy, birdseye	Most plain, occasionally curly and wavy, small dark rays	B	A	B	A	
A. rubrum	Red maple	B	Faint growth ring, occasionally curly or wavy, often with pith flecks	...do...	B	B	A	A	
A. saccharinum	Silver maple	B	...do...	...do...	C	B	A	A	
A. saccharum	Sugar maple	A	Faint growth ring, occasionally curly, fiddleback, birdseye, wavy	...do...	B	A	B	A	
A. negundo	Boxelder	C	Faint growth ring, close grained like the maples	Plain	C	B	C	B	
Aesculus glabra	Ohio buckeye	--	Faint growth ring, close grain	...do...	C	C	A	B	
A. octandra	Yellow buckeye	--	...do...	...do...	C	C	A	B	
Alnus nepalensis	Nepal alder	B	Faint growth ring. Large rays slightly darker than background	Scattered large flakes from wood rays	C	B	A-B	A	
A. rubra	Red alder	C	...do...	Occasional large flakes	C	B	B	B	
Arbutus menziesii	Pacific madrone	B	Faint growth ring, close grain, figure due to pigment changes in heartwood	Bland figure is limited to color changes in the heartwood	C	A	C	B	
Betula alleghaniensis	Yellow birch	A	Distinct not conspicuous growth ring, occasionally wavy	Generally plain, occasionally wavy	B	A	B	B	
B. lenta	Sweet birch	A	...do...	...do...	B	A	B	B	
B. nigra	River birch	-	...do...	...do...	B	B	B	B	
B. papyrifera	Paper birch	B	...do...	...do...	B	A-B	B	B	
B. papyrifera var. *humilis*	Alaskan paper birch	C	Faint growth ring pattern. Slow grown. Many knots and burls	Too small to quarter-slice	B	A-B	B	B	
B. populifolia	Gray birch	C	Distinct not conspicuous growth ring, occasionally wavy	Generally plain, occasionally wavy	C	B	B	B	

Carya aquatica	Water hickory	:	C	Distinct not conspicuous growth ring, almost always straight grain	Faint growth rings, fine rays, occasional dark stripes	:	B	:	A	:	C	:	B	:		
C. cordiformis	Bitternut	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. glabra	Pignut hickory	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. illinoensis	Pecan	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. laciniosa	Shellbark hickory	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. myristicaeformis	Nutmeg hickory	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. ovata	Shagbark hickory	:	C	do	do	:	B	:	A	:	C	:	B	:		
C. tomentosa	Mockernut hickory	:	C	do	do	:	B	:	A	:	C	:	B	:		
Cecropia peltata	Yagrumo hembra	:	A	Plain, moderate-sized vessels	Plain	:	C	:	C	:	B-C	:	B	:	Toy airplanes	
Celtis laevigata	Sugarberry	:	--	Conspicuous growth ring	Distinct not conspicuous growth stripe, fine sparkle from small rays	:	B	:	B	:	C	:	A	:		
C. occidentalis	Hackberry	:	B	do	do	:	B	:	A-B	:	C	:	A	:		
Diospyros virginiana	Common persimmon	:	C	Distinct not conspicuous growth ring	Occasional ribbon due to interlocked grain	:	C	:	A-B	:	C	:	B	:	Laminated golf club heads	
Eucalyptus robusta	Eucalyptus	:	B	Faint growth patterns. Occasional crossbar. Many pin knots	Ribbon grain. Occasional crossbar. Many pin knots	:	B	:	A-B	:	C	:	B	:		
Fagus grandifolia	American beech	:	B	Faint growth ring	Numerous small flakes up to 1/8 inch in height	:	B	:	B	:	C	:	A	:	Plywood flooring	
Fraxinus americana	White ash	:	A-B	Conspicuous growth ring, occasional burls and cross figure	Distinct not conspicuous growth ring, occasional burl	:	B	:	A	:	B	:	A	:		
F. latifolia	Oregon ash	:	B	do	do	:	C	:	A	:	B	:	A	:		
F. nigra	Black ash	:	B	do	do	:	B	:	A	:	B	:	A	:		
F. pennsylvanica	Green ash	:	B	do	do	:	B	:	A	:	B	:	A	:		
F. profunda	Pumpkin ash	:	B	do	do	:	C	:	B	:	C	:	B	:		
F. quadrangulata	Blue ash	:	B	do	do	:	B	:	A	:	B	:	A	:		
F. uhdei	Shamel ash	:	A	Pronounced parabolas from the wide growth rings. Occasional pin knots	Distinct stripe from growth rings. Faint crossbar	:	B	:	A	:	B	:	A	:		
Gleditsia triacanthos	Honeylocust	:	A	Conspicuous growth ring	Distinct not conspicuous growth ring, occasional mild cross figure	:	C	:	A	:	C	:	B	:		

Table 8.–Clear veneer, figure in veneer, and suitability for different uses--continued

Botanical name	Common name	Clear veneer[1]	Figure of veneer		Relative suitability for--[2]				
			Rotary- and flat-sliced	Quarter- and rift-sliced	Construction plywood	Decorative face veneer	Inner plies of decorative panels	Container veneer and plywood	Other
				UNITED STATES HARDWOODS--continued					
Grevillea robusta	Silk-oak	A	Faint growth ring pattern	Moderate-sized ray flakes lead to the name "lacewood"	B	A	B	B	
Ilex opaca	American holly	C	Very close grain, almost no visible pattern	Very plain uniform texture	C	A	C	C	
Juglans cinerea	Butternut	C	Faint to moderate growth ring, very lustroua	Plain; the figure is due to color and luster	C	A	C	C	
J. nigra	Black walnut	B	Distinct not conspicuous growth ring, occasional wavy and cross figure	Inconspicuous growth stripe, occasional burl, crotch, curly	B	A	B	B	
Liquidambar styraciflua	Sweetgum	A	Faint growth ring, occasionally irregular darker streaks	Distinct not pronounced ribbon, occasionally irregular darker streaks	B	B	B	A	
Liriodendron tulipifera	Yellow-poplar	A	Faint growth ring	Plain	B	B	A	A	
Lithocarpus densiflorus	Tanoak	B	Plain, occasional burls	Inconspicuous wood rays and occasional burls	B	B	C	B	
Magnolia acuminata	Cucumbertree	A	Faint growth ring	Plain	B	C	A	A	
M. grandiflora	Southern magnolia	A	...do...	...do...	B	C	A	A	
M. virginiana	Sweetbay	A	...do...	...do...	B	C	A	A	
Metrosideros polymorpha	Ohia	B	Faint growth ring pattern. Occasional burls	Poorly defined ribbon grain	B	B	C	B	Face for plywood flooring
Nyssa aquatica	Water tupelo	A	Faint growth ring	Distinct not pronounced ribbon, low luster	B	B	B	A	
N. sylvatica	Black tupelo	A	...do...	...do...	B	B	B	A	
N. sylvatica var. *biflora*	Swamp tupelo	A	...do...	...do...	B	B	B	A	
Platanus occidentalis	American sycamore	B	...do...	Pronounced reddish flakes up to 1/4 inch in height	B	A	B	A	
Populus balsamifera	Balsam poplar	B	...do...	Plain	C	B	B	A	
P. deltoides	Eastern cottonwood	B	...do...	...do...	C	C	B	A	
P. grandidentata	Bigtooth aspen	B	...do...	Occasional cross figure, silky luster	C	B	A	A	Underlayment plywood
P. heterophylla	Swamp cottonwood	B	...do...	Plain	C	B	B	A	
P. tremuloides	Quaking aspen	B	...do...	Occasional cross figure, silky luster	C	B	A	A	Do.

P. trichocarpa	Black cottonwood	B	ditto	Plain	C	C	B	A		
Prunus serotina	Black cherry	B	Faint growth ring, occasional burl, pin knots, and gum spots common	Light colored small ray flecks, satiny luster	B	A	B	A		
Quercus alba	White oak	B	Conspicuous growth ring, rotary-cut veneer has a watery figure with great contrast	Pronounced flake on the true quarter and a narrow flake when rift cut; distinct not conspicuous growth ring stripe	B	A	B	B		
Q. bicolor	Swamp white oak	B	ditto	ditto	B	A	B	B		
Q. coccinea	Scarlet oak	B	ditto	ditto	B	A	B	B		
Q. durandii	Durand oak	B	ditto	ditto	B	A	B	B		
Q. falcata	Southern red oak	B	ditto	ditto	B	A	B	B		
Q. falcata var. *pagodaefolia*	Cherrybark oak	B	ditto	ditto	B	A	B	B		
Q. garryana	Oregon white oak	C	ditto	ditto	C	B	C	B		
Q. kelloggii	California black oak	C	ditto	ditto	B	A	B	B		
Q. laurifolia	Laurel oak	C	ditto	ditto	B	B	C	B		
Q. lyrata	Overcup oak	B	ditto	ditto	B	B	C	B		
Q. macrocarpa	Bur oak	B	ditto	ditto	B	B	B	B		
Q. michauxii	Swamp chestnut oak	B	ditto	ditto	B	A	B	B		
Q. muehlenbergii	Chinkapin oak	B	ditto	ditto	B	B	C	B		
Q. nigra	Water oak	C	ditto	ditto	B	B	C	B		
Q. nuttallii	Nuttall oak	B	ditto	ditto	B	A	B	B		
Q. palustris	Pin oak	C	ditto	ditto	B	A	C	B		
Q. phellos	Willow oak	C	ditto	ditto	B	B	C	B		
Q. prinus	Chestnut oak	B	ditto	ditto	B	A	B	B		
Q. rubra	Northern red oak	B	ditto	ditto	B	A	B	B		
Q. shumardii	Shumard oak	B	ditto	ditto	B	A	B	B		
Q. stellata	Post oak	C	ditto	ditto	B	B	C	B		
Q. stellata var. *mississippiensis*	Delta post oak	B	ditto	ditto	B	A	B	B		
Q. velutina	Black oak	C	ditto	ditto	B	A	B	B		
Q. virginiana	Live oak	C	Moderate growth ring	Pronounced ray flakes	C	B	C	B		
Robinia pseudoacacia	Black locust	C	Distinct growth ring, dark streaks associated with borer holes	Distinct not conspicuous growth ring	C	B	C	B		
Salix nigra	Black willow	B	Faint growth ring	Plain, fine texture	C	B-C	B	B		
Sassafras albidum	Sassafras	--	Pronounced growth ring	Distinct not conspicuous growth ring	C	B	C	B		
Tectona grandis	Teak	A	Moderate growth rings, dark irregular streaks, occasional burls	Faint growth stripe, dark irregular streaks, sometimes mottled, fiddleback or curly grain	B	A	B	B		
Tilia americana	American basswood	A	Faint growth ring	Plain, fine texture	C	C	A	A		
T. heterophylla	White basswood	A	ditto	ditto	C	C	A	A		
Ulmus alata	Winged elm	B	Distinct growth ring with fine wavy pattern within each ring	Faint growth ring stripe	B	A	C	A		
U. americana	American elm	B	ditto	ditto	B	A	B	A		

Table 8.--Clear veneer, figure in veneer, and suitability for different uses—continued

Botanical name	Common name	Clear veneer[1]	Figure of veneer		Relative suitability for--[2]				
			Rotary- and flat-sliced	Quarter- and rift-sliced	Construction plywood	Decorative face veneer	Inner plies of decorative panels	Containertype veneer and plywood	Other
UNITED STATES SOFTWOODS--continued									
U. crassifolia	Cedar elm	B	....do....	....do....	B	A	C	A	
U. rubra	Slippery elm	B	Conspicuous growth ring with fine wavy pattern within each ring	Distinct growth ring stripe	B	A	B	A	
U. thomasii	Rock elm	B	....do....	Faint growth ring stripe	B	A	C	A	
Umbellularia californica	California laurel	C	Faint growth ring, occasional burl or blisters	Mixture of plain and highly figured due to mottle, stumps, and burls	C	A	C	C	
UNITED STATES SOFTWOODS									
Abies amabilis	Pacific silver fir	C	Conspicuous growth ring	Faint growth ring stripe	A-B	C	B-C	A	
A. balsamea	Balsam fir	C	Distinct, not conspicuous growth ring	....do....	B-C	C	C	A	
A. concolor	White fir	C	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	A-B	C	B-C	A	
A. grandis	Grand fir	C	....do....	....do....	A-B	C	B-C	A	
A. lasiocarpa	Supalpine fir	C	....do....	....do....	B-C	C	C	A	
A. magnifica	California red fir	B-C	....do....	....do....	A-B	C	B-C	A	
A. magnifica var. *shastensis*	Shasta red fir	B-C	....do....	....do....	A-B	C	B-C	A	
A. procera	Noble fir	B	....do....	....do....	A-B	C	B-C	A	
Chamaecyparis lawsoniana	Port-Orford-cedar	A	Faint growth ring	Faint growth ring stripe	B	B	A	A	
C. nootkatensis	Alaska-cedar	B	....do....	None	B	B	A	A	Small boat parts
C. thyoides	Atlantic white-cedar	C	Distinct, not conspicuous growth ring	None	C	B	A	A	
Juniperus deppeana	Alligator juniper	C	Distinct growth ring, many knots, mixed white sapwood and light red-brown heartwood	Too small to quarter-slice	C	C	C	C	
J. occidentalis	Western juniper	C	....do....	....do....	C	C	C	C	
J. scopulorum	Rocky Mountain juniper	C	....do....	....do....	C	C	C	C	
J. virginiana	Eastern redcedar	B-C	Distinct growth ring, many knots, streaks of white sapwood alternating with purple-red to dark red heartwood	Faint growth rings. Spike knots included sapwood	C	A	B	C	Cedar chests

Larix laricina	Tamarack	C	Conspicuous growth ring	Distinct, not conspicuous growth-ring stripe	A-B	B	C	B		
L. occidentalis	Western larch	B	do.	do.	A	B	C	B		
Lithocedrus decurrens	Incense-cedar	C	Faint growth ring	Faint growth ring stripe	B-C	B	B	B		
Picea engelmannii	Engelmann spruce	C	Faint growth ring	None	B	C	C	A		
P. glauca	White spruce	C	do.	None	B-C	C	C	A		
P. mariana	Black spruce	C	do.	None	B-C	C	C	A		
P. pungens	Blue spruce	C	do.	None	B-C	C	C	A		
P. rubens	Red spruce	C	do.	None	B	C	C	A		
P. sitchensis	Sitka spruce	B	do.	None	A-B	B	B	A	Aircraft parts	
Pinus albicaulis	Whitebark pine	C	do.	None	B-C	C	C	A		
P. attenuata	Knobcone pine	C	Distinct, not conspicuous growth ring	Faint growth ring stripe	B-C	C	C	A		
P. banksiana	Jack pine	C	do.	do.	B-C	C	C	B		
P. clausa	Sand pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	B-C	C	C	B		
P. contorta	Lodgepole pine	C	Distinct, not conspicuous growth ring; faint "pocked" appearance	Faint growth ring stripe	B	B	C	A	Decorative knotty face	
P. echinata	Shortleaf pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	A	C	C	B		
P. elliottii	Slash pine	B	do.	do.	A	C	C	B		
P. flexilis	Limber pine	C	Faint growth ring	None	B-C	C	C	A		
P. glabra	Spruce pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	B-C	C	C	B		
P. jeffreyi	Jeffrey pine	B	Distinct, not conspicuous growth ring	Faint growth ring stripe	B	A	B	A		
P. lambertiana	Sugar pine	A	Faint growth ring	None	B-C	A	B	A		
P. monticola	Western white pine	A	do.	None	B	A	B	A		
P. palustris	Longleaf pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	A	C	C	B		
P. ponderosa	Ponderosa pine	B	Distinct, not conspicuous growth ring	do.	B	A	B	A		
P. pungens	Table-Mountain pine	C	Conspicuous growth ring	do.	B-C	C	C	B		
Pinus resinosa	Red pine	B	Distinct, not conspicuous growth ring	Faint growth ring stripe	B	B	C	A		
P. rigida	Pitch pine	C	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	B-C	C	C	B		
P. sabiniana	Digger pine	C	Distinct, not conspicuous growth ring	Faint growth ring stripe	B-C	C	C	B		
P. serotina	Pond pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	B	C	C	B		
P. strobus	Eastern white pine	B	Faint growth ring	None	B-C	A-B	B	A	Decorative knotty faces	
P. taeda	Loblolly pine	B	Conspicuous growth ring	Distinct, not conspicuous growth ring stripe	A	C	C	B		
P. virginiana	Virginia pine	C	do.	do.	B-C	C	C	B		
Pseudotsuga menziesii	Douglas-fir coast	A-B	do.	do.	A	B-C	B	A-B		
P. menziesii	Douglas-fir interior west	B	do.	do.	A	B-C	B	A-B		
P. menziesii var. *glauca*	Douglas-fir interior north	B	do.	do.	A	B-C	B	A-B		

Table 8.--Clear veneer, figure in veneer, and suitability for different uses--continued

Botanical name	Common name	Clear veneer[1]	Figure of veneer		Relative suitability for--[2]				
			Rotary- and flat-sliced	Quarter- and rift-sliced	Construction plywood	Decorative face veneer	Inner plies of decorative panels	Containerveneer and plywood	Other
P. taeda var. *pungens*	Douglas-fir interior south	B	...do...	...do...	B	B-C	B	A-B	
Sequoia gigantea	Big tree	A	Distinct, not conspicuous growth ring	Faint growth ring stripe	B	A	C	A	
S. sempervirens	Redwood	A	Distinct, not conspicuous growth ring; occasionally wavy and burl	Faint growth ring stripe; occasionally wavy and burl	A-B	A	C	A	Decorative etched veneer faces
Taxodium distichum	Baldcypress	B	Conspicuous irregular growth ring	Distinct, not conspicuous growth ring stripe	A-B	A	B	A	
T. distichum var. *nutans*	Pondcypress	B	...do...	...do...	B	A	B	A	
Taxus brevifolia	Pacific yew	C	Mild growth ring figure	Not quarter-sliced	C	A	C	B	
Thuja occidentalis	Northern white-cedar	C	Faint growth ring	Faint growth ring stripe	B-C	B	B	B	
T. plicata	Western redcedar	B	Distinct, not conspicuous growth ring	Faint growth ring stripe	A-B	A	B-C	B	Decorative knotty faces and etched veneer
Tsuga canadensis	Eastern hemlock	C	...do...	...do...	B-C	C	B-C	A-B	
T. heterophylla	Western hemlock	B	...do...	...do...	A-B	C	B	A	
T. mertensiana	Mountain hemlock	C	...do...	...do...	B	C	B	A	

[1] An A rating indicates veneer logs of the species tend to have a high percent of clear wood, a C rating indicates a low percent of clear wood, and a B is intermediate.

[2] A, indicates species is well suited for end product; B, intermediate; and C, generally not well suited for this product.

Table 9.--United States veneer species

Commercial name of veneer		Official common tree name	Botanical name
		UNITED STATES HARDWOODS	
Alder	Nepal alder	Nepal alder	*Alnus nepalensis*
	Red alder	Red alder	*A. rubra*
American ash	Black ash	Black ash	*Fraxinus nigra*
	Oregon ash	Oregon ash	*F. latifolia*
	Pumpkin ash	Pumpkin ash	*F. profunda*
	White ash	Blue ash	*F. quadrangulata*
		Green ash	*F. pennsylvanica*
		White ash	*F. americana*
	Shamel ash	Shamel ash	*F. uhdei*
Aspen	Popple	Bigtooth aspen	*Populus grandidentata*
		Quaking aspen	*P. tremuloides*
Basswood		American basswood	*Tilia americana*
		White basswood	*T. heterophylla*
Beech		American beech	*Fagus grandifolia*
Birch		Yellow birch	*Betula alleghaniensis*
		Sweet birch	*B. lenta*
		Paper birch	*B. papyrifera*
		Alaskan paper birch	*B. papyrifera* var. *humilis*
		Gray birch	*B. populifolia*
		River birch	*B. nigra*
Box elder		Boxelder	*Acer negundo*
Buckeye		Ohio buckeye	*Aesculus glabra*
		Yellow buckeye	*A. octandra*
Butternut		Butternut	*Juglans cinerea*
Cherry		Black cherry	*Prunus serotina*
Cottonwood		Balsam poplar	*Populus balsamifera*
		Black cottonwood	*P. trichocarpa*
		Eastern cottonwood	*P. deltoides*
		Swamp cottonwood	*P. heterophylla*
Elm	Rock elm	Cedar elm	*Ulmus crassifolia*
		Rock elm	*U. thomasii*
		Winged elm	*U. alata*
	Soft elm	American elm (gray elm)	*U. americana*
		Slippery elm (red elm)	*U. rubra*
Eucalyptus		Robusta eucalyptus	*Eucalyptus robusta*

Table 9.--United States veneer species--continued

Commercial name of veneer		Official common tree name	Botanical name
		UNITED STATES HARDWOODS--continued	
Gum		Sweetgum	*Liquidambar styraciflua*
Hackberry		Hackberry	*Celtis occidentalis*
		Sugarberry	*C. laevigata*
Hickory		Mockernut hickory	*Carya tomentosa*
		Pignut hickory	*C. glabra*
		Shagbark hickory	*C. ovata*
		Shellbark hickory	*C. laciniosa*
Holly		American holly	*Ilex opaca*
Koa		Koa	*Acacia koa*
Locust		Black locust	*Robinia pseudoacacia*
		Honeylocust	*Gleditsia triacanthos*
Madrone		Pacific madrone	*Arbutus menziesii*
Magnolia		Cucumbertree	*Magnolia acuminata*
		Southern magnolia	*M. grandiflora*
		Sweetbay	*M. virginiana*
Maple	Hard maple	Black maple	*Acer nigrum*
		Sugar maple	*A. saccharum*
	Oregon maple	Bigleaf maple	*A. macrophyllum*
	Soft maple	Red maple	*A. rubrum*
		Silver maple	*A. saccharinum*
Oak	Red oak	Black oak	*Quercus velutina*
		California black oak	*Q. kelloggii*
		Cherrybark oak	*Q. falcata* var. *pagodaefolia*
		Laurel oak	*Q. laurifolia*
		Northern red oak	*Q. rubra*
		Nuttall oak	*Q. nuttallii*
		Pin oak	*Q. palustris*
		Scarlet oak	*Q. coccinea*
		Shumard oak	*Q. shumardii*
		Southern red oak	*Q. falcata*
		Water oak	*Q. nigra*
		Willow oak	*Q. phellos*
	White oak	Bur oak	*Q. macrocarpa*
		Chestnut oak	*Q. prinus*
		Chinkapin oak	*Q. muehlenbergii*
		Delta post oak	*Q. stellata* var. *mississippiensis*
		Durand oak	*Q. durandii*
		Live oak	*Q. virginiana*
		Oregon white oak	*Q. garryana*
		Overcup oak	*Q. lyrata*
		Post oak	*Q. stellata*
		Swamp chestnut oak	*Q. michauxii*
		Swamp white oak	*Q. bicolor*
		White oak	*Q. alba*

Table 9.--United States veneer species--continued

Commercial name of veneer	Official common tree name	Botanical name
	UNITED STATES HARDWOODS--continued	
Ohia	Ohia	*Metrosideros polymorpha*
Oregon myrtle	California laurel	*Umbellularia californica*
Pecan	Bitternut hickory	*Carya cordiformis*
	Nutmeg hickory	*C. myristicaeformis*
	Water hickory	*C. aquatica*
	Pecan	*C. illinoensis*
Persimmon	Common persimmon	*Diospyros virginiana*
Poplar	Yellow-poplar	*Liriodendron tulipifera*
Sassafras	Sassafras	*Sassafras albidum*
Silk-oak	Lacewood	*Grevillea robusta*
Sycamore	American sycamore	*Platanus occidentalis*
Tanoak	Tanoak	*Lithocarpus densiflorus*
Teak	Teak	*Tectona grandis*
Tupelo	Black tupelo	*Nyssa sylvatica*
	Swamp tupelo	*N. sylvatica* var. *biflora*
	Water tupelo	*N. aquatica*
Walnut	Black walnut	*Juglans nigra*
Willow	Black willow	*Salix nigra*
Yagrumo hembra	Yagrumo hembra	*Cecropia peltata*
	UNITED STATES SOFTWOODS	
Cedar		
Alaska cedar	Alaska-cedar	*Chamaecyparis nootkatensis*
Incense cedar	Incense-cedar	*Libocedrus decurrens*
Port Orford cedar	Port-Orford-cedar	*Chamaecyparis lawsoniana*
Eastern red cedar	Eastern redcedar	*Juniperus virginiana*
Western red cedar	Western redcedar	*Thuja plicata*
Northern white cedar	Northern white-cedar	*T. occidentalis*
Southern white cedar	Atlantic white-cedar	*Chamaecyparis thyoides*
Cypress	Baldcypress	*Taxodium distichum*
	Pond cypress	*T. distichum* var. *nutans*

Table 9.--United States veneer species--continued

Commercial name of veneer		Official common tree name	Botanical name
		UNITED STATES SOFTWOODS--continued	
Fir	Balsam fir	Balsam fir	*Abies balsamea*
	Douglas-fir	Coast Douglas-fir	*Pseudotsuga menziesii*
		Interior west Douglas-fir	*P. menziesii*
		Interior north Douglas-fir	*P. menziesii* var. *glauca*
		Interior south Douglas-fir	*P. menziesii* var. *glauca*
	Noble fir	Noble fir	*Abies procera*
	White fir	Subalpine fir	*A. lasiocarpa*
		California red fir	*Abies magnifica*
		Shasta red fir	*A. magnifica* var. *shastensis*
		Grand fir	*A. grandis*
		Pacific silver fir	*A. amabilis*
		White fir	*A. concolor*
Hemlock	Eastern hemlock	Eastern hemlock	*T. canadensis*
	Mountain hemlock	Mountain hemlock	*T. mertensiana*
	West Coast hemlock	Western hemlock	*T. heterophylla*
Juniper	Western juniper	Alligator juniper	*Juniperus deppeana*
		Rocky Mountain juniper	*J. scopulorum*
		Western juniper	*J. occidentalis*
Western larch		Western larch	*Larix occidentalis*
Pine	Digger pine	Digger pine	*Pinus sabiniana*
	Jack pine	Jack pine	*P. banksiana*
	Jeffrey pine	Jeffrey pine	*P. jeffreyi*
	Knobcone pine	Knobcone pine	*P. attenuata*
	Limber pine	Limber pine	*P. flexilis*
	Lodgepole pine	Lodgepole pine	*P. contorta*
	Norway pine	Red pine	*P. resinosa*
	Ponderosa pine	Ponderosa pine	*P. ponderosa*
	Sugar pine	Sugar pine	*P. lambertiana*
	Idaho white pine	Western white pine	*P. monticola*
	Northern white pine	Eastern white pine	*P. strobus*
	White bark pine	White bark pine	*P. albicaulis*
	Southern pine	Loblolly pine	*Pinus taeda*
		Shortleaf pine	*P. echinata*
		Longleaf pine	*P. palustris*
		Slash pine	*P. elliottii*
		Spruce pine	*P. glabra*
		Pond pine	*P. serotina*
		Virginia pine	*P. virginiana*
		Pitch pine	*P. rigida*
		Sand pine	*P. clausa*
		Table-Mountain pine	*P. pungens*

Table 9.--United States veneer species--continued

Commercial name of veneer		Official common tree name	Botanical name
		UNITED STATES SOFTWOODS--continued	
Redwood		Big tree	*Sequoia gigantea*
		Redwood	*S. sempervirens*
Spruce	Eastern spruce	Black spruce	*Picea mariana*
		Red spruce	*P. rubens*
		White spruce	*P. glauca*
	Engelmann spruce	Blue spruce	*P. pungens*
		Engelmann spruce	*P. engelmannii*
	Sitka spruce	Sitka spruce	*P. sitchensis*
Tamarack		Tamarack	*Larix laricina*
Pacific yew		Pacific yew	*Taxus brevifolia*

ADDITIONAL SPECIES INFORMATION

HARDWOOD

Acacia

The only species of this genus that grows in the United States and is important for its wood is koa (A. koa). Koa is native to Hawaii and has long been prized for the beauty and usefulness of its wood.

Tree and Log Characteristics

The tree is variable in form from gnarled, twisted specimens so crooked that they will not yield a single veneer block to large trees up to 4 feet (120 cm.) in diameter and 100 feet (30 m.) in height. The tree grows in mixed and in pure stands. Koa is intolerant of shade. Young trees and the seeds are subject to attack by various insects. The trunk is often irregular in shape and may have end splits and shake.

Wood Characteristics

The wood reportedly has a specific gravity from 0.46 to 0.55. It is similar to black walnut in density and many strength properties. The narrow sapwood is yellow. The lustrous heartwood is golden brown with red and dark brown areas. Large trees may have straight grain. Curly or wavy-grained wood may occur particularly near the butts of the trees. Quarter-sliced veneer may show "fiddle-back" figure. The wood is diffuse-porous with medium-sized pores. Gummy streaks may occur near the pith of old trees. Koa is not used for food containers as it is thought to flavor the food disagreeably.

Veneer Cutting

Industry reports koa can be rotary-cut at temperatures of 20° to 25° C. (70° to 80° F.). In a laboratory test, a flitch at 65° C. (150° F.) sliced well. The wood is readily cut into smooth, tight veneer. Quarter-sliced veneer is preferred by the furniture industry because of the attractive figure it develops.

Veneer Drying

The green wood has an average moisture content of about 80 percent. Time required to dry the veneer is similar to the average for U.S. mainland hardwoods. The veneer dries flat and tree of splits. Shrinkage from green to dry is about 5 percent radially and 6 percent tangentially.

Veneer Uses

Koa has long been prized as a decorative face veneer. The most desired figure is obtained by quarter-slicing butt logs.

Acer

There are 13 species of the genus Acer in North America. Five of these (two hard maples and three soft) are used in some volume as veneer in the United States. They are:

Common Name	Botanical Name	Commercial Name
Sugar maple	A. saccharum	Hard maple
Black maple	A. nigrum	Hard maple
Red maple	A. rubrum	Soft maple
Silver maple	A. saccharinum	Soft maple
Bigleaf maple	A. macrophyllum	Oregon maple (Soft maple)

Boxelder, A. negundo, is a species of Acer that occurs commonly in the United States but is not generally used for veneer.

Tree and Log Characteristics

Hard maples.--Sugamaple constitutes by far the largest volume of standing maple timber and is the most important species in the genus Acer. It grows throughout northeastern United States and southeastern Canada. Sugar maple is a shade-tolerant, generally slow-growing tree that occurs in mixed stands. It reaches its test growing conditions in New England, Middle Atlantic, and Lake States. Mature trees may be 30 to 40 inches (75 to 100 cm.) in diameter. Typical veneer logs are 12 to 24 inches (30 to 60 cm.) in diameter.

Sugar maple trees get their name from the fact they are sometimes tapped for their sap, which is boiled down to make maple syrup or maple sugar. As a result, a gray stain generally extends several feet in the wood longitudinally from tapholes in the butt log. Sugar maple wood is seldom seriously damaged by insects, although the sugar maple borer damages occasional trees.

Black maple is very similar to sugar maple with the best stands occurring in Iowa and northern Missouri. Actually the two species sometimes cross when they grow together. Both forms of hard maple have considerable amounts of mineral stain.

Soft maples.--Red, silver, and bigleaf maple are all considered soft maples. Red and silver maple grow throughout the eastern United States and in southeastern Canada. Bigleaf maple grows on the Pacific Coast of British Columbia, Washington, Oregon, and California. It is therefore geographically completely separated from the other four maples.

Red maple occurs over a wide range of growing conditions from very wet to very dry. It occurs in mixed stands throughout the eastern United States. Red maple grows fast when young and slows down after it reaches a diameter of 12 inches (30 cm.) or more. Mature trees are about 18 to 30 inches (45 to 75 cm.) in diameter. On good sites, red maple has a medium height of clear bole, but on poor sites it generally has poor form and numerous defects due to insect attack and decay. The trees are easily wounded and are subject to damage from ice and from fire.

Silver maple is the fastest growing maple. Like red maple, it grows in mixed stands throughout the eastern United States. It makes its best growth on bottomlands where trees may reach a diameter of 24 to 35 inches (60 to 90 cm.). Silver maple is not generally bothered by insects but is subject to damage from wind, ice, and fire. Both red and silver maple growing in the lower South are often infested with an ambrosia beetle. Each small insect tunnel in the wood develops a blotch or streak of green or blue stain. This is called "spot" or "flagworm." Silver maple trees generally have a shorter bole than red maple. Old trees are subject to decay. Typical veneer logs of red and silver maple are about the same diameters as veneer logs of sugar maple.

Bigleaf maple grows in mixed stands and occasionally in pure stands on the alluvial soils of western Washington and Oregon. The trees grow rapidly when young and slow down when over a diameter of about 12 inches (30 cm.). On good sites, the trees have good form and may reach a diameter of 30 inches (75 cm.). On poor sites, the tree is generally small and crooked. Older trees often have heart rot.

Wood Characteristics

The wood of all the maples is diffuse-porous with very small pores. The wood is generally straight grained but is occasionally curly or wavy. The wide sapwood is desired for veneer because of its white color. Hard maple veneer logs are often three-fourths sapwood. The heartwood is light red brown.

Pith flecks occur in both soft and hard maples but are perhaps more common in soft maple. Mineral streaks occur in all maples, but are more common in hard maple than in the soft maples.

All the maples are free from gum, odor, or taste.

Mill operators report that tension wood is common in the lower quality maple logs now being used for veneer.

Maple logs are moderately subject to end splits, particularly if stored without protection in the summer. Such logs may also develop blue stain and a brown-gray chemical stain that penetrates from the log ends. Quick processing of felled trees, use of end coatings, and use of water sprays help control the stain.

Hard maple.--The wood of sugar maple and black maple is indistinguishable and is sold together as hard maple. The hard maples can generally be distinguished from the soft maples because the wood is denser, harder, and stiffer. Also hard maple wood has rays of two distinct sizes, with the widest rays not as broad as those in the other maples.

While hard maple is generally straight grained, occasional trees have curly, wavy, fiddleback, or birdseye figure. Such wood is especially valuable for use as decorative face veneer.

Soft maple.--The wood of red maple is denser, harder, and stiffer than wood from silver maple. The specific gravity of the wood of bigleaf maple is about the same as that for silver maple.

The heartwood of the soft maples is light brown, sometimes with a gray or green tinge. Heartwood of bigleaf maple has a darker color and a pinkish cast that helps separate it from the other maples. Bigleaf maple is generally straight grained but occasionally has burls, blisters, curly, and quilted figure.

Veneer Cutting

High conditioning temperatures and long conditioning periods before cutting tend to darken the sapwood. To maintain the light-colored sapwood, heating of bolts or flitches is restricted to as low a temperature and for as short a time as is consistent with the production of smooth, tight veneer. Hard maple is generally heated to 70° to 85° C. (160° to 190° F.) and soft maple to 50° to 65° C. (120° to 150° F.). The maples all cut well and, if care is taken to set up the knife and pressure bar, smooth, tight veneer can readily be produced. It is essential that good nosebar pressure be used to minimize checks into the veneer.

Veneer Drying

Maple is average in length of time required to dry veneer, being about the same as most other U.S. hardwood species. Oxidative stain may develop in veneer that is allowed to

stand overnight prior to drying. Again, to maintain light color, veneer should be dried as soon as possible after it is cut, Maple is not particularly subject to iron stain; but like all woods, it will develop blue-black stain if the wet wood is held in contact with iron. Such stain is particularly noticeable on the light color of the sapwood. Most maple dries flat and relatively free of splits, checks, and buckle. However, maple that contains tension wood may buckle during drying. Heavy mineral-streaked areas, particularly in thicker veneers, may honeycomb and collapse during drying.

Veneer Uses

Straight-grained hard maple is generally preferred to straight-grained soft maple for face veneer in the manufacture of furniture. Conversely, straight-grained soft maple veneer is preferred to hard maple for core and crossband veneer of decorative panels. Figured wood of both hard and soft maple is used for face veneer of wall paneling. Figured- and straight-grained maple is used for cabinets and specialty furniture. All of the maples make good container veneer and plywood.

Other Species of Acer

Boxelder, Acer negundo, has the widest distribution of any species of the genus Acer in North America. It grows throughout the United States and in south-central Canada, where it is called Manitoba maple. It is slightly lower in density than silver maple. Because of the poor form and generally small size of the trees, boxelder is seldom used for veneer in the United States.

The wood of boxelder often has a coral-red stain due to a soluble pigment produced by the colored hyphae of a fungus, Fusarium negundi Sherb.

Aesculus

Two forest trees of this genus grow in the United States--Ohiobuckeye (A. glabra) and yellow buckeye (A. octandra).

Tree and Log Characteristics

Both buckeyes are small- to medium-sized trees that grow best on moist soils such as in river bottoms and along the banks of streams. Yellow buckeye has its best development in the mountains of North Carolina and Tennessee. Ohio buckeye has a wider range occurring,, from Ohio to Texas, Yellow buckeye may reach a diameter of 30 inches (75 cm.), but most trees available for veneer cutting would be about 14 inches (35 cm.) in diameter. (Ohio buckeye is a smaller tree and seldom reaches diameters of 24 inches (60 cm.). Logs available for veneer cutting are probably 14 inches (35 cm.) or smaller. Both buckeyes grow in mixed stands where they may make up as much as 5 percent of the stand. The trees are intermediate in tolerance to shade and root competition and so can readily maintain themselves in mixed stands. Good form of the timber is obtained only when the trees grow in reasonably dense. stands. The buckeyes are relatively free of insect attack. They are also relatively resistant to decay unless the stand has been burned.

Wood Characteristics

The wood of both species of buckeye is low in density and comparatively soft and weak. The white sapwood merges gradually into the creamy white or yellowish-white heartwood. The wood frequently has grayish streaks caused by oxidative sap stain. Buckeye is diffuse-porous with small pores and straight grain. The wood is free of gum, odor, or taste. The wood of buckeye resembles the sapwood of basswood.

Veneer Cutting

Based on its specific gravity, buckeye should cut well at 5° to 20° C. (40° to 70° F.).

Veneer Drying

Buckeye is reported to have moderately large shrinkage for a species of this density. The veneer should be dried quickly after cutting to keep oxidation stain to a minimum.

Veneer Uses

Based on its physical and mechanical properties, buckeye veneer should be well suited for use as core and crossbands for decorative panels. The light color, uniform texture, and ease of nailing make buckeye a preferred species for use as containers.

Alnus

There are two species of alder that grow in the United States. They are red alder (A. rubra) and nepal alder (A. nepalensis). Both are small hardwood trees found on moist sites. Red alder is native to the Pacific coast and represents a much larger volume of trees in the United States than nepal alder. Nepal alder grows naturally in Bengal, Burma, and Kashmir. It is one of several species that have been planted in Hawaii to rehabilitate damaged watersheds and to support a timber industry. This report describes red alder from natural stands in the Pacific coast and nepal alder cut from a 25-year-old plantation in Hawaii.

Tree and Log Characteristics

Red alder grows in pure stands on bottomlands and in mixture with other moisture-seeking trees. While occasional trees may be 18 inches (45 cm.) in diameter, most are 14 inches (35 cm.) or smaller. The trees sometimes have slight to moderate crook and are often knotty. Logs from trees up to about 50 years old are sound and relatively free of decay and splits.

The 25-year-old plantation trees of nepal alder were 15 to 20 inches (38 to 50 cm.) in diameter at breast height. The growth rate was from one to five rings per inch of radius. The butt logs were somewhat irregular with the trunks becoming more nearly cylindrical at higher parts of the stem. Trunks and roots of some trees were reported to have butt rot. The plantation has also been subject to damage by windthrow. The sample logs and flitches had short heart checks and many knots.

Wood Characteristics

The wood of these two alders is similar with red alder being slightly denser. Both are relatively low in density and have corresponding mechanical properties, The wood is relatively soft, of uniform close texture, diffuse-porous, and the grain is straight. There is only a faint distinction between sapwood and heartwood. The sapwood is nearly white when first cut and the heartwood has a faint roseate tinge. Both quickly change to a light tan with a faint roseate cast when exposed to air and dried. This may be due to oxidation. Both alders have many small rays and sporadic large rays. The wood is free of gum, hard deposits, odor, and taste.

Veneer Cutting

Both alders are excellent veneer species and can be satisfactorily rotary-cut into veneer at room temperature. Heating bolts to 60° C. (140° F.) improved the tightness of the veneer. Flitches of nepal alder at 70° C. (160° F.) were in good condition for slicing. These species are tolerant to some variation in the knife and pressure bar settings on the lathe and slicer. Considering the knots in the wood, the veneer produced was smooth and well cut.

Veneer Drying

The time required to dry alder veneer is about average for U.S. mainland hardwoods. In laboratory experiments at Madison, Wis., the veneer dried flat and free of splits except in areas of distorted grain.

Veneer Uses

Red alder is the most important hardwood in the Pacific Northwest and is used primarily as lumber for medium-grade furniture. Selected logs are very suitable for cutting into veneer. Rotary-cut veneer is rather plain, but could be used as faces of decorative panels. The wood forms a desirable base material for painting or enameling and could be used as faces for cabinets and other interior applications. The wood also appears to have suitable properties for use as crossbands or inner plies for decorative panels. Lower grades of alder are suitable for containers, either as veneer or as plywood. Nepal alder could be used interchangeably with red alder.

Arbutus

Tree and Log Characteristics

Pacific madrone (Arbutus menziesii) is the only species of this genus of commercial importance in the United States. It is a medium-sized tree that grows on the western slopes of the Cascade and Sierra Mountains in Washington, Oregon, and California. The tree is moderate in tolerance to shade and generally grows in mixed stands, although it may be found in pure stands--particularly on poorer sites. On good sites in dense stands, it forms a straight symmetrical bole. However, much of the stand is open grown on poor sites. Trees on such sites are typically short and crooked. Madrone may reach a diameter of 24 inches (60 cm.) or more, but typical trees are 16 inches (40 cm.) or smaller in diameter. The trees are relatively free of stain, decay, and insect attack. Stresses in the tree tend to cause splits at the log ends.

Wood Characteristics

The diffuse-porous wood has small vessels. It is moderately dense and correspondingly hard. The light-colored sapwood is 3/4 to 1-1/2 inches (2 to 4 cm.) in width. The dried sapwood veneer often has a pink tinge. The heartwood veneer varies from light-pink color through shades of red and brown to gray-green. As there is little distinction between earlywood and latewood, the figure in this species is due largely to differences in pigment color in the heartwood. Veneer and plywood exposed to sunlight gradually become more uniformly light brown.

Veneer Cutting

It is suggested that bolts of madrone be heated in water at 65° to 70° C. (150° to 160° F.) prior to rotary-cutting. Flitches should be heated to 80° to 90° C. (180° to 190° F.)

prior to slicing. In experiments at Madison, higher heating temperatures tended to aggravate splits in the ends of the bolts hut did not affect the flitches. Madrone is a good cutting species and smooth, tight veneer was produced by both rotary and slicing processes.

Veneer Drying

Madrone has high moisture content and requires longer drying time than most U.S. hardwoods. Tangential shrinkage is high during drying of the veneer to a moisture content of 3 to 8 percent, averaging 12 to 13 percent of the green dimensions. Most of the veneer dries flat, but ends of the rotary-cut veneer sometimes wrinkle during drying and splits in the rotary-cut veneer open wider during drying.

Veneer Uses

Madrone is best suited for faces for decorative panels. The most attractive panels made experimentally were faced with flat-sliced veneer which show an attractive grain and color pattern. Madrone veneer has been marketed as western cherry. Its use as a face veneer is limited by the relatively small volume of veneer-grade timber.

Betula

Three economically important species of birch (Betula) grow in the United States:

Common Name	Botanical Name	Commercial Name
Yellow birch	B. alleghaniensis	Yellow birch
Sweet birch	B. lenta	Yellow birch
Paper birch	B. papyrifera	Paper birch

There are three varieties of paper birch that grow in Alaska and readily hybridize with one another. This has caused some confusion in names. According to the Check List of Native and Naturalized Trees of the United States (including Alaska)[5] these three birches are:

Western paper birch	B. papyrifera var. commutata
Alaska paper birch	B. papyrifera var. humilis
Kenai birch	B. papyrifera var. kenaica

The Alaskan species are similar to paper birch growing in the Lower 48. Western paper birch grows in southeastern Alaska; Alaska paper birch grows in the interior forests and south to the Pacific coast; and Kenai birch grows in southern and interior Alaska.

Two minor species whose wood is somewhat like paper birch are:

Gray birch	B. populifolia
River birch	B. nigra

The different species of Betula that grow in the United States cannot be separated once cut into veneer.

Tree and Log Characteristics

About three-fourths of the birch veneer cut in the United States comes from yellow birch. Traditionally, yellow birch has been the standard to which other hardwood veneers were compared. Yellow birch and a similar species, sweet birch, grow in the northeastern United States and southeastern Canada. Both yellow and sweet birch grow in mixed stands. Both are medium-sized trees with average diameters of mature trees of 24 inches (60 cm.).

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[2]Little, E. L. Check list of native and naturalized trees of the United States (including Alaska). USDA Agr. Handb. 41. 1953.

Commercial logs are generally 12 to 18 inches (30 to 45 cm.) in diameter. Logs larger than 18 inches (45 cm.) in diameter often have decay in the heartwood. However, yellow birch up to 24 inches (60 cm.) in diameter is sliced.

Logs of both yellow birch and sweet birch generally have good form and are relatively free from shake. However, log end splits are common. Logs with smooth bark generally have straight grain, while those with rough bark often have curly grain. An unknown disease called birch dieback, as well as heavy cutting in the United States, has greatly reduced the supply of birch veneer-grade timber. Much of the birch veneer now used in the United States comes from Canada. Birch is relatively free from insect attack, but weakened trees may be damaged by the bronze birch borer.

Paper birch, also called white birch, (B. papyrifera) is the most widely distributed of the birches. It is smaller, faster growing, shorter lived, and of poorer form than either yellow birch or sweet birch. Mature trees of paper birch have a diameter of about 18 inches (45 cm.), while typical veneer logs have a diameter of about 10 to 14 inches (25 to 35 cm.). Logs up to 18 inches (45 cm.) are cut into veneer. These smaller diameter logs have more knots than yellow or sweet birch. Rapidly grown paper birch up to about 10 inches (25 cm.) in diameter may be entirely sapwood. Heartwood in white birch trees is often decayed.

The Alaskan birches are small- to medium-sized trees 6 to 12 inches (15 to 30 cm.) in diameter with only an occasional tree 18 inches (45 cm.) in diameter. The best stands are reported to occur in the Susitna Valley at the head of Cook Inlet. The total volume is estimated to be 1-3/4 billion board feet. Of this, 1-1/2 percent is in grade 1 logs, 13-1/2 percent in grade 2 logs, 77 percent in grade 3 logs, and the remainder, grade 4. By comparison, 42 percent of the paper birch growing in Maine is in log grades 1 and 2. Alaskan birch is of Low grade primarily due to the small diameter of average logs, about 9 inches (23 cm.), the high incidence of stain and decay in the heartwood, and the high percent of knotty material. The Alaskan logs reportedly have less sweep than birch grown in the Lake States.

Gray birch (B. populifolia) and river birch (B. nigra) are considered minor species. The wood of these two species is more like paper birch than yellow birch, Gray birch is the smallest of the northeastern birches, generally being 12 inches (30 cm.) or smaller in diameter. The bole is generally poorly shaped and limby. Gray birch and aspen cover extensive areas of burned-over land and abandoned farms in New England. River birch grows only near stream banks and is the only typically southern birch. It is a medium-sized tree typically about 16 inches (40 cm.) in diameter. It is little used for veneer because of its poor form with leaning trunks that often divide about 15 feet from the ground.

Wood Characteristics

All birches that grow in the United States are diffuse-porous and have straight to curly grain. The vessels are of medium size and may or may not be filled for finishing. In general, the wood of yellow birch and sweet birch is harder, heavier, and stronger than wood from the other species of birch that grow in the United States. Yellow birch and sweet birch are used interchangeably.

On yellow birch the creamy white sapwood is 3 to 5 inches (7 to 13 cm.) wide. On sweet birch the sapwood is narrower. The heartwood of yellow birch is light to dark red-brown, while that of sweet birch is generally darker. Because of species interchangeability, the sapwood of both species is often sold as white birch and the heartwood as red birch. In 1970, red birch face veneer sold at a higher price than white birch face veneer.

As mentioned earlier, the sapwood of paper birch may occupy most of the volume of the tree. The wood of paper birch is less dense than yellow or sweet birch and frequently the veneer is more defective. Nevertheless, paper birch is commonly cut into veneer and has the same end uses as yellow and sweet birch.

The wood of Alaskan paper birch is very similar to the wood of paper birch. Because of the slow growth rate the sapwood of Alaskan birch is not as wide as the sapwood of paper

birch. It is reported to average 2 to 4 inches (5 to 10 cm.) in width. Sample sheets of Alaskan birch veneer sent to the Laboratory had some tension wood which caused fuzzy surfaces.

The wood of river birch frequently has pith flecks. The heartwood of river birch is red compared to a red-brown color for the other birches,

Veneer Cutting

Yellow birch is generally considered one of the best cutting species that grows in the United States. Thin birch veneer, such as 0.05 inch (1 mm.) in thickness, can be cut from birch logs at room temperature, For cutting thicker veneer, a heating temperature of 60° to 70° C. (140° to 160° F.) is recommended. In addition to improving the tightness of the veneer, heating inactivates enzymes that sometimes turn unheated birch sapwood to a yellow color, Flitches of yellow and sweet birch should be heated to 80° C. (180° F.) prior to slicing. Paper, gray, and river birch, being of lower density, need only be heated to about 50° to 60° C. (120° to 140° F.) for bolts and 70° C. (160° F.) for flitches.

Straight-grained birch cuts extremely well. It is smooth, uniform in thickness, and can be cut with relatively few checks into the veneer. Extremely curly birch tends to break in the short grain during rotary-cutting. For this reason, extremely curly birch bolts are not desired for rotary-cut face veneer.

Veneer Drying

Birch veneer dries as fast or faster than any other U.S. hardwood species. White sapwood birch veneer may be stained by an oxidation stain if the veneer is allowed to remain in wet stacks for a time, such as overnight, prior to drying. This oxidation stain can be reduced by heating the woods properly, which tends to inactivate the enzyme that causes the stain, and secondly by drying the veneer as soon as possible after it is cut. Straight-grained birch dries flat, while curly or irregular grained veneer may buckle.

Veneer Uses

Yellow birch and sweet birch veneers have long been favorites as faces for flush doors, kitchen cabinets, and prefinished wall paneling. Relatively clear veneer of paper birch and the other soft birches are used for the same type of products.

In spite of trials by various commercial interests Alaskan birch has not been used regularly as veneer or plywood. The logs are apparently too low in quality to be successfully used in a typical U.S. hardwood plywood plant. However, Finnish birch which is about the same size and density as Alaskan birch is successfully used in Finland. Automatic machinery, the use of short bolts, veneer patching, and manufacture of thick plywood from many thin plies of veneer are some techniques used in Finland. Perhaps when the market conditions are right, similar techniques could be used with Alaskan birch. End uses might include furniture, fixtures, and similar products.

Carya

Eleven species of Carya grow in the United States and eight are of commercial importance. Half of these are commonly referred to as "true hickories" and half as "pecan hickories."

Common Name	Botanical Name	Commercial Name
Shagbark hickory	C. ovata	True hickory
Shellbark hickory	C. laciniosa	True hickory
Pignut hickory	C. glabra	True hickory
Mockernut hickory	C. tomentosa	True hickory
Pecan (sweet pecan)	C. illinoensis	Pecan hickory
Water hickory	C. aquatica	Pecan hickory
Nutmeg hickory	C. myristicaeformis	Pecan hickory
Bitternut hickory	C. cordiformis	Pecan hickory

Tree and Log Characteristics

All eight species of hickory grow in mixed stands in the eastern United States. The total cubic volume of standing true hickory is at least two to three times as great as pecan hickory.

All of the hickories are susceptible to fire damage, bird pecks, and to attack by cambium-mining insects. This causes dark stain streaks and sometimes mineral deposits. If the injury to the cambium is extensive, bark pockets are often formed. The hickories have large growth stresses that generally cause splits at the log ends as soon as the trees are felled. Many of the old-growth trees have ring shake. This defect is reportedly particularly prevalent in water hickory grown on very wet sites. Pecan is least subject to these degrading features. It grows fast and is the species of best quality.

All of the hickories will grow to a diameter of 24 inches (60 cm.). Water hickory and shagbark hickory may be 30 inches (75 cm.) in diameter when mature. The largest of the hickories is sweet pecan, which may reach a diameter of 44 inches (110 cm.). Typical veneer logs of the hickory species vary in diameter from 14 to 36 inches (35 to 90 cm.).

Wood Characteristics

The true hickories have long been recognized as the world's foremost wood where high strength and toughness are required, as for striking tool handles and vehicle parts. The pecan hickories are not quite as dense and strong as the true hickories. True hickory and pecan hickory veneer are commonly mixed and sold as pecan hickory, pecan, or hickory. While the species overlap in many properties, there are some general differences. True hickory is denser, stronger, has higher shrinkage, and is slower growing than pecan hickory. True hickory is ring-porous, while pecan hickory is semi-ring-porous. In water hickory, the pores change in size so gradually that the wood appears almost diffuse-porous. In general, veneer producers prefer pecan to the true hickories.

The white sapwood of the hickories varies from 1-1/2 to 7 inches (4 to 18 cm.) in width. It sometimes dries with a light-pink-tan tinge. The heartwood is red-brown. The wood from leaning trees often has gelatinous fibers. Because of the large vessels in the ring-porous true hickory, the rotary-cut and flat-sliced veneer has distinct growth-ring patterns. This pattern is less conspicuous in pecan, which tends to be semi-ring-porous.

Veneer Cutting

Because of the high density of the wood, hickory cuts best at a temperature of about 95° C. (200° F.), Hickory bolts are subject to enlargements of splits and ring shakes during heating, As a compromise, it is recommended that bolts be heated to about 70° to 80° C. (160° to 180° F.) prior to rotary-cutting. Flitches are not as likely to split in heating. It is therefore recommended that they be heated to about 90° to 95° C. (190° to 200° F.). A temperature of 75° to 80° C. (170° to 180° F.) and a longer heating time are sometimes used with pecan. It is difficult to peel the bark from bolts at room temperature, but heating the bolts to 75° C. (170° F.) or higher facilitates bark removal.

Mineral deposits associated with overgrown tracing of cambium-mining insects and bird pecks frequently nick the lathe or slicer knife. Use of a microbevel and frequent honing of the knife help to minimize the effect of the deposits. Ring shake can cause considerable loss at the lathe, especially with water hickory.

Veneer Drying

There was a wide range in moisture content of the sapwood and heartwood veneer cut from various species of hickory studied at the Laboratory. Water hickory had the highest moisture content and required about 25 percent more drying time than sweet pecan and the true hickories For all species, the heartwood required 10 to 25 percent longer drying time than the sapwood. The sapwood of sweet pecan and true hickory took about the same time to dry as the sapwood of yellow birch.

A slight buckle appeared from springwood to summerwood in 1/16-inch and thinner hickory veneer. Veneer from quarter-sliced flitches bowed slightly toward the sapwood during drying. Neither of these drying defects was serious enough to limit the use of hickory as veneer.

Industry reports that some hickory buckles excessively due to the presence of tension wood.

Veneer Uses

From 1960 to 1970, the use of face veneer of pecan and hickory greatly increased for prefinished wall paneling and furniture in the United States. In 1968, pecan hickory was second to walnut as a decorative face veneer used in furniture. In 1969, pecan hickory was first in use in the United States as a decorative furniture wood. Some insect tracings, bird pecks, and stain are well accepted as character marks in plywood paneling. While sweet pecan is the preferred species for these uses, all species of hickory are mixed and sold for the same uses.

A small amount of hickory has been used for parquet flooring, for school furniture, and for skis. Lower grades of hickory veneer have been used in containers and industrial fiber brooms.

Cecropia

The only timber tree of this genus that grows in the United States is yagrumo hembra (C. peltata). Yagrumo hembra is a fast-growing, short-lived tree that occurs in Puerto Rico, Cuba, Central America, and as far south as Brazil. Experimental work was with logs from Puerto Rico.

Tree and Log Characteristics

Mature trees are typically about 1 foot (30 cm.) in diameter with occasional specimens 2 feet (60 cm.) in diameter.

The species is intolerant of shade and in cleared areas often takes over in almost pure stands. The center part of the main trunk is exceptionally lightweight and soft. The tree sometimes develops prop roots around the base.

Wood Characteristics

The average specific gravity of the wood outside of the central core is reported to be about 0.26. The wood in the central 4-inch (10-cm.) core is as low as 0.20 in specific gravity. The wood is correspondingly soft and low in strength. All the wood appears to

be sapwood. It is white when cut and becomes cream to pale brown when dried. The wood is diffuse-porous but rather coarse textured. Some sample logs contained streaks of tension wood. The wood is without hard deposits, odor, or taste. It is highly susceptible to blue stain and decay.

Veneer Cutting

Satisfactory veneer 1/100 to 1/8 inch (0.25 to 3.2 m.) in thickness was rotary cut from bolts at 13° C. (55° F.). The knife used was very hard, testing about 62 on the Rockwell C-scale. It was ground to a bevel of 21° and honed to a keen edge. Cold water was sprayed on the pressure bar during cutting to flush away loose fibers that might otherwise have collected at the edge of the bar. These techniques have been found helpful for cutting other low-density woods that tend to develop a fuzzy surface during cutting. Spinout of the core was a problem when cutting 1/8-inch (about 3-mm.) veneer from a 4-foot-long (1.2-m.) bolt. When cutting thinner veneer, spinout was not a problem.

Veneer Drying

The wood has a green moisture content of 110 to 180 percent. Drying time was about average for U.S. mainland hardwood species. End splits in the green veneer become wider and longer during drying.

The green veneer contained tension wood streaks that appeared to be wetter than the surrounding wood. The dry sheets of 1/16-inch (1.6-m.) and thinner veneer buckled at these areas. Clear veneer with no tension wood dried flat and with no splits. Tension wood dried to a light brown color in contrast to the creamy white color of normal wood.

Veneer Uses

Yagrumo hembra might be used for core or crossbands. However, it is variable in specific gravity with the lower weight wood exceedingly subject to collapse during hot pressing. Possibly its best use would be for novelties like toy airplanes where it might be used similar to balsa wood,

Celtis

Hackberry (C. occidentalis) and sugarberry (C. laevigata) are the only important timber trees of this genus that grow in the United States.

Tree and Log Characteristics

Both hackberry and sugarberry are small- to medium-sized trees, They may reach a diameter of 18 to 24 inches (45 to 60 cm.), but most logs available for veneer cutting would be 12 to 20 inches (30 to 50 cm.) in diameter. Hackberry grows throughout the northeastern part of the United States and sugarberry, the southeastern part of the United States. Both occur in mixed stands and make their best growth on bottomland sites. Both species are moderately tolerant to shade but they are generally of very poor form if they are suppressed for a long time. In dense, even-aged stands, they produce boles of good form. Hackberry and sugarberry are moderate in resistance to insect attack but are highly susceptible to fire damage, which in turn may be followed by extensive wood decay. The wide sapwood of hackberry is very susceptible to blue stain. If the logs cannot be processed quickly, they should be held under a water spray to keep blue stain to a minimum.

Wood Characteristics

Hackberry and sugarberry are very similar in wood characteristics. Both are moderately dense, strong, and hard. The sapwood is pale yellow but frequently develops a gray cast due to oxidation stain. It usually makes up more than half of the volume of sawlogs. The heartwood is similar in color to the sapwood, but commonly darker, There is no distinct color contrast between the sapwood and heartwood. Both species are ring-porous with large vessels and have straight to interlocked grain. The wood is free of gum, hard deposits, odor, or taste. Hackberry and sugarberry are similar to American elm in appearance but generally have wider sapwood with a distinct yellowish tinge. Quarter-sliced hackberry has a fine sparkle from small rays. Flat-sliced veneer has a feathered appearance from wavy tangential parenchyma.

Veneer Cutting

Based on its specific gravity, we suggest heating bolts of these species to about 50° to 60° C. (120° to 140° F.) prior to rotary-cutting. Flitches should be heated to about 60° to 70° C. (140° to 160° F.) prior to slicing. Industry reports that hackberry cuts well.

Veneer Drying

Hackberry has a moderately large to large shrinkage. However, it has a reputation for drying flat. We would expect it to be average in drying time compared to other U.S. hardwoods.

Veneer Uses

Hackberry can be used much the same as elm. Better grades are made into prefinished wall panels and into "blond" furniture. The lower grades make good containers. A limited supply of timber is the main reason it is not used more extensively.

Diospyros

The only species of this genus of importance for its wood in the United States is common persimmon (D. Virginiana).

Tree and Log Characteristics

Persimmon is a small- to medium-sized tree which may reach a diameter of 18 inches (45 cm.). Most trees available for veneer cutting would probably be 10 to 14 inches (25 to 35 cm.) in diameter. The tree grows in a variety of conditions from Pennsylvania to Texas and south to Florida. Best growth occurs in the first bottom of the Mississippi River. Trees growing on upland sites are generally not as good as those grown on bottomland. Persimmon is very tolerant to shade and root competition. It generally occurs singly or in small groups in mixed stands. Dead and dying trees often have the wood riddled by powderpost beetle. Persimmon is susceptible to fire and decay usually enters the burned face of the trees. Some persimmon is killed by persimmon wilt, a fungus disease. The total volume of persimmon is small.

Wood Characteristics

Persimmon is a hard, heavy wood having a specific gravity similar to true hickory. The white to creamy-white sapwood is often 3 to 6 inches (7 to 15 cm.) in thickness. It darkens on exposure to air to a light yellow-brown or gray-brown color. Fast-growing trees may

be entirely sapwood, The narrow heartwood is dark brown with black stripes. Persimmon is semi-ring-porous, with medium to large vessels, and generally straight grain but may be interlocked. The growth rings are distinct but not conspicuous. The wood wears to a smooth surface.

Veneer Cutting

Based on its specific gravity, we suggest heating persimmon bolts or flitches to about 95° C. (200° F.) prior to cutting. If the bolts split excessively during heating, then the heating temperature should be lowered to about 65° to 70° C. (150° to 160° F.). Because of its density, persimmon is sensitive to slight changes in the knife and pressure bar setting .

Veneer Drying

Persimmon has very high tangential shrinkage. The sapwood reportedly can be dried satisfactorily, but the heartwood is prone to excessive checking during drying.

Veneer Uses

Traditionally, persimmon has been used like dogwood for shuttles or golf club heads. It has been used for both furniture and wall paneling in limited quantities and is considered very acceptable, The primary obstacle to greater use of persimmon is the small volume of available timber,

Eucalyptus

Robusta eucalyptus (E. robusta) is native to Australia and has been planted in areas of Hawaii having 80 to over 200 inches of rain per year. This report describes material from plantations in the Puueo and Pahala areas of Hawaii.

Tree and Log Characteristics

In Australia the trees are reported to grow to a diameter of 3 to 4 feet (90 to 120 cm.) and 150 feet (45 m.) high. Trees from the 32-year-old plantations in Hawaii were about 2 feet (60 cm.) in diameter with larger trees coming from the areas of higher rainfall. The trunks of the trees were straight but somewhat irregular in cross section. The stands in Hawaii are somewhat subject to windfall. This species, like many eucalpyts, has pronounced growth stresses which tend to cause brittleheart and log end splits immediately upon felling. Small burls and pin knots are reported to be common in the plantation-grown wood.

Wood Characteristics

Eucalyptus has an average specific gravity of 0.60 based on green volume and ovendry weight. This is similar to the U.S. mainland species pecan. On the average, eucalyptus is higher in bending strength, stiffness, and in maximum crushing strength but lower than pecan in hardness. The yellow-white sapwood is 1 to 2 inches (2.5 to 5.0 cm.) in width and turns light brown during veneer drying. The heartwood is reddish pink. The diffuse-porous wood has medium texture, interlocked grain with occasional cross figure. The wood is free of gum and hard deposits. Some eucalyptus reportedly has tension wood but this was not a problem in the flitches sliced into veneer at the Laboratory.

Veneer Cutting

Due to growth stresses in the logs, it is suggested bolts for rotary cutting not be heated above 65° C. (150° F.). Flitches should be heated to 80° C. (180° F.). Flitches should be strapped together to minimize bowing during heating. This dense wood cuts smoothly if good nosebar pressure is applied. The wet heartwood will develop a blue-black stain if it is allowed to contact iron longer than a second or two. The best veneer was produced by quarter-slicing the wood into pieces 1/28 inch (0.9 mm.) in thickness.

Veneer Drying

Sapwood of the samples cut at Madison, Wis., had a moisture content of about 70 percent and the heartwood 90 to 110 percent. The wood has a reputation for being subject to collapse during drying of lumber. Consequently, a mild temperature, 95° C. (200° F.), was used to dry the eucalyptus veneer. This required a longer drying time than is used for drying most U.S. mainland hardwoods at higher temperatures. The veneer dried flat and with no apparent collapse. Tangential shrinkage green to dry was about 10-1/2 percent and radial shrinkage about 6 percent. Drying turned the sapwood light brown. The tight side of the dry heartwood was pink while the loose side had deeper magenta red streaks. This color difference is probably due to faster movement of soluble pigments toward the loose side during drying.

Veneer Uses

Based on the small sample cut at Madison, Wis., this species should be quarter-sliced into thin face veneer for wall panels and furniture. The interlocked grain and occasional cross figure makes an attractive wood when seen on the quarter. The wood sands well and has good luster.

The wood could be rotary-cut for use in structural plywood but will have many splits and is very heavy. High drying temperatures may cause collapse of thick veneer. There is also some evidence the wood is difficult to glue.

Fagus

American beech (Fagus grandifolia) is the only species of this genus that grows in the United States.

Tree and Log Characteristics

American beech is a slow-growing, medium-sized hardwood tree that occurs in mixed stands throughout the eastern half of the United States. While it may reach a diameter of 36 inches (90 cm.), typical logs available for cutting into veneer are 24 inches (60 cm.) or smaller in diameter. The logs are generally of good form, but the tree is subject to bark disease, frost cracks, and heart rot. Heart rot is particularly likely to be present in stands that have been burned. Beech is very tolerant to shade, and the trees may develop heavy limbs.

Wood Characteristics

Beech is a moderately dense wood and has correspondingly good properties of hardness and wear resistance. Beech is diffuse-porous with small vessels, a faint growth ring, and many prominent rays. The wood is generally straight grained but may be interlocked. The sapwood is white, tinged with red, and is commonly 2 to 6 inches (5 to 15 cm.) in width. It merges gradually into the heartwood, which may be light brown or reddish. The sapwood

is quite permeable and readily treated. Beech is free of objectionable odor or taste. Second-growth beech generally has a higher percentage of white sapwood than old-growth timber.

Veneer Cutting

The uniform texture helps make beech a good veneer-cutting species. Occasional logs have curly grain, which tends to cut rough. Bolts with dote or decay are subject to spinout when being cut on the lathe. A bolt conditioning temperature of 70° to 80° C. (160° to 180° F.) was found suitable in Laboratory tests at Madison for conditioning the wood before rotary cutting. Beech flitches should be heated to a temperature of 80° to 90° C. (180° to 190° F.) prior to slicing.

Veneer Drying

Beech sapwood dries at about the same rate as yellow birch sapwood. The heartwood of beech takes slightly longer drying time. The veneer cut experimentally dried flat and with no new splits developing in the dryer. Splits already in the green veneer opened in width. The veneer developed some end waviness during drying. Rotary-cut veneer had high tangential shrinkage.

Veneer Uses

While beech is readily cut into smooth, tight veneer, it is not used in proportion to the amount that grows in the forest. Its characteristics of hardness, good wearing properties, and easy treatability of the sapwood should make it well suited for products like compreg and resin-impregnated plywood flooring. Lower grades of veneer are well suited for containers because of the wood's good bending properties, high strength, and lack of odor and taste.

Fraxinus

Three of the 16 ashes (Fraxinus) that grow in the United States are of importance for use as veneer:

Common Name	Botanical Name	Commercial Name
Black ash	F. nigra	Black ash
White ash	F. americana	White ash
Green ash	F. pennsylvanica	White ash

Three other species of ash are occasionally used for veneer:

Blue ash	F. quadrangulata	White ash
Pumpkin ash	F. profunda	Pumpkin ash
Oregon ash	F. latifolia	Oregon ash

An evergreen ash that is native to Mexico but has been planted in Hawaii is:

Shamel ash	F. uhdei	Shamel ash

Tree and Log Characteristics

In general, the ashes grow in mixture with other species and form only a small portion of the stand. All of the ashes prefer moist, well-drained, fertile, porous soils. Ash logs are generally of good form except for flaired butts of trees grown in wet river bottoms

and shallow swamps, Ash trees are generally relatively free from insect attack and decay. White and green ash may reach diameters of 24 to 30 inches (60 to 76 cm.), while mature black ash is 16 to 20 inches (40 to 50 cm.). Most ash logs available for veneer are 18 inches (45 cm.) or smaller in diameter, Shamel ash from a 27-year-old plantation in Hawaii averaged 13 inches (33 cm,) in diameter, Logs of all the ashes are susceptible to lyctus beetle damage.

Wood Characteristics

The wood from all of the species of ash grown on the mainland of the United States is sometimes mixed and sold as American ash. When a distinction is made, black ash is sold separately and the heavy, strong, and tough wood from white ash and green ash is grouped and sold as white ash. Much green ash from flaired butts tends to be brash. The wood from blue ash is mixed and sold with white ash.

In general, black ash is lower in density than white ash. It is also slower grown, has narrower sapwood, and has darker brown heartwood color. Black ash is sometimes called brown ash.

Pumpkin ash is lighter in weight than white ash and is subject to flaired butts. Such wood is light in weight and brittle. When rotary cut, it is also short grained. Logs with excessive flaired butts should not be used for veneer.

Oregon ash is the only ash that grows on the west coast of the United States. The wood of Oregon ash is similar to white ash, but it is less dense and lower in mechanical properties.

Most ash is second growth with typical trees 12 to 24 inches (30 to 60 cm.) in diameter. Sapwood on second-growth veneer logs of white ash and green ash is generally from 3 to 6 inches (8 to 15 cm.) in width. Wide sapwood is generally preferred in order to produce all-white face veneer. All the ashes are ring-porous and have straight grain. The heartwood of the white ash group is gray-brown. The heartwood of black ash is moderately dark brown. Because of the ring-porous growth pattern, the ashes have conspicuous growth rings when rotary cut or flat sliced. Quarter-sliced veneer has a distinct but not conspicuous growth ring,

Shamel ash is similar in density but slightly heavier than U.S. mainland black ash and lighter than white ash. Like the other ashes, the sapwood is wide and merges gradually to the light tan heartwood. From the color standpoint, shamel ash is more like white ash than black ash.

Veneer Cutting

All of the ashes are readily cut into smooth and tight veneer of uniform thickness. Bolts of black ash should be heated to about 50° to 60° C. (120° to 140° F.), while bolts of white ash group should be heated to about 60° to 70° C. (140° to 160° F.). Flitches of black ash should be heated to about 70° C. (160° F.), while white ash flitches should be heated to about 80° C. (180° F.). Good cutting was obtained with bolts of shamel ash heated at 70° C. (160° F.) and from flitches at 80° C. (180° F.).

Veneer Drying

Ash dries in about the same time as yellow birch. Most of the veneer dries quite flat and splitting is not a problem. However some rotary-cut shamel ash veneer 1/16 inch (1.6 mm.) in thickness buckled during storage. This buckle had to be removed by redrying prior to gluing.

Veneer Uses

All of the ashes have been well accepted for use as decorative face veneer for many years, Lower grade ash veneer makes an excellent material for containers.

Seasoned ash sapwood is subject to attack by powder-post beetles. Such damage can be prevented by proper storage of the wood.

Gleditsia

Honeylocust (Gleditsia triacanthos) is the only important tree of this genus found in the United States,

Tree and Log Characteristics

Honeylocust is a medium-sized tree that grows sparsely in scattered mixed stands in the Mississippi Valley, with the best growth in the lower Ohio Valley, Individual trees may reach a diameter of 36 inches (90 cm.) or more. Typical logs, however, are about 18 inches (45 cm.) in diameter. The species is intolerant of shade and fast growing. Forest-grown trees have good form and are relatively free of insect attack.

Wood Characteristics

Honeylocust is a dense, strong species. The sapwood is 1.5 to 2.5 inches (4 to 6 cm.) in width. The light red-brown heartwood has attractive figure, particularly when flat-sliced. The ring-porous wood is generally straight grained. The springwood vessels are moderately large, making a conspicuous growth-ring pattern when rotary or flat-sliced and a moderate pattern when quarter-sliced. Occasionally, logs have slight cross figure which is seen to advantage on quarter-sliced veneer. Occasional vessels are darker in color. Like black locust, the heartwood of honeylocust fluoresces strongly in ultraviolet light.

Veneer Cutting

It is suggested that honeylocust bolts be heated at 60° to 70° C. (140° to 160° F.) to keep end splitting to a minimum. Flitches should be heated to about 90° C. (190° F.). The wood cuts well into smooth, tight veneer.

Veneer Drying

Honeylocust veneer dries flat. The tangential shrinkage of 6 to 7 percent is very low for a species of this density. Thin face veneer is relatively brittle and must be handled with care.

Veneer Uses

Honeylocust veneer produced by rotary-cutting, flat-slicing, or quarter-slicing makes an attractive appearance. Perhaps the best way to utilize the species would be by quarter-slicing where the pink heartwood contrasts with the white sapwood. The only reason the species is not more widely used is because of a scarcity of timber.

Grevillea

Silk-oak, Grevillea robusta, is native to Australia where it may reach a diameter of 3 feet (90 cm.) and a height of about 120 feet (36 m.), Silk-oak, sometimes called lacewood, is well accepted in the United States as a decorative face veneer. Silk-oak has been planted in Hawaii as a shade tree, to control erosion, and as a source of timber. This report describes the veneer potential of the Hawaiian-grown wood.

Tree and Log Characteristics

Fifty- to 60-year-old plantations have trees 12 to 24 inches (30 to 60 cm.) in diameter. The faster grown trees come from an area having 85 inches (215 cm.) of rain a year and the slower grown trees from an area having 50 inches (125 cm.) of rain per year.

Some of the sample logs had eccentric piths and irregular cross sections. Other logs were cylindrical. Similarly, some logs had diametric end splits and others did not. The wood was free of decay, stain, and insect attack.

Wood Characteristics

The specific gravity of the plantation silk-oak varied from 0.45 to 0.56 with the average 0.51. The slower grown material was higher in density than the fast-grown material. The hardness of the wood is similar to U.S. mainland species of similar density, such as paper birch. The light-colored sapwood is about 1 inch (2.5 cm.) in width. The heartwood is light pink when first cut and turns to a light tan after exposure to sunlight. The wood is diffuse-porous with generally straight grain and moderate-sized pores. The most prominent feature is many light-colored rays that show on quarter-sliced wood. It is this feature that probably led to the name lacewood. The dry wood has a somewhat waxy feel.

The sawdust and wet wood caused irritation to the eyes and some skin parts of some, but not all, who handled it. Use of skin cream and good hygiene were generally effective in preventing skin rash on the workers.

Veneer Cutting

Bolts should be heated to 70° C. (160° F.) and flitches to 80° C. (180° F.). Smooth, tight veneer of uniform thickness was produced by rotary-cutting and slicing. Because the most desirable figure is obtained by quarter-slicing, it is suggested that trees for veneer cutting be allowed to reach a minimum diameter of 24 inches (60 cm.). Log end splits can often be eliminated when preparing flitches for quarter-slicing.

Veneer Drying

The wood had a moisture content from 100 to 130 percent. The drying time was slightly longer than for U.S. mainland hardwoods like yellow birch. Sliced and rotary-cut veneer dried flat and without defects. Tangential shrinkage green to ovendry averaged 7.7 percent and radial shrinkage 2.7 percent. This veneer's low radial shrinkage indicates that quarter-sliced veneer would be very resistant to face checking in use. The dry veneer had a waxy feel and required care in gluing,

Veneer Uses

It is suggested that this species be grown to a minimum diameter of 24 inches (60 cm.) and be quarter-sliced for decorative face veneer for products like wall paneling and furniture.

Ilex

Tree and Log Characteristics

American holly (Ilex opaca) is the largest of the native hollies and is the only species of this genus that is commercially important in the United States for its wood. It grows as a scattered tree throughout the southeastern United States. Holly may reach a diameter of 18 inches (45 cm.) or larger. However, most trees available for veneer cutting are 12 inches (30 cm.) or smaller in diameter. Holly has good tolerance to shade, and so can maintain itself in mixed forest stands. The thin bark is susceptible to fire damage. The total volume of holly is small. The sapwood of holly is susceptible to blue stain.

Wood Characteristics

The heartwood of holly is a distinctive ivory white in color. The wide sapwood is also white but lacks the ivory tinge of the heartwood. The wood turns light brown with age and exposure to light. The wood is diffuse-porous with very small pores and is usually straight grained. Holly is moderately dense and hard. The wood is permeable and can be readily stained any color.

Veneer Cutting

Based on its specific gravity, we suggest heating holly bolts to about 65° to 70° C. (150° to 160° F.) and the flitches to 75° to 80° C. (170° to 180° F.). The uniform-textured wood has a reputation for cutting with a smooth surface.

Veneer Drying

The wood has moderately high shrinkage. Information is not available on the veneer drying properties of this species.

Veneer Uses

Small amounts of holly have been sliced and used as inlays in musical instruments and for furniture. It has sometimes been dyed black to resemble ebony for use as piano keys.

Juglans

Three species of Juglans are used for veneer in the United States. By far the most important in terms of volume and use is black walnut (J. nigra). A second U.S. species is butternut (J. cinerea). The third in terms of volume is claro walnut, generally considered to be J. hindsii.

Tree and Log Characteristics

Black walnut is one of the best known species used for face veneer throughout the world. Black walnut grows in scattered small stands on soil that is rich, moist, and deep but well drained, Although it occurs throughout the eastern United States, the trees grown in the center of its range, the central states of the United States, are preferred by producers of face veneer, Trees from some areas may have spot-worms and bird pecks. Walnut is a fast-grown tree that will reach a very large size if allowed to mature. Because of the demand for the wood, most standing trees are 24 inches (60 cm.) or smaller in diameter. This heavy demand also means that black walnut is in short supply. However, it has a wide

growth range and is being planted particularly in farm woodlots. Walnut heartwood is subject to a chemical stain in late spring and summer that can lower the value of the face veneer substantially. This can be prevented by end coating fresh-cut logs and storing them under a water spray.

Butternut is a small- to medium-sized tree that grows sparsely in scattered stands throughout the northeastern part of the United States. Typical trees may be 12 to 20 inches (30 to 50 cm.) in diameter. They often are poor in form. Old trees frequently have decay near the pith. The most serious disease of butternut is canker dieback.

Claro walnut is generally considered to be the species J. hindsii. However, some authorities believe it comes from the European walnut J. regia, which has been planted in Oregon and California. Claro walnut is a very widely scattered tree which reaches large size much like black walnut.

Wood Characteristics

Black walnut is a moderately dense, semi-ring-porous wood. The sapwood of old slow-grown forest trees is nearly white and about 1 inch (3 cm.) wide. Open-grown trees may have sapwood as wide as 3 inches (8 cm.). The heartwood is light gray-brown with some dark purplish-brown streaks. Black walnut is normally straight grained, but occasionally has wavy and curly grain near knots, and forks. Burls and stumpwood are also cut into veneer having a variety of figures. Some of the lower grade logs now being cut into veneer have tension wood. This may be due to more open-grown trees that move in response to light openings and wind.

The wood of butternut resembles black walnut but is much less dense and is lighter in color. It is sometimes called white walnut. The sapwood of butternut is generally narrow. The heartwood is light brown. Like black walnut, it is semi-diffuse-porous and makes an attractive leafy appearance when flat-sliced. Tension wood is common in butternut.

Claro walnut resembles American black walnut. It is a fast-growing tree and frequently has prominent dark and light stripes.

Veneer Cutting

Black walnut cuts well at a temperature of about 65° C. (150° F.). However it is common practice to darken the sapwood and even the colors in the heartwood by first heating the wood to a higher temperature. One schedule calls for heating the flitches to 80° C. (180° F.) for several days, followed by dropping the temperature to 65° C. (150° F.) for slicing. Claro walnut is heated much like black walnut. Based on the specific gravity of the species, butternut can be cut at room temperature, 20° C. (70° F.), Butternut is generally heated to 40° to 50° C. (100° to 120° F.) for slicing. Black walnut is very susceptible to blue-black iron stain. Consequently, the lathe or slicer must be kept as clean as possible to keep iron contamination to a minimum. Most walnut cuts well. Logs containing a high proportion of tension wood may cut with a fuzzy surface. Similarly, lower grade logs having very short grain may tend to some rough cutting. A sharp knife and bar must be used for satisfactory cutting of butternut.

Veneer Drying

To further darken the sapwood, black walnut veneer is sometimes held in a warm room until oxidative darkening occurs. The green veneer is checked from time to time and when a desired color is reached the veneer is dried. The time required to dry black walnut is average for American hardwood species. Most black walnut dries flat, but veneer that contains excessive amount of tension wood may buckle.

Veneer Uses

All three species of Juglans are used primarily as face veneer. Black walnut and claro walnut are used for furniture. Because butternut is softer, it is not as well suited as these species for furniture. All three species are used for decorative wall paneling. Because of the high decorative and attractive appearance of all three species of Juglans, they should be used primarily for decorative face veneer.

Liquidambar

Sweetgum (Liquidambar styraciflua) is the only species of this genus that grows in the United States. It has long been one of the principal hardwood veneer species used in the United States.

Tree and Log Characteristics

Sweetgum grows in pure and mixed stands. It reaches its best development in the moist lands of the lower Ohio and Mississippi Basins and in the lowlands of the southeastern coast of the United States. Mature trees may be 36 inches (90 cm.) or more in diameter, but more typical trees available for veneer cutting are 14 to 30 inches (35 to 75 cm.) in diameter, Sweetgum is intolerant of shade and is generally dominant in the stand. The tree trunks are of good form. Old trees are moderately subject to shake, and if the stand has been burned, they may have heart rot. The trees are relatively free from insect attack. Some logs have bird pecks and adventitious buds. Occasional logs have "flag" wormholes and bark and gum pockets, but these are not common characteristics. Unprotected logs may develop blue stain and ambrosia beetle infestation in 1 week to 10 days during humid summer weather.

Wood Characteristics

Sweetgum has moderate density and correspondingly moderate mechanical properties. The wood is diffuse-porous with small vessels and the grain is typically interlocked. Recently, geneticists have been working to develop straight-grained sweetgum trees. Such a development will greatly improve the usefulness of sweetgum as a veneer species,

Most old-growth sweetgum trees have been cut. Because the sapwood of sweetgum is very wide, 5 to 8 inches (12 to 20 cm.), second-growth logs available for veneer cutting are mainly sapwood. The red-brown heartwood frequently has darker streaks that make figured veneer when rotary-cut, flat-sliced, or quarter-sliced. Some logs have tangential bands of red-brown wood in the sapwood zone. Such wood is called pathological heartwood and is generally not considered a defect. The wood is not as lustrous as some other hardwoods that are preferred for decorative face veneer.

The sapwood of sweetgum is very susceptible to blue stain. Logs held for storage should therefore be protected by end coating, sprinkling, or underwater storage.

Veneer Cutting

The diffuse-porous, moderate-density sweetgum wood is nearly ideal for cutting into smooth, tight veneer. It may be cut at room temperature; but to minimize checks into the wood, it is suggested that bolts be heated to 50° to 60° C. (120° to 140° F.) and flitches to 60° to 70° C. (140° to 160° F.).

Veneer Drying

Because of high moisture content, the sapwood of sweetgum takes longer to dry than the average U.S. hardwood. The heartwood of sweetgum is relatively impervious and requires a longer drying time than the sapwood. In general, sweetgum veneer dries flat but may wrinkle at the ends of rotary-cut sheets. Heartwood veneer thicker than approximately 1/8 inch (3 mm.) may honeycomb if dried at temperatures above 150° C. (300° F.).

Veneer Uses

Large, old-growth logs supply figured veneer for use in furniture and decorative wall paneling. This shows to the best advantage when quarter-sliced. The white sapwood has relatively little figure but can be readily stained. It is frequently used in furniture, flush doors, and wall paneling. Because of the uniform structure, sweetgum veneer is sometimes used for inner plies of decorative panels. However the interlocked grain tends to cause such panels to twist if they are subject to changes in moisture content. Lower grade sweetgum logs are preferred raw material for many types of veneer and plywood containers.

Liriodendron

Tree and Log Characteristics

Yellow-poplar (Liriodendron tulipifera) is the only species of this genus that grows in the United States. It occurs in both pure and mixed stands throughout the eastern United States. The best stands are in the lower Ohio Valley and on the mountain slopes of North Carolina, Tennessee, Kentucky, and West Virginia. Old-growth trees reach a diameter of 40 inches (100 cm.) or more. Most trees available for cutting into veneer are 24 inches (60 cm.) or smaller in diameter. Yellow-poplar is intolerant of shade, and forest-grown trees have clear boles from an early age. The trunk is typically tall, straight, and cylindrical. Yellow-poplar is relatively free from insect attack, although it may be attacked by ambrosia beetles. Occasional trees have bird pecks caused by the yellow-bellied sap sucker. Open-grown trees may have adventitious buds. U.S. Forest Service data show an increase in the volume of standing yellow-poplar of 19 percent from 1963 to 1968.

Wood Characteristics

Yellow-poplar has moderately low density and correspondingly moderate mechanical properties. The sapwood on second-growth trees may he 2 to 6 inches (5 to 15 cm.) in width. 'The light yellow-green heartwood occasionally has darker streaks of green, purple, or black. The wood of yellow-poplar is diffuse-porous and has small vessels. The grain is typically straight and moderately permeable. The wood is free of gum, odor, taste, or hard deposits.

Veneer Cutting

Yellow-poplar is relatively tolerant to changes in the knife and pressure bar settings. It is often cut into veneer without heating. In tests at the Forest Products Laboratory, tighter veneer was produced by heating the bolts to 50° C. (120° F.) and flitches to 60° C. (140° F.).

Veneer Drying

The time required to dry yellow-poplar veneer is near the average for U.S. hardwood species. Yellow-poplar generally dries flat without development of splits, end waviness, or buckle.

Veneer Uses

Because of the uniform texture, moderately low density and shrinkage, and ease of gluing, yellow-poplar is one of the preferred species for use as core and crossbands of decorative panels. It is also used as a face veneer for panels intended to be painted. Lower grades of yellow-poplar make good containers.

Lithocarpus

Tanoak (Lithocarpus densiflorus) is the only species of this genus that grows in the United States. It is the most abundant hardwood species found in the coast ranges of California and southwestern Oregon.

Tree and Log Characteristics

On favorable sites, forest-grown trees are 24 inches (60 cm.) or larger in diameter. Typical trees available for veneer cutting are about 18 inches (45 cm.) in diameter. Tanoak Logs frequently have good form, but they have a decided tendency to develop end splits. The trees are subject to fire damage. Such trees often develop beetle damage, stain, and decay.

Wood Characteristics

The diffuse-porous wood is hard, heavy, and strong. It is generally straight grained but may have burls and some cross figure. The light tan sapwood is generally 6 to 7 inches (15 to 18 cm.) wide. The heartwood is considered pathological and is light red-brown in color. The wood is free of gum, odor, or taste and hard deposits.

Veneer Cutting

Bolts for rotary-cutting should be heated to 65° to 70° C. (150° to 160° F.) as higher temperatures cause excessive bolt-end splits. A temperature of 80° C. (180° F.) was found suitable at FPL for heating flitches before slicing. Flat-sliced veneer tended to be rough when cutting against the rays.

Veneer Drying

Tanoak veneer requires longer drying time than average U.S. hardwood species. The sapwood dries flat and relatively free of defects. However, the heartwood is extremely difficult to dry without developing collapse and checks. For this reason, rotary-cut veneer--which is almost entirely sapwood--is preferred to flat- or quarter-sliced veneer, which contains some heartwood.

Veneer Uses

Plywood flooring blocks faced with 1/8-inch (3-mm.) rotary-cut sapwood veneer performed very well in a Laboratory office. This floor was in excellent condition when it was removed after 17 years of hard service. Because sapwood tanoak veneer may darken when hot pressed, it is suggested that decorative panels be made by cold pressing. Tanoak is stiff enough to make a good construction plywood, but the plywood is quite heavy. Tanoak can also be made into containers, but it is a heavy wood and somewhat prone to splitting when nailed.

Magnolia

The most important veneer species of this genus is southern magnolia (Magnolia grandiflora). Two minor species are cucumbertree (M. acuminata) and sweetbay (M. virginiana).

Tree and Log Characteristics

Southern magnolia grows along the southeastern coast of the United States from Texas to North Carolina. Cucumbertree grows in the Appalachian Mountains, with the production centered at West Virginia and adjoining states. Sweetbay grows in the same areas as southern magnolia and also farther north. However, trees in the northern part of the range are generally of smaller size and poorer quality. All of the magnolias grow in scattered stands. The southern magnolia and cucumbertree may reach a diameter of 24 to 36 inches (60 to 90 cm.). Most logs cut into veneer would be considerably smaller than this. The trees are generally well formed and cucumber may be clear of branches up to 40 feet (12 m.) from the ground. Older southern magnolia trees may have butt rot. These trees are generally sound above a short butt hole.

Wood Characteristics-

The wood of the magnolia is diffuse-porous and the annual rings are marked by a thin, whitish line at the end of a year's growth. The wood is usually straight grained and fairly heavy. It resembles the wood of yellow-poplar but is slightly heavier. The light-colored sapwood of the magnolias is variable in width from 1.5 to 5 inches (4 to 13 cm.). The heartwood is light to dark brown, tinged with yellow or green. The heartwood of southern magnolia is sometimes greenish black. The wood is free of gum, hard deposits, odor, or taste.

Veneer Cutting

All of the magnolias are good veneer species. Like yellow-poplar, they can be cut at room temperature--20° C. (70° F,). Thicker veneer such as 1/8 inch (3 mm.) will cut better if the bolts are conditioned to about 50° C. (120° F.). Veneer from heated bolts will probably be tighter cut than veneer cut from unheated bolts.

Veneer Drying

The magnolias are average in drying time for U.S. hardwoods. The veneer typically dries flat and without developing splits.

Veneer Uses

The wood from cucumbertree and sweetbay is often mixed with and sold as yellow-poplar, Like yellow-poplar, the veneer is used primarily for core and crossbands of furniture panels. The magnolias may also be used as paint surfaces for decorative panels and they make excellent container veneer.

Metrosideros

Ohia (M. polymorpha) is a slow-growing tree that reportedly constitutes over 50 percent of the native forest growth on the island of Hawaii.

Tree and Log Characteristics

Mature trees may be 3 feet (90 cm.) or more in diameter. While the trees may grow in dense, pure stands, they are slow to prune themselves. The trees often have a large buttress at their bases. The boles may be twisted. Sample logs were relatively free of splits, shake, and decay.

Wood Characteristics

The wood is very dense, averaging 0.70 based on green volume and ovendry weight. It is therefore heavier than shagbark hickory, one of the heaviest of the commercial species of the U.S. mainland. Ohia is generally comparable to hickory in its strength properties, except that ohia is much lower in toughness. The yellow to light brown sapwood is generally 1 to 2 inches (2.5 to 5 cm.) in width. The heartwood is dark brown with a reddish cast. The diffuse-porous wood is generally straight grained but may be mildly interlocked. The pores are of medium size. Hard deposits in the wood are abrasive to cutting tools.

Veneer Cutting

Flitches should be heated to about 95° C. (200° F.). No trials were made by rotary-cutting. A temperature of 95° C. (200° F.) is suggested providing bolt end splits are not a problem. Short-grained areas tended to be rough cut, while the straight-grained areas were relatively smooth. The wood contained an abrasive material which rapidly dulled the slicer knife, so in Laboratory trials the knife was rehoned after slicing each flitch.

Veneer Drying

The green wood had a moisture content of 60 to 70 percent. It required about the same or slightly longer drying time as typical U.S. mainland hardwoods. All of the veneer dried flat. Tangential shrinkage was about 12 percent and radial shrinkage 7 percent from green to ovendry. High shrinkage is to be expected with such a dense wood. The wood in lumber form is reported to be subject to checking and warp during drying.

Veneer Uses

The wood has no outstanding figure but it may be suitable as a face veneer for cabinetwork or paneling. Its good wearing characteristics should make it suitable for the exposed portion of plywood flooring.

Nyssa

Species of tupelo (Nyssa) that are used for veneer include:

Common Name	Botanical Name
Water tupelo	N. aquatica
Black tupelo	N. sylvatica var. sylvatica
Swamp tupelo	N. sylvatica var. biflora

A tupelo not generally used for veneer is:

Ogeechee tupelo N. ogeche

Tree and Log Characteristics

Water tupelo and swamp tupelo, as the names indicate, are water-loving trees that grow principally in the fresh water swamps and along the edges of streams and ponds in southeastern United States. These trees grow in essentially pure stands and also in mixed stands with cypress. The base section of trees that grow in swamps often is flaired or swelled. These swelling butts are undesirable for use as veneer. Black tupelo occurs throughout the eastern United States but does not often occur in large quantities in any one location. Black tupelo generally grows on upland sites and does not develop flaired butts like water tupelo and swamp tupelo. All three tupelos may reach a diameter of 36 inches (90 cm.) or more, but logs commonly available for veneer cutting are about 20 inches (50 cm.) or smaller. old trees often develop ring shake by the time much heartwood has formed. Small burls are common on tupelo logs. The tupelos are generally resistant to insect attack, but they are all susceptible to fire damage and subsequent development of stain and decay.

Wood Characteristics

The wood of all :he tupelos is similar, being of moderate density with small pores and generally interlocked grain. Black tupelo develops more pronounced ribbon figure and is preferred for quarter-slicing. The texture of the wood is very uniform as all species are diffuse-porous. The sapwood of the tupelos may be 2 to 6 inches (5 to 15 cm.) wide. The heartwood is light brown-gray and may be darker and wider in black tupelo than in the other tupelos. Tupelos are generally free of odor, taste, and hard deposits.

Veneer Cutting

All the tupelos cut well in experimental veneer cutting at the Madison Laboratory. Short grain which sometimes occurred in the area of burls and due to interlocking grain resulted in occasional patches of slightly rough surfaces on the veneer. Fire scars and shake in older logs have been known to cause breakage at the lathe and a corresponding reduction in veneer recovery. A suggested conditioning temperature for bolts that are to be rotary-cut is 50° to 60° C. (120° to 140° F.) and for flitches that are to be sliced 65° to 70° C. (150° to 160° F.).

Veneer Drying

Due to high moisture content, tupelo veneer requires longer drying time than the average American hardwood species. The dry veneer tends to have slight end waviness but otherwise is flat and relatively free of splits or other defects. During drying the sapwood veneer of water and swamp tupelo sometimes develops a brown surface discoloration. This stain is shallow and can be easily removed by sanding.

Veneer Uses

The uniform texture of tupelo makes a good paint base for stock panels. Tupelo is often used as inner plies for decorative panels. The uniform texture is desirable for this use, reducing showthrough to a minimum, but interlocked grain may cause the panels to warp if they change moisture content in use. The light, uniform-textured wood of tupelo makes excellent containers.

Other Species

Ogeechee tupelo is limited to swampy areas in northern Florida and southern Georgia. It may mature as a shrub only a few feet tall or as a 65-foot tree. However, it is most frequently a small, crooked, often many-stemmed tree 25 to 35 feet tall. It is generally not used for veneer because of poor form and because the diameter is usually not over 16 inches (40 cm.).

Platanus

Tree and Log Characteristics

American sycamore (Platanus occidentalis) is the only important species of this genus that grows in the United States. It reaches a larger diameter than any other American hardwood. Mature trees are about 32 to 44 inches (80 to 112 cm.) in diameter. Trees available for cutting into veneer would commonly be up to 36 inches (90 cm.) in diameter. Sycamore grows best along streams and flat lands where there is adequate moisture. Scattered trees and small groups of trees of sycamore are found throughout many of the eastern United States.

Sycamore trees grown in forest conditions have good form, but open-grown trees may have a short trunk that divides into massive irregular limbs. Old trees often have ring shake and are decayed at the base. These are not problems with trees up to 30 inches (76 cm.) in diameter. Sycamore is sometimes attacked by ants, resulting in bark pockets in the wood, Because of its rapid growth and relative freedom from insect and fungus disease, sycamore has recently been planted as a crop tree. If this becomes a widespread practice, sycamore may be a more important veneer species in the future.

Wood Characteristics

Sycamore has moderate density and corresponding strength properties. The sapwood is 2 to 6 inches (5 to 15 cm.) in width and merges gradually into the light red-brown heartwood. The wood is diffuse-porous with small vessels and generally has mildly interlocked grain. Sycamore has many dark-colored rays that show prominently on a quarter-sliced surface. The wood is free of gum, odor, or taste and hard deposits.

Veneer cutting

Sycamore has good density and texture for veneer cutting. It can be readily cut into smooth, tight veneer of uniform thickness. Based on its specific gravity, bolts of sycamore should be heated at 50° to 60° C. (120° to 140° F.) and flitches at 65° to 70° C. (150° to 160° F.) before cutting veneer.

Veneer Drying

Because of its high moisture content, sycamore veneer probably requires longer drying times than the average U.S. hardwood species. Industry reports that sycamore can be dried with relatively little buckle, splits, or other drying problems,

Veneer Uses

Quarter-sliced veneer should make attractive decorative faces because of the dark-colored rays that show prominently. This characteristic has not been adequately promoted for a figured face veneer. Quarter-sliced veneer faces are sometimes used for interior paneling. Rotary-cut sycamore has long been a preferred species for use in containers. Because of relatively high tangential shrinkage and interlocked grain, sycamore is not recommended for crossbands of decorative panels.

Populus

Seven species of Populus native to the United States are used for veneer. Five of these are sold as cottonwood and two as aspen:

Common Name	Botanical Name	Commercial Name
Balsam poplar	P. balsamifera	Cottonwood
Black cottonwood	P. trichocarpa	Cottonwood
Eastern cottonwood	P. deltoides	Cottonwood
Plains cottonwood	P. sargentii	Cottonwood
Swamp cottonwood	P. heterophylla	Cottonwood
Bigtooth aspen	P. grandidentata	Aspen
Quaking aspen	P. tremuloides	Aspen

Several hybrids of this genus, such as P. grandidentata plus P. alba (European aspen) are also planted in the United States and are known as aspen or poplar.

Tree and Log Characteristics

All of the species of Populus that grow in the United States are fast-growing, intolerant of shade, and relatively short lived.

Cottonwood.--Allof the cottonwoods prefer moist river-bottom sites. Black cottonwood, eastern cottonwood, and balsam poplar grown on good sites generally have good form. However, swamp cottonwood and plains cottonwood are often malformed and are seldom used for veneer. Cottonwood trees may be up to 48 inches (120 cm.) in diameter, but typical veneer logs would generally be in the range from 16 to 36 inches (40 to 90 cm.) in diameter. Occasionally logs up to 60 inches (150 cm.) in diameter are brought to veneer mills. Large cottonwood logs sometimes have ring shake.

Aspen.--Aspen, like cottonwood, is characterized by rapid growth but unlike cottonwood, it is limited in diameter to about 10 to 14 inches (25 to 35 cm.). Aspen grows in pure stands and also as scattered trees in mixed stands. Trees over 12 inches (30 cm.) in diameter generally have heart rot. While aspen has good natural pruning, typical logs yield a high proportion of knotty veneer because of their small diameters. The logs are frequently of good form and relatively free of splits and shake.

Wood Characteristics

The wood of all species of Populus is moderately low in specific gravity and correspondingly moderately low in most strength properties. The diffuse-porous wood is generally straight grained. Pores in aspen are small, while those in cottonwood are small to medium. Tension wood is relatively common in all of the species of Populus. The wood is generally free of taste and gum. The sapwood of cottonwood is variable in width from 1.5 to 5 inches (4 to 13 cm.) and merges gradually with the gray-white to light gray-brown heartwood. The sapwood of aspen varies from 2 to 4 inches (5 to 10 cm.) in width and changes gradually into the heartwood without being clearly marked. The heartwood of aspen is creamy to light gray-brown. Both aspen and cottonwood are subject to small zones of "wet wood." Aspen has good luster and cottonwood has little luster.

Veneer Cutting

Because of low density, the various species of Populus can be cut at room temperature--20° C. (70° F.). Wood of these species that contain tension wood is likely to result in a fuzzy surface during cutting. This tendency to develop fuzzy surfaces can be reduced by cooling the bolts to 5° C. (40° F.) prior to cutting.

A second method of reducing fuzzy cutting is to use an extra hard knife such as a 62 on the Rockwell C-scale. Such a knife will maintain a sharp edge longer than a softer steel. The knots in aspen and cottonwood are not hard enough to nick such a knife. A third method that reduces fuzzy surfaces is to run cold water between the knife and the pressure bar during cutting.

Veneer Drying

Because of high moisture content, aspen and cottonwood require longer drying times than average U.S. hardwood species. Tension wood in both species may cause buckling during drying. Wetwood in aspen and cottonwood is subject to checking and collapse during drying. Aspen veneer free of tension wood and wetwood dries flat. Cottonwood veneer often develops end waviness during drying.

Veneer Uses

Cottonwood veneer and plywood is used for containers where its light color, ease of nailing, and uniform texture are assets. Cottonwood free of tension wood makes good core and crossband veneer for furniture panels. Cottonwood-faced plywood is readily painted or stained and has been used successfully for such products as kitchen cabinets and house siding.

Selected figured aspen has been used as face veneer for decorative panels. Much of this decorative veneer came from P. alba that had been planted in the United States. Like cottonwood, aspen veneer that is clear and free of tension wood and wetwood makes good core and crossband veneer. Because of its light color and weight, aspen is a preferred container wood. Aspen plywood made from rotary-cut veneer has been used successfully for underlayment beneath flexible vinyl, rubber, or linoleum floors. Rotary-cut aspen and cottonwood veneers have been used successfully for matches. Some of the hybrid poplars have attractive cross figure such as that found in the planted Populus alba.

Prunus

Tree and Log Characteristics

Black cherry, Prunus serotina, is the only species of the genus that is an important forest tree in the United States. Back cherry grows in scattered stands throughout the eastern United States and southeastern Canada, with varieties in Texas, Mexico, and Guatemala. It grows best in the Northern Allegheny Plateau. It is fast-growing and intolerant to shade. Consequently the tree must be dominant to reach maturity. Mature trees are about 28 inches (70 cm.) in diameter. Most timber available for veneer cutting is 14 to 20 inches (35 to 50 cm.) in diameter. Cherry trees are generally of good form and are sound. The tree is susceptible to fire damage. It is also subject to insect attack, which causes pith flecks and gum spots. Gum spots and streaks are probably the most common defects in veneer-grade logs of cherry.

Wood Characteristics

Cherry is a moderately dense and hard wood. The sapwood is generally 1 to 1.5 inches (2.5 to 4 cm.) in width. The heartwood is light to dark red-brown. The wood generally darkens on exposure to the sunlight. Cherry is diffuse-porous with small pores and straight grain. The rotary-cut veneer shows a moderate growth ring while quarter-sliced veneer shows small, numerous, light-colored rays. The wood is free of odor or taste. Gum spots and gum streaks are common in cherry wood. The wood has a high natural luster.

Veneer Cutting

Cherry is an excellent species for veneer cutting. The extractives in cherry heartwood react readily with iron to cause a blue-black stain. It is therefore necessary to keep the lathe or slicer as clean as possible when cutting cherry. The wood is readily cut into veneer that is smooth, tight, and uniform in thickness. Bolts of cherry should be heated to about 50° to 60° C. (120° to 140° F.) and flitches to about 65° to 75° C. (150° to 170° F.) before slicing.

Veneer Drying

The time for drying cherry is average for U.S. hardwoods. The veneer dries flat and with little Loss due to splitting.

Veneer Uses

Cherry is used extensively for furniture. Small gum spots and streaks are permitted in some grades of prefinished cherry paneling, one of the major uses of the veneer.

Quercus

The oaks, genus Quercus, are the most important hardwood group that grows in the United States. There are 60 or more species and many hybrids that grow mainly in the Eastern States, They make up one-third or more of the total hardwood stand in the United States. The oaks are divided into two subgenera, "red oaks" (Erythrobalanus) and "white oaks" (Lepidobalanus). Individual species are generally not separated or distinguished in commercial practice except as belonging either to the red oak or the white oak group. Approximately 40 percent of the oak stand is white oak and 60 percent is red oak.

The oaks grow under a wide range of conditions, from widely scattered to mixed to pure stands and from swampy areas to dry ridges. They vary from intolerant to moderate in tolerance to shade. Given such a wide variety of species and hybrids and the wide difference in growing conditions, it is not surprising that the quality of oak logs also varies widely. Not only is there a large range of quality from species to species, but also within species. With these limitations in mind, the following is a rough guide to the preferred veneer species.

Red Oaks (Erythrobalanus)

Common Name	Botanical Name	Approximate Rating for Veneer Use
Northern red oak	Q. rubra	Best
Cherrybark oak	Q. falcata var. pagodaefolia	Rest
Shumard oak	Q. shumardii	Best
Southern red oak	Q. falcata	Best
Black oak	Q. velutina	Second
Nuttall oak	Q. nuttallii	Second
Willow oak	Q. phellos	Second
Water oak	Q. nigra	Second
Laurel oak	Q. laurifolia	Third
Scarlet oak	Q. coccinea	Third
Pin oak	Q. palustris	Third
California black oak	Q. kelloggii	Third

Black jack oak, Q. marilandica, occurs over extensive areas on poor sites and is generally not considered a veneer species because of small size and poor form.

White oaks (Lepidobalanus)

Common Name	Botanical Name	Approximate rating for Veneer Use
White oak	Q. alba	Best
Swamp white oak	Q. bicolor	Best
Swamp chestnut oak	Q. michauxii	Best
Bur oak	Q. macrocarpa	Second
Chestnut oak	Q. prinus	Second
Chinkapin oak	Q. muehlenbergii	Second
Durand oak	Q. durandii	Second
Delta post oak	Q. stellata var. mississippiednsis	Second
Overcup oak	Q. lyrata	Third
Post oak	Q. stellata	Third
Oregon white oak	Q. garryana	Third

Live oak, Q. virginiana, is in the white oak group but is generally not considered a veneer species. Forest-grown Live oak may develop clear trunks but open-grown trees have short trunks that divide into large branches. The wood is very hard and is used only in small amounts for specialty items.

Tree and Log Characteristics

All red oaks are susceptible to and may be killed by the oak-wilt disease Ceratocystis fagacerum. The white oaks are moderately resistant to the oak-wilt disease.

Ked oaks.--Northern red oak grows in the eastern United States and southeastern Canada. It is an upland tree that occurs in both pure and mixed stands. Mature trees are generally about 30 inches (75 cm.) in diameter. Trees available for veneer cutting are generally about 12 to 24 inches (30 to 60 cm.) in diameter. Red oak may be attacked by wood borers, which cause holes in the wood and associated brown stains. Northern red oak generally has a trunk clear of branches for considerable height and is well formed. It is the best species of the red oak group.

Southern red oak is the most common of the upland hardwood trees. It grows in mixed stands in the southeastern United States. Much of it is off site and of poor quality. Epicormic branches are common on southern red oak trees except those grown in dense stands or on good sites where dominance can be asserted. Wood borers and bark scarrers attack the species on poor sites and cause holes and associated brown stain in the wood. Like northern red oak, mature trees on good sites are about 30 inches (75 cm.) in diameter and of good form. Typical veneer logs are about 15 to 24 inches (38 to 60 cm.) in diameter.

Cherrybark oak is a variety of southern red oak. It grows in mixed stands on the best bottomland sites in the coastal plain from Virginia to Texas and the Lower Mississippi Valley. It is a hardy, fast-growing oak that often reaches a diameter of 36 inches (90 cm.) and a height of 100 feet (30 m.). Most trees available for veneer are about 28 inches (70 cm.) or less in diameter. Cherrybark oak usually has a clear bole in contrast to other bottomland red oaks. Wood borers attack fire-scarred and overmature cherrybark oak trees. On poorly drained sites, the wood may have brown stain and mineral streaks. Cherrybark oak is a preferred face veneer species.

Shumard oak grows singly or in small groups in mixed stands on well-drained soils adjacent to streams in southeastern United States. It is cine of the largest oaks and may reach

a diameter of 36 inches (90 cm.). Most veneer logs are 24 inches (60 cm.) in diameter or smaller. While the volume of this species is not great, it is considered a high-quality wood. The heartwood of shumard oak is generally yellow tan rather than light brown with a pink tinge.

Black oak is found in nearly all upland hardwood forests in the eastern United States. It is commonly found on dry, sandy ridges but grows best on lower slopes and coves. The largest trees, 24 to 30 inches (60 to 75 cm.) in diameter, grow in the lower valley of the Ohio River. Such trees produce good veneer logs. However, most black oak grows on poor soils and is too small and defective for use as veneer.

Nuttall oak is a bottomland species with a limited range in the Lower Mississippi Valley from Alabama to Arkansas and eastern Texas. It grows well on more or less poorly drained clay soils in the first bottoms of the Mississippi Delta and the flood plains of all the alluvial rivers in the area. Nuttall oak is a fast-growing tree intolerant to shade that reaches a diameter of about 24 inches (60 cm.) in 70 years. Most veneer logs are 14 to 24 inches (35 to 60 cm.) in diameter. On poor sites the wood is knotty and insect damage and stain are severe. Over-age trees on good sites degenerate rapidly. Many trees growing on ordinarily good sites yield good-quality veneer logs.

Water oak, willow oak, and laurel oak are bottomland species that grow in the coastal plains from New Jersey to Florida and eastern Texas. These three species are sometimes grouped as water oaks and are thought of as a special class of fast-growing hard and sappy red oaks. Water oak and willow oak are generally of better quality than laurel oak. On good sites they may reach diameters from 24 to 32 inches (60 to 80 cm.). Veneer logs are typically 12 to 24 inches (30 to 60 cm.) in diameter. The trees have high growth stresses and therefore the Logs are prone to end checking in storage and especially during heating. Veneer logs are often long butted to reduce the effect of butt swell and flutes. Trees on poor sites are subject to damage by wood borers and bark scarrers. The damaged areas generally have associated brown stain. Willow oak grown off site or on poor sites tends to have pin knots much like pin oak. The water oaks are important because they represent a large proportion of the southern bottomland oaks.

Scarlet oak is an upland species that grows on average to poorer than average sites. It is of medium size with mature trees on good sites reaching a maximum diameter of about 24 inches (60 cm.). Most trees available for veneer cutting are about 18 inches (45 cm.) or less in diameter. Scarlet oak is rapid growing and intolerant of shade. Because of its thin bark and the dry environment in which it grows, scarlet oak is susceptible to fire damage and related attack by decay and insects. Trees from medium to poor sites generally have wood of much lower quality than northern red oak. Trees from the better sites yield good-quality veneer logs.

Pin oak is a wet site tree of the Middle Atlantic and Central States of the United States. It is of medium size with mature trees having diameters of 24 to 30 inches (60 to 70 cm.). Typical veneer logs are about 14 to 22 inches (35 to 55 cm.) in diameter. Well-situated trees are the fastest growing oaks outside of the South. Pin oak is intolerant of shade. As its name suggests, pin oak produces many small limbs. In closed stands the lower limbs die, but they are tough and persistent causing many pin knots in the veneer cut from them. Pin oak like other alluvial land oaks is very sensitive to site. As little as 1 foot change in elevation will affect the form and quality of the trees.

California black oak is found on dry or gravelly soils in California. It is a moderately large tree with diameters from 18 to 30 inches (45 to 75 cm.) at maturity. Typical veneer logs are about 15 inches (38 cm.) in diameter. Most California black oak trees have short, crooked boles and many branches. However, on good sites the tree may produce tall, clear boles. 'The tree is slow grown and so produces wood of excellent texture for face veneer. Unfortunately, most mature trees are of low grade due to knots, shake, and decay. Perhaps by selective breeding and silvicultural practice, this species can be developed for use as veneer in the hardwood-scarce area of the western United States.

White oaks.--Thespecies, white oak, occurs throughout the eastern United States. In terms of volume, size, and quality of timber, it is the most important oak veneer species. Mature trees may be 36 to 40 inches (90 to 100 cm.) in diameter. Typical logs available for manufacturing into veneer are 30 inches (75 cm.) or less in diameter. White oak grows in mixed stands, is moderately tolerant, and in well-stocked stands develops a clean bole. White oak may occasionally be attacked by wood borers, resulting in holes and associated brown stain.

Swamp chestnut oak is a large tree 24 to 36 inches (60 to 90 cm.) in diameter that grows best in the bottomlands of the Mid and Lower South and Southeast. It is estimated that logs available for veneer cutting average 24 inches (60 cm.) in diameter. The quality of swamp chestnut oak is similar to white oak.

Swamp white oak is a lowland tree that reaches its best size in western New York and northern Ohio. Mature trees may reach a diameter of 36 inches (90 cm.), but most trees available for veneer cutting have a diameter of 20 inches (50 cm.) or less. The volume of swamp white oak timber is small. Trees grown in swampy areas may have brown stain. The wood of swamp white oak generally compares favorably with the best white oak.

Bur oak grows on the extremes of dry and moist sites scattered throughout the eastern United States. Mature trees on the better moist or bottomland sites reach diameters of 36 inches (90 cm.). Trees available for veneer cutting generally are 30 inches (75 cm.) or smaller in diameter. Because of a deep brown heartwood color, bur oak is a preferred veneer species for European trade. On dry sites bur oak sometimes occurs in pure stands of widely spaced trees having very short boles. These dry site trees are generally not of veneer quality.

Chestnut oak grows mainly on the upper slopes and ridges of the Appalachian Mountains. On better sites, trees may reach a diameter of 18 to 30 inches (45 to 75 cm.). Trees available for veneer cutting are generally 18 inches (45 cm.) or smaller in diameter. While most chestnut oak grows on poor sites and has poor form, trees that do grow on the better sites product clear boles that are very satisfactory for cutting into high-quality veneer.

Durand oak grows on the Gulf Coast from Florida to Louisiana. It is thought to be the evolutionary connection with the first primitive oak species. The trees are generally of good quality and are classified as select white oaks by the Forest Survey. There is little volume of this species.

Chinkapin oak grows on well-drained soils throughout the eastern United States. It is uncommon over most of its range. On upper slopes and ridges, trees seldom reach diameters over 20 inches (50 cm.). On better sites in the Ohio Valley and the Ozark Mountains as well as the fertile bluffs east of the Delta, it may reach a diameter of 30 inches (75 cm.). It is estimated that most trees available for veneer cutting are 14 to 22 inches (35 to 55 cm.) in diameter. Chinkapin oak is listed as a select white oak in the Forest Survey. The wood tends to have a dark color and kinky or spiral grain.

Overcup oak is a bottomland species that grows in poorly drained backwater flats and in the river bottoms of the coastal plains from Delaware to Texas and throughout the Delta. The trees vary widely in form depending on the locality and site. Most trees are short-boled and many are crooked. Some stands on good soil have trees of good form. The tree is subject to insect and wood borer damage which in turn may cause bark pockets and dark brown stains. As with tree form, insect damage varies with locality and soil. Overcup oak trees generally have high growth stresses which tend to cause splits at the ends of logs cut from such trees.

Post oak grows from southeastern New England to Texas. Over most of this range it grows on dry sites and is short, knotty, and frequently attacked by wood borers. "Spot" or flagworm insect damage generally leaves a fine visible indication in the bark. Upland post oak is low grade and is used for such things as crossties, pallets, and posts. However, in the bottomlands of the Lower Mississippi Valley, the variety mississippiensis is the only post oak and is of the highest quality and very suitable for veneer. This tree may reach 32 inches (80 cm.) in diameter. It occurs in sparse amounts and is often found in association with swamp chestnut oak and Durand oak.

Oregon white oak is a medium-sized tree that grows in western Washington, Oregon, and northern California. The trunk of this tree is generally short and crooked even under forest conditions. Consequently, it has limited possibilities for use as veneer.

Wood Characteristics

All of the oaks are dense, ring-porous, straight grained, have large rays, high strength, and high shrinkage. Oaks having slow, uniform growth rate are generally preferred for use as face veneer, In general the wood of the two subgenera differ as follows:

White Oaks	Red Oaks
Heartwood generally light brown	Heartwood light brown, generally with a pink tinge
Earlywood pores in the heartwood generally have tyloses; an exception is chestnut oak	Earlywood pores in the heartwood are generally open
Large rays are frequently taller than 1-1/2 inches (3.8 cm.)	Large rays are rarely taller than 1-1/2 inches (3.8 cm.)
Latewood pores not sharply defined with a 10-power hand lens	Latewood pores plainly visible with a 10-power hand lens

The sapwood on the oaks varies from about 1 to 3.5 inches (3 to 9 cm.) in width. Red oaks, particularly those growing on moist sites in the South, generally have wider sapwood while northern-grown upland white oaks have narrower sapwood.

Veneer Cutting

Oaks are dense woods which cut well at a temperature of about 95° C. (200° F.). However, due to growth stresses in the trees, oaks are subject to enlargement of end splits during heating of bolts. For this reason, it is suggested that bolts for rotary cutting be heated to 60° to 70° C. (140° to 160° F.). Flitches for slicing should be heated to 80° to 95° C. (180° to 200° F.). Long heating times at high temperature darkens the wood of oak and increases the shrinkage during drying. All of the oaks are very susceptible to iron stain. The knife and pressure bar should be kept as clean as possible to keep stain to a minimum. Oaks are good bending woods and generally cut well into smooth veneer of uniform thickness. The exception is flat-sliced oak where rough surfaces may develop in that part of the flitch where the cut is against the grain of the wood rays, Some lathe operators advocate using relatively low nosebar pressure to minimize damage to the wood rays during cutting.

Veneer Drying

Oak veneer requires about the same or slightly longer drying times than the average for U.S. hardwood species. Veneer from the better oaks dries flat and free of buckle and splits. However, water oak, laurel oak, willow oak, and overcup oak, have a pronounced tendency to check during drying. The heartwood of overcup has a pronounced tendency to collapse during drying.

Veneer Uses

The oaks are widely used for furniture, decorative paneling, and plywood flooring blocks. Lower grade oak veneer is commonly used for containers. Oak would appear to have some potential for construction plywood providing glue bonds can be made that will meet the requirements of Commercial Standard PS-1-66.

Robinia

Tree and Log Characteristics

Black locust, Robinia pseudoacacia, is a small tree that occurs in mixed stands in the Appalachian and Ozark Mountains in eastern United States. It is fast growing and intolerant of shade. Black locust matures at 30 to 40 years of age when trees on good sites may be about 10 inches (25 cm.) in diameter. Some trees reach a diameter of 24 inches (60 cm.), but most available for cutting would be 12 inches (30 cm.) or smaller in diameter. Black locust that has been grown in the open generally is crooked and limby. The species is severely attacked by the locust borer which weaken and may kill individual trees. The borers cause large holes and associated stain in the wood. Bird peck also causes discoloration of the wood. The species has been planted widely, particularly on mine spoil banks.

Wood Characteristics

The sapwood of black locust is quite narrow, being about 1/2 inch (1 cm.) wide. The heartwood is gulden brown, sometimes with a green tinge. Black locust is dense, but has only moderate shrinkage. The wood is ring-porous with large pores and is generally straight grained. The heartwood fluoresces strongly when exposed to ultraviolet light.

Veneer cutting

In a Laboratory trial, it was found that flitches of black locust heated to 80° C. (180° F.) could be readily flat sliced into veneer 1/36 inch (0.7 mm.) in thickness.

Veneer Drying

The locust veneer dried in about the same time as the average for U.S. hardwood species. The dried veneer had a slight buckle that may have been associated with tension wood. However, this was not severe enough to prevent edge gluing of the veneer for faces.

Veneer Uses

Because most black Locust is small in diameter and is usually defective, it has been little used except for such items as fenceposts and insulator pins. Based on the small sample cut at the Laboratory, if sufficient veneer quality logs are available, black locust might be promoted as faces for "pecky" or "character marked" wall paneling.

Salix

Tree and Log Characteristics

Black willow, Salix nigra, is the only willow of commercial importance that grows in the United States. It occurs throughout the eastern United States but has its best development in the bottomlands along the banks of the lower Mississippi. It is a fast-growing tree intolerant of shade that may occur in pure or mixed stands. Thirty-year-oldtrees may be 24 inches (60 cm.) in diameter. Trees older than 50 years are usually senile and dying. Common veneer log sizes are 16 to 20 inches (40 to 50 cm.) in diameter. Stands on good sites produce three- to four-log trees. Willow is a weak wood and is subject to wind damage. The broken limbs are sources of decay. The wood may also develop compression failures in the standing tree. End splits are common log defects. Open-grown trees have many adventitious buds and burls.

Wood Characteristics

Willow is a low-density, comparatively weak wood with moderately high shrinkage. The light-colored sapwood is 2 to 3 inches (5 to 8 cm.) in width. The heartwood is pale reddish brown to gray brown with faint growth rings showing on rotary-cut veneer. It superficially looks like walnut. Willow is nearly diffuse-porous with small pores and straight to interlocked grain. Tension wood is common in leaning trees of willow. The wood is without odor or taste.

Veneer Cutting

The wood is sort enough that it can be readily cut at room temperature, 20° C. (70° F.). There is a tendency for bolts with tension wood to cut with a fuzzy surface. Cooling the wood to 5° C. (40° F.) will reduce the tendency for fuzzy surfaces to occur during cutting.

Veneer Drying

Willow veneer requires a much longer drying time than the average for U.S. hardwood species. Veneer containing tension wood tends to buckle during drying.

Veneer Uses

Selected willow veneer has been used satisfactorily for paneling, cores and crossbands of decorative panels, and for containers.

Sassafras

Tree and Log Characteristics

Sassafras (Sassafras albidum) is the only species of this genus that grows in the United States. It is generally a small- to medium-sized tree. However, on the best sites it may reach a diameter of 30 inches (75 cm.). Probably most trees available for veneer cutting would be 16 inches (40 cm.) or smaller in diameter. On poor sites sassafras is a shrub. Sassafras is intolerant of shade and grows best in open woods on moist, well-drained soil. In well-stocked stands, natural pruning is good. It generally occurs as individual trees or in small groups and is usually in the dominant overstory. Sassafras is very susceptible to tire damage. There is relatively little sassafras that reaches a size suitable for veneer cutting. However, enough does reach veneer size to consider it for a specialty face veneer.

Wood Characteristics

Sassafras is moderate in density and has low shrinkage. It is ring-porous with large vessels and generally has straight grain. The sapwood is light yellow and the heartwood is dull gray-brown to orange-brown. Freshly cut wood has a distinct odor and a spicy taste. Sassafras has a strong, interesting grain character somewhat like black ash.

VeneerCutting

Based on the specific gravity of the species, we suggest heating bolts to about 40° to 50° C. (100° to 120° F.). Flitches could be heated to 50° to 60° C. (120° to 140° F.). Industry reports that sassafras cuts well.

VeneerDrying

Sassafras veneer is reported to dry flat and without checks or splits. This is to be expected based on the wood properties of low shrinkage and straight grain.

VeneerUses

Sassafras veneer should be suitable for use in furniture and wall paneling. However, difficulties in finishing have been reported and further research may be necessary to produce a desirable appearance in finished products.

Tectona

Teak (T. grandis) is native to India, Burma, Thailand, Indochina, and Indonesia. Because of the high value of its wood, plantations have been developed in many tropical areas. This report describes teak from plantations in Puerto Rico.

Tree and Log Characteristics

Under good growth conditions teak will reach a diameter of 3 feet (90 cm.) or more. The plantation-grown teak from Puerto Rico was about 1 foot (30 cm.) in diameter. Teak generally has a straight stem and is free of disease. Old trees reportedly may develop fluted and buttressed bases. Literature from India indicates that trees grown in drier zones may have dark wavy streaks in the wood. The plantation-grown logs did not have any large end splits.

Wood Characteristics

The literature indicates teak has an average specific gravity based on green volume and ovendry weight of 0.59. Specific gravity of the plantation teak varied from 0.56 near the pith to 0.67 for the sapwood. The wood therefore has a density and strength properties similar to U.S. mainland white oak.

White to pale yellow-brown sapwood is narrow to medium wide on mature trees. It was 1 to 2 inches (2.5 to 5 cm.) wide on the plantation-grown trees and hence made up a good share of the volume. The heartwood varies from yellow brown to a rich brown and frequently has irregular dark colored streaks. The plantation material had such streaks. The wood is ring- to semi-ring-porous, has a coarse texture, is usually straight grained, and has a greasy feel. The wood has a mild but somewhat unpleasant odor which may be accentuated by moisture and heat. Silica contents of up to 1.4 percent have been reported. Occasional white deposits of calcium phosphate are found in vessels in the heartwood.

Veneer Cutting

Teak bolts and flitches heated to 95° C. (200° F.) cut well. Bolt end splits and spinout were not problems. The veneer produced was smooth, tight, and uniform in thickness. Hard deposits did not cause any noticeable knife wear when cutting the plantation teak into veneer.

Veneer Drying

The moisture content of the plantation-grown teak varied from 70 to 110 percent and averaged 90 percent. Time required to dry the veneer was longer than the average for U.S. mainland hardwoods. The veneer dried flat and did not split. Tangential shrinkage from green to dry averaged 6.6 percent and radial shrinkage 2.4 percent.

Veneer Uses

Teak is a well-recognized and preferred face veneer wood. Teak grown in plantations in Puerto Rico is satisfactory for decorative face veneer. The only limitation is that the trees should be grown to a larger diameter than the 1-foot (30-cm.) size used in Laboratory evaluations.

Tilia

Two species of basswood, Tilia, grow in the eastern United States. The most important is American basswood, T. americana, and the second species is white basswood, T. heterophyllia.

Tree and Log Characteristics

American basswood grows throughout the northeastern United States and white basswood reaches its largest size in the Appalachian Mountain regions. Under favorable conditions, trees of American basswood may reach a diameter of 38 inches (100 cm.). White basswood is slightly smaller with mature trees about 28 inches (70 cm.) in diameter. Large logs are often hollow. Because of heavy cutting, trees larger than 24 inches (60 cm.) are rare. Typical logs are 12 to 20 inches (30 to 50 cm.) in diameter. Logs from trees of basswood are of good form and relatively free of splits and shake. Brown discoloration may occur in basswood following wounding. Basswood is susceptible to fire damage and butt rot is very common in burned stands.

Wood Characteristics

The wood of the two basswood species is similar and is intermixed and sold as basswood. The wide, creamy white sapwood merges gradually into the pale yellow-brown heartwood. The wood is low in density, is diffuse-porous, straight grained, and has a fine, even texture. Basswood has from 1 to 13 percent ether-soluble extractives. The wood is free of gum, hard deposits, odor, or taste.

Veneer Cutting

Some basswood veneer tends to fuzzy surfaces due to its low specific gravity and the presence of tension wood. Basswood bolts are cut at 20° C. (70° F.) or sometimes cooled to 5° C. (40° F.) before rotary cutting to minimize fuzzy surfaces on the veneer. Use of an extra hard knife, such as a 62 on the Rockwell C-scale, is also recommended for cutting basswood. Such a knife will retain a sharp edge well and will not be nicked by a low-density wood like basswood.

Veneer Drying

Basswood requires slightly longer drying time than the average for U.S. hardwood species. Wood free of tension wood dries flat and without splits. Wood containing pronounced tension wood may buckle during drying.

Veneer Uses

In general, the properties of basswood are excellent for core and crossband veneer for furniture and other decorative panels. While basswood can generally be readily glued, it is not as easy to glue as would be expected from its low specific gravity. Glue interference may be caused by ether-soluble extractives. Lower grades of the light colored, easily nailed basswood make excellent container veneer and plywood.

Ulmus

The three most important species of elm that grow in the United States are American elm (Ulmus americana), slippery elm (U. rubra), and rock elm (U. thomassii). Two southern elms grow to tree sizes and have properties similar to rock elm. They are winged elm (U. alata) and cedar elm (U. crassifolia). They are sometimes marketed as southern rock elm.

Tree and Log Characteristics

American elm is the largest of the elms. Forest-grown trees may be 36 inches (90 cm.) in diameter. Typical veneer logs would be about 12 to 24 inches (30 to 60 cm.) in diameter. American elm trees grow in mixed stands. The form of forest-grown trees is good with large trees being slightly buttressed. American elm is relatively free from decay. However, like all the elms, they are vulnerable to the Dutch elm disease which was introduced on burl elm veneer logs imported from Europe about 1930. This disease is rapidly destroying elm stands in the United States. Unless a remedy is found for this disease, it is expected that elm will no longer be of commercial importance in the United States after 1980.

Slippery or red elm is a medium-sized tree with diameters of mature trees of about 24 inches (60 cm.). Typical veneer logs are about 12 to 20 inches (30 to 50 cm.) in diameter. Like American elm, slippery elm grows in scattered stands throughout the eastern half of the United States. American elm and slippery elm are frequently mixed and sold as soft elm.

Rock elm is a slow-growing tree that generally has a straight columnar bole. Rock elm may reach a diameter of 20 inches (50 cm.) but typical logs are about 14 inches (35 cm.) in diameter. Because of slow growth, poor reproduction, and heavy cutting in the past, rock elm is in limited supply.

Wood Characteristics

All of the elms are ring-porous. Rotary-cut and flat-sliced elm has a conspicuous growth-ring figure and a characteristic delicate wavy figure within each annual ring.

The sapwood of American elm may be 1.5 to 3 inches (4 to 8 cm.) in width. The grain is occasionally straight but generally interlocked. The heartwood is light gray-brown, frequently with a reddish tinge.

The sapwood of slippery elm is narrow, generally 1 to 1.5 inches (2 to 3 cm.). The heartwood of slippery elm is a darker red-brown than the heartwood of American elm. Slippery elm heartwood sometimes has yellow streaks identified as sesquiterpenes. Surface deposits of the extractives can be removed with alcohol. However, gradual diffusion of the yellow material may result in a return of the stain. The discoloration of white paint over stained areas can be reduced by wiping the wood with alcohol before painting.

Rock elm is similar to the soft elms in structure but has a higher specific gravity and consequently is harder and stronger. In this respect, it resembles white oak. The heartwood color of rock elm is similar to the color of American elm.

Veneer Cutting

A temperature of 50° to 60° C. (120° to 140° F.) is recommended for heating American elm and red elm bolts prior to cutting into veneer. A uniform red-brown color is sometimes desired for face veneer from red elm. The flitches are therefore heated to a higher temperature such as 80° C. (180° F.) for several days and then the temperature is dropped to 65° C. (150° F.) before flat-slicing. Based on its specific gravity, bolts of rock elm should be heated to about 70° to 75° C. (150° to 170° F.) prior to rotary-cutting. Flitches of rock elm should be heated to about 95° C. (200° F.) before slicing.

Veneer Drying

Elm requires about the same drying time as the average for American hardwood species, Elm veneer that contains tension wood may buckle and split during drying.

Veneer Uses

Elm has been used as face veneer for furniture panels and for decorative wall paneling. It is also used for core and crossbands of decorative panels. The good bending properties of elm make it well suited for baskets and crates. The rock elms are not used as much for veneer as the soft elms. As stated earlier, unless a cure is found for Dutch elm disease, elm may cease to be a commercial timber in the United States after this decade.

Umbellularia

Tree and Log Characteristics

California-laurel, Umbellularia californica, also known as Oregon-myrtle, is a moderate-sized tree that grows best on protected bottomland sites in southwestern Oregon and northern California. It may reach a diameter of 24 inches (60 cm.) or larger, but typical trees are about 14 to 18 inches (35 to 45 cm,) in diameter. The bole of the tree frequently divides near the ground, even on good sites. Large burls are often found on the trunks of older trees.

Wood Characteristics

The sapwood of California-laurel is generally about 2 inches (5 cm.) in width. The rich, light brown heartwood often has darker streaks. Some of the wood has a yellowish-green cast. The heartwood reportedly darkens appreciably when soaked in water. Freshly cut heartwood has a spicy odor. The wood is dense, diffuse-porous, has small pores and straight to interlocked grain.

Veneer Cutting

Bolts of California-laurel should be heated to about 65° to 70° C. (150° to 160° F.) before rotary cutting. Flitches heated to 95° C. (200° F.) cut well.

Veneer Drying

Gelatinous fibers are common in California-laurel. This, combined with curly and other irregular grain patterns, makes the veneer susceptible to buckling during drying. The drying time is slightly longer than the average for American hardwoods.

Veneer Uses

The wood has long been valued for use as attractive decorative face veneer.

There is relatively little volume of California-laurel.

SOFTWOOD

Abies

Seven species of Abies are considered of commercial importance in the United States. These seven species and one variety are:

Common Name	Botanical Name	Rating for Use as Veneer
Noble fir	A. procera	Good
California red fir	A. magnifica	Good
Shasta red fir	A. magnifica var. shastensis	Good
Pacific silver fir	A. amabilis	Intermediate
White fir	A. concolor	Intermediate
Grand fir	A. grandis	Intermediate
Subalpine fir	A. lasiocarpa	Less suited
Balsam fir	A. balsamea	Less suited

Balsam fir grows in Canada, the Lake States, and the New England States. All of the other species of Abies are native to the Western United States. The good ratings above are based on the percentage of clear wood in typical logs of the Abies genus.

Tree and Log Characteristics

Balsam fir reaches a maximum diameter of 18 inches (45 cm.), subalpine fir from 18 to 24 inches (45 to 60 cm.), grand fir and Pacific silver fir about 24 to 40 inches (60 to 100 cm.), California red fir and shasta red fir from 30 to 40 inches (75 to 100 cm.), and noble fir from 36 to 60 inches (90 to 150 cm.). Typical logs of any of these species would be 6 to 18 inches (15 to 45 cm.) less than the diameter of mature timber. fill of the firs grow in mixed stands. They may occasionally occur in small patches of pure stands.

There is a wide range among individual fir species in tolerance to shade. Noble fir is intolerant; California red fir and shasta red fir are intermediate in tolerance; Pacific silver fir and grand fir are tolerant; white fir is tolerant to very tolerant; and subalpine fir and balsam fir are very tolerant. Noble fir, being intolerant, prunes itself well in closed stands. At the opposite extreme, subalpine fir and balsam fir retain their branches throughout most of their life. As a result, noble fir provides considerable clear material while veneer cut from the tolerant to very tolerant fir species contains many knots.

In general, the form of the fir species is good. Exceptions are occasional trees of California red fir and grand fir which may have sweep in the butt log due to bending of young trees under snow loads. Balsam fir and subalpine fir have moderate taper.

Noble fir is relatively free of disease. All of the other true firs are susceptible to heart rot when the trees reach maturity. This is such a problem with balsam fir that a maximum rotation age not exceeding 70 years has been suggested. The firs are subject to varying degrees of attack by insects such as bark beetles and the balsam woolly aphid. California red fir and white fir may be attacked by mistletoe, Frost cracks are common in the butt logs of white fir grown on the east slopes in California.

Wood Characteristics

These true firs are moderately low in specific gravity and have corresponding strength properties. Balsam fir and subalpine fir are lighter and less strong than the others, The sapwood on the true firs is relatively wide and varies from about 2 to 7 inches (5 to

18 cm.). The heartwood is indistinguishable in color from the sapwood. The wood is white to light buff in color, with the wide springwood being nearly white and the narrow summerwood being light brown or having a lavender tinge.

The wood of the true firs cannot be distinguished by species once it is cut into veneer. The wood is generally straight-grained and of medium texture. The earlywood zone usually occupies more than half of the ring and the transition from earlywood to latewood is very gradual, The latewood zone is distinct to the eye.

True firs have gum in the bark but not in the wood. Compression wood occurs in logs that have sweep but this is not a major problem with the true fir species.

All of the true firs are reported to be subject to wetwood. Wetwood is generally considered to be due to saprophytic or weakly parasitic bacteria in the standing tree. One result is that wetwood has a high moisture content and dries unevenly. Furthermore, wetwood in the green veneer has an objectional odor even though dry veneer from the true firs is without characteristic odor.

Veneer Cutting

Slow-grown, clear wood of any of the true firs can be cut into satisfactory veneer at a wood temperature of about 20° C. (70° F.). Fir knots at room temperature are hard enough to turn the edge of a knife ground to an angle of 21°. The problem of hard knots can he solved by putting a back bevel on the knife to strengthen the edge. A different approach is to heat the bolts to 55° to 65° C. (130° to 150° F.) prior to cutting veneer. This softens the knots so they can be cut with a sharp knife ground to an angle of 21° and improves the tightness of the veneer.

A second problem in cutting veneer from the true firs is "shelling" or mashing of the grain, particularly in areas where the sapwood and heartwood have very high moisture content. Heating for long periods and use of heating temperatures higher than 65° C. (150° F.) accentuates the tendency of the wood to "shell" during veneer cutting. Shelling can be kept to a minimum by accurately alining the pressure bar to the knife edge and using moderate nosebar pressure and moderate cutting speed.

Very smooth and tight white fir veneer was produced by quarter-slicing flitches that had been heated to 70° C. (160° F.). The same precautions suggested for rotary-cut veneer should be applied for flat-slicing.

The true firs have only a slight tendency to develop iron stain.

Veneer Drying

The sapwood of white fir requires about the same or slightly more drying time than the sapwood of Douglas-fir. Wet streaks in the heartwood require as much drying time as the sapwood. Heartwood that does not contain wet streaks can be dried twice as fast as the sapwood. Luckily, heartwood veneer that is free of wet streaks can be readily identified and segregated for drying on a faster schedule. Depending on the raw material, it may or may not be worthwhile to make this segregation. In one trial we found that about 90 percent of the total white fir veneer produced had to be run on the slow-sapwood and wet-heartwood schedule compared to about 40 percent for Douglas-fir. This would mean about twice as much drying capacity would be needed for a given volume of white fir as for the same volume of Douglas-fir.

Heartwood veneer containing wet streaks is prone to develop splits at the streaks during drying. Black knots in white fir often fall out during drying.

Veneer Uses

While not as stiff and strong as Douglas–fir, western larch, and southern pine, white fir is commonly used for construction plywood. Due to its light color and freedom from gum and resin, white fir has been extensively used as veneer and as plywood for containers,

Chamaecyparis

Three species of the Chamaecyparis genus grow in the United States and are known as cedars, although they are not true cedars. None occur in much volume. The species are:

Common Name	Botanical Name	Rating for Use as Veneer
Port–Orford–cedar	C. lawsoniana	Good
Alaska–cedar or yellow–cedar	C. nootkatensis	Good
Atlantic white–cedar	C. thyoides	Fair

Atlantic white–cedar is an eastern species that grows from Maine to Florida. The other two species grow on the West Coast. Alaska–cedar grows from Alaska to Oregon, and Port–Orford–cedar is restricted to southwest Oregon and northwest California.

Tree and Log Characteristics

Port–Orford–cedar is the largest of these species and may reach a diameter of 40 to 60 inches (100 to 150 cm.). Typical trees available for cutting into veneer would be 3 feet (90 cm.) or less in diameter. Port–Orford–cedar generally occurs as scattered trees in the forest. This species is reported to sometimes develop multiple stems. Mature trees of Port–Orford–cedar are noted for yielding a high percentage of clear wood.

Alaska–cedar may reach a diameter of 24 to 36 inches (60 to 90 cm.). Like Port–Orford–cedar, Alaska–cedar generally occurs as scattered trees in the forest. Mature trees of Alaska–cedar may be buttressed and have moderate taper. Mature trees of Alaska–cedar are reported to yield a moderate amount of clear wood.

Atlantic white–cedar is considerably smaller than the Port–Orford– or Alaska–cedar. Mature trees of Atlantic white–cedar are seldom larger in diameter than 24 inches (60 cm.). Trees available for veneer cutting would typically be 10 to 14 inches (25 to 35 cm.) in diameter. In contrast to the western cedars, Atlantic white–cedar generally occurs in pure, dense, even–age stands. Because almost all of the old–growth Atlantic white–cedar has been cut, the smaller trees available for veneer produce little clear wood.

All three of these cedars have very desirable wood characteristics. As a result, they have all been heavily cut. In addition, they are all very slow growing and, consequently, the volume of wood available for use as veneer in the future is likely to be very small.

Each of the three species of this genus require a good water supply. Even with adequate water they all are very slow growing. They are generally tolerant to shade early in life, becoming less tolerant as the trees become older. All three species are highly resistant to decay and insect attack.

Wood Characteristics

The wood of these three cedars is slow grown, unusually fine and uniform in texture, and generally straight grained. All three have narrow sapwood generally lighter in color than the heartwood, The wood is free from hard deposits and free from gum or resin.

The wood of Alaska–cedar and Port–Orford–cedar is moderate in density and similar in physical and mechanical properties. If anything, Port–Orford–cedar is slightly stronger than Alaska-cedar. The thin sapwood of these two cedars merges gradually into the heartwood. The heartwood of Port–Orford–cedar is light yellow to pale brown while the heartwood of Alaska-cedar is a bright, clear yellow. Aromatic oils in Port–Orford–cedar give it a gingerlike odor or a pleasant spicy odor. Alaska–cedar has an agreeable resinous odor sometimes described as a sweet cedary odor or as a raw potato odor.

Some Port–Orford–cedar has compression wood. Because of warp, the compression wood is not suitable for products like arrows, battery separators, or venetian blinds.

The wood of Atlantic white–cedar is less dense and not as strong as the wood of the other two species. The thin sapwood of Atlantic white-cedar has a sharp color difference between it and the light pink–brown heartwood. Atlantic white–cedar has a slight spicy aromatic odor.

Veneer Cutting

The fine uniform texture and slow growth make all three of these cedars well suited to being cut into veneer with a knife. Because of hard encased knots, we suggest heating Port–Orford–cedar and Alaska–cedar to 60° to 70° C. (140° to 160° F.) prior to cutting veneer. Atlantic white–cedar is low enough in specific gravity so that it should cut satisfactorily at room temperature, 20° C. (70° F.).

Veneer Drying

All three of these species have a reputation for drying without difficulty. In Laboratory trials, the sapwood veneer of Port–Orford–cedar required about the same drying time as the sapwood of Douglas–fir. Like Douglas–fir the heartwood contains much less moisture than the sapwood and so requires less drying time. Flat–sliced knotty Port–Orford–cedar dried with slight buckle but quarter–sliced clear veneer dried flat. Encased knots fell out during drying.

Veneer Uses

In the past, Port–Orford–cedar has been the preferred wood for use as battery separators. This material was produced by rotary–cutting, slicing, or sawing veneer. Materials other than wood have taken over most of this market. Port–Orford–cedar is a preferred wood for use in venetian blinds, because of its good stability and paintability.

Fine texture, good durability, and good finishing properties make the heartwood of these three species particularly suited for such uses as small boat parts. Due to the small volume of these species, they will probably be used primarily for specialty items.

Juniperus

There are 13 species of juniper native to the United States, but only eastern redcedar (J. virginiana) is of importance for veneer. Several western species, including alligator juniper (J. deppeana), western juniper (J. occidentalis), and Rocky Mountain juniper (J. scopulorum) have been tried at the Forest Products Laboratory for use as veneer. Under present practice none of these western junipers is suitable for use as veneer.

Tree and Log Characteristics

Eastern redcedar is a moderate-sized tree which under optimum growth conditions may reach a diameter of 2 to 3 feet (60 to 90 cm.). Because the species has been so heavily cut, a tree with a diameter of 18 inches (45 cm.) is considered large today. Eastern redcedar occurs in pure stands and as scattered trees throughout the Eastern United States. It is considered intolerant to very intolerant of shade. Since it generally occurs in open stands, most of the veneer produced from eastern redcedar contains many knots.

Eastern redcedar is very subject to fire damage. The species is relatively resistant to insect attack and decay, although some decay occurs in trees grown in the South. Eastern redcedar is the alternate host for apple cedar rust. This disease is very damaging to apple trees but does not affect the use of the cedar.

Western juniper, Rocky Mountain juniper, and alligator juniper are generally small trees or shrubs, 12 inches (30 cm.) or smaller in diameter. However, alligator juniper may occasionally reach a diameter of 24 inches (60 cm.). The trunks of these western junipers are ragged and gnarled in appearance. Most of them have deep fissures. White-pocket rot is very severe on old trees of western juniper.

Wood Characteristics

Eastern redcedar is moderately dense and moderately hard. The thin sapwood is nearly white and the heartwood is purplish to bright red when first cut. After exposure to air and light, the wood becomes dull red or reddish-brown. The grain is generally straight and fine textured. Figure consists of intergrown knots, distinct growth rings, reddish heartwood, and occasionally lighter streaks of included sapwood. The wood has a characteristic cedar odor. Leaning trees may have compression wood.

The western junipers are similar to eastern redcedar except they have wider sapwood and the heartwood is generally a dull brown when first cut. The odor of western junipers is less pronounced than that in eastern redcedar. Western junipers have more loose knots and bark pockets than eastern redcedar. Because of their small size and bark fissures, most western junipers are not suitable for veneer.

Veneer Cutting

Commercially, almost all eastern redcedar cut into veneer is produced by flat-slicing. Flitches are generally heated to a temperature of about 80° C. (180° F.). Thin veneer, 1/22 inch (1.1 mm.) of thickness, can be satisfactorily rotary-cut from bolts at 70° C. (160° F.). The relatively dry heartwood of eastern redcedar and of the western junipers is somewhat brittle. For this reason, some commercial producers of sliced veneer use a knife with an included angle of 18° rather than 21° as is common for most other species. With properly heated flitches and use of a sharp knife, satisfactory veneer can be produced from eastern redcedar and the western junipers.

Veneer Drying

Because of the much higher moisture content in the sapwood of these species, it requires more drying time than the heartwood. Intergrown knots develop small shrinkage splits during drying and loose knots often fall out during drying.

Some veneer of the western junipers cut experimentally buckled slightly due to the presence of compression wood. Shrinkage of eastern redcedar and of the western junipers is relatively low. The thin dry veneer must be handled carefully as it is somewhat brittle.

Veneer Uses

Eastern redcedar is flat-sliced for use as faces of cedar chests and paneling for cedar closets.

Since there are relatively few veneer grade logs of eastern redcedar, laboratory and industrial tests were made with several western junipers to determine if they could be used as substitutes for eastern redcedar. Because of the differences in color, odor, and the high percentage of seams, bark pockets, and loose knots, the western junipers have not been accepted for use as face veneer.

Larix

Two species in the Larix genus are of commercial importance in the United States. They are L. occidentalis, western larch, and L. laricina, tamarack. An interesting characteristic of this genus is that the needles turn yellow and fall from the tree each year.

Tree and Log Characteristics

Both tamarack and western larch may grow either in pure stands or in mixed stands, Both species are very intolerant of shade so that in closed stands the lower two-thirds of the tree trunks are generally free of branches. Tamarack has a very wide range, growing from New England to the Lake States, Canada, and into Alaska. Western larch grows in Washington, Oregon, Idaho, Montana, and into Canada.

Western larch is a large tree that may reach a diameter of 18 to 36 inches (45 to 90 cm.). Typical trees available for use as veneer are 16 to 24 inches (40 to 50 cm.) in diameter. Western larch has a deep root system and so resists the force of the wind very well. Older trees may have swollen butts and considerable taper,

Western larch is moderately resistant to decay, although overmature stands may have significant amounts of decay. Dwarf mistletoe damages some trees and the species is also subject tu attack by the larch sawfly. Some of the older stands of western larch have a high proportion of ring shake in butt logs.

Tamarack is a medium-sized tree that may reach a diameter of 14 to 24 inches (35 to 60 cm.). Logs available for cutting into veneer are typically 10 to 16 inches (25 to 40 cm.) in diameter. Tamarack often is found in peat bogs. It has a shallow root system and so is subject to damage by wind. Tamarack stands have been invaded by attacks of the larch sawfly that may eventually kill the trees. Some areas in the Lake States and in Maine have been extensively attacked by porcupines which deform the trees.

Wood Characteris tics

Both western larch and tamarack are moderately heavy and hard. Western larch has a slightly higher modulus of elasticity and strength than tamarack. Both species have narrow sapwood, generally 1 to 1-1/2 inches (2.5 to 4 cm.) or less. The sapwood of both species is whitish. The heartwood of western larch is russet or reddish-brown, while the heartwood of tamarack is yellowish-brown with a slight greenish cast. Both species have conspicuous growth rings with marked contrast in density between the springwood and summerwood. Western larch is generally more uniform and slow grown than tamarack.

Both species have resin ducts but relatively little resin in the wood. Western larch has galactan, a true gum. This material is concentrated primarily in the outer heartwood of the butt logs and is readily water soluble. Limited amounts of galactan do not interfere with gluing. Leaning tamarack or western larch trees may contain compression wood, but this is not a major problem with either species.

Veneer Cutting

Both larch and tamarack cut well by the rotary method if the bolts are heated in water at 65° C. (150° F.) until the core diameter reaches a minimum temperature of 50° C. (120° F.). Flitches heated at 80° C. (180° F.) sliced well except that there was excessive shelling in the sapwood of the tamarack. For this reason, it would probably be well to limit heating of flitches to 70° C. (160° F.). There was some breakout at shake in old-growth western larch peelers. The heartwood of both tamarack and western larch develops iron stain if it comes in contact with iron in the presence of water.

Veneer Drying

The sapwood of western larch and tamarack requires about the same drying time as the sapwood of Douglas-fir. The heartwood of these species has higher moisture content than the heartwood of Douglas-fir. This is particularly true of butt logs of western larch which may have moisture contents over 100 percent. As a result, the heartwood of western larch may require considerably longer drying time than the heartwood of Douglas-fir. The heartwood of tamarack requires slightly longer drying time than the heartwood of Douglas-fir.

Veneer of both species dries flat with the exception of buckle that may occur if there is pronounced compression wood in the veneer. Deposits of galactan were heavier on the loose side than on the tight side of the western larch veneer and were heavier on veneer dried at 325° F. than on veneer dried at 250° F.

Veneer Uses

Western larch is comparable to Coast Douglas-fir in strength properties and is used interchangeably with it as construction plywood. Quarter-sliced western larch has an attractive modern appearance and has been used to a small extent for paneling. Edge-grain larch also makes a good flooring material,

Because of the small-diameter logs, tamarack has not been used much for veneer. From laboratory tests, it would appear to be suitable for construction plywood when cut by the rotary method. Tamarack plywood faced with knotty or clear sliced veneer makes attractive decorative paneling. The knots are small and fairly tight, and the wood has a warm yellowish-brown color with a slight greenish cast.

Rotary-cut veneer from both species is suitable for use in containers.

Libocedrus

Incense-cedar (L. decurrens) is the only species of this genus that is native to the United States.

Tree and Log Characteristics

Incense-cedar is a large tree that will reach a diameter of 36 to 48 inches (90 to 120 cm.). Such large trees often have a fluted and buttressed base. As the result, the butt log has considerable taper. Old-growth trees now being harvested are primarily 24 to 36 inches (60 to 90 cm.) in diameter. Incense-cedar generally grows in mixed stands and rarely occupies more than 30 percent of the stand. It grows from Oregon through California into Lower California .

The tree is tolerant to shade, and as a result, most of the second-growth material contains many knots. Old-growth stands of incense-cedar have as much as two-thirds cull due to

pocket dry rot, This is not expected to be a serious problem in managed second-growth stands. Most of the rot apparently began after fire damage. The flat-headed borer mines in the living sapwood and heartwood of incense-cedar and thus slightly damages the wood.

Wood Characteristics

The thin sapwood is nearly white and the heartwood is reddish-brown to dull brown, sometimes with a lavender tinge. The wood is relatively low in density, and correspondingly low in hardness and most strength properties. The grain of the wood is straight and even. The growth rings are faint because the transition from springwood to summerwood is gradual. The wood has a characteristic pungent odor and spicy taste. Incense-cedar does not contain gum, but it does have essential oils which give it a characteristic odor and taste.

Veneer Cutting

Based on its specific gravity, we believe incense-cedar could be cut at room temperature. If it is important to cut veneer with a minimum of knife checks, it may be desirable to heat the bolts or flitches to about 50° C. (120° F.). Due to the high moisture content of the wood, it would probably be well not to use high nosebar pressure. The uniform texture and gradual transition from springwood to summerwood of this species should be favorable for cutting of veneer.

Veneer Drying

Based on the high moisture content, we would expect the heartwood of incense-cedar to require considerably longer drying time than the heartwood of Douglas-fir. This species would probably stain readily if it contacts iron in the presence of moisture. As some incense-cedar has collapsed when dried in lumber form, use moderate drying temperatures when drying veneer of incense-cedar, The wood has low shrinkage and would probably dry flat as veneer.

Veneer Uses

The main use for this species at present is as sawn slats for pencils. Second-growth incense-cedar should be suitable for cutting into knotty veneer for decorative paneling. Veneer should also be suitable for such products as cedar chests and closets. The limitation for such products would probably be the softness of the wood. Clear veneer should make good core and crossbands for decorative panels.

Picea

Six species of spruce, Picea, grow to a size large enough for use as veneer. These species are:

Common Name	Botanical Name	Rating for Use as Veneer
Sitka spruce	P. sitchensis	Good
Engelmann spruce	P. engelmannii	Intermediate
White spruce	P. glauca	Intermediate
Red spruce	P. rubens	Intermediate
Black spruce	P. mariana	Less suited
Blue spruce	P. pungens	Less suited

Tree and Log Characteristics

Sitka spruce is the largest of the spruces. It grows along the Pacific Coast from California to Alaska. Trees may reach a diameter of 42 to 54 inches (105 to 140 cm.).

Engelmann spruce and blue spruce grow throughout the Rocky Mountains from British Columbia to New Mexico and Arizona. In volume, Engelmann spruce is exceeded by only four other western softwoods--Douglas-fir, ponderosa pine, lodgepole pine, and western hemlock. Engelmann spruce is a medium-sized tree that may reach a diameter of 18 to 30 inches (45 to 75 cm.). Blue spruce is similar to Engelmann spruce but is smaller, reaching a diameter of 12 to 24 inches (30 to 60 cm.).

Red spruce is an eastern species growing from Canada down through the Appalachians to the Carolinas. It is a small- to medium-sized tree 12 to 24 inches (30 to 60 cm.) in diameter when mature. White spruce and black spruce have very wide ranges from Northeastern United States to Southeastern Canada across the center of Canada and up into Alaska. White spruce is about the same size as red spruce, reaching a diameter of 12 to 24 inches (30 to 60 cm.). Black spruce is the smallest and seldom reaches a diameter of over 12 inches (30 cm.).

All of the spruces may be found in pure stands, but generally occur in mixed stands. All of the spruces are classified as tolerant to shade. As a result, the branches do not die for a long time, and most of the wood contains many small- to medium-sized knots. An exception is the large old-growth trees of Sitka spruce that have grown in dense stands for long periods of time. These trees produce clear wood suitable for such things as aircraft parts. While the spruces are generally classed as tolerant, they are not as tolerant to shade as some of their common competitors; for example, black spruce is not as tolerant as balsam fir and northern white-cedar; Engelmann spruce is not as tolerant as subalpine fir; red spruce is not as tolerant as balsam fir; white spruce is not as tolerant as balsam fir; and Sitka spruce is not as tolerant as western hemlock. As a result, the spruce must overtop these more tolerant competitive species or lose out in the stand composition.

In general, the form of spruce is good, with cylindrical boles. However, old-growth Sitka spruce often has a buttressed and swollen base. The eastern spruces--black, red, and white--have moderate taper. All of the spruces are relatively shallow-rooted and as a result are subject to damage by wind.

Second-growth spruce is relatively resistant to decay, but old-growth or overmature trees of red spruce and Sitka spruce are reported to have a high percentage of decay. The spruce budworm and the spruce bark beetles have caused extensive damage in some spruce stands; for example, heavy blowdowns in Colorado, Montana, and Idaho were followed by devastating attacks by the spruce bark beetle that destroyed an estimated 9 million board feet of Engelmann spruce. A study made by the University of Maine indicates that seams in eastern spruce, particularly mature red spruce, cause considerable degrade in rotary-cut veneer.

If a stand of Sitka spruce is opened by cutting or other means, the trees will quickly develop epicormic branches.

Wood Characteristics

All of the spruces are moderately low to low in specific gravity. Engelmann spruce, lowest of the group, is one of the lightest important commercial woods of the United States. The spruces are correspondingly low in hardness but are stiff for their weight. As a result, clear spruce has been a preferred wood where high stiffness and low weight are important.

The sapwood of the spruces is thin and nearly white. The heartwood of black, red, white, and Engelmann spruce is also nearly white. The heartwood of Sitka spruce is a light reddish-brown. The grain of the spruces is generally straight, although red and white spruce may have small amounts of spiral grain. The annual growth rings of spruce are fairly distinct with a difference in color between summerwood and springwood. The transition from the springwood to summerwood is gradual.

The wood of all the spruces is relatively impermeable. All of the spruces have resin canals, but pitch is not a limiting factor in the use of these species. Moderate amounts of compression wood have been reported for all of the spruces. The wood is free of odor and taste and hard deposits. Sitka spruce is frequently dimpled on the tangential surface.

Veneer Cutting

In laboratory tests, satisfactory rotary veneer was cut from spruce at room temperature, 15° to 25° C. (60° to 80° F.). Knots in Engelmann spruce cut at room temperature at the Forest Products Laboratory in Madison did not nick or damage a sharp lathe knife. This knife was ground to an angle of 21° and had a hardness on the Rockwell C–scale of 56 to 58. Tests at the Canadian Laboratory at Ottawa showed that unheated knots in white spruce would nick a sharp knife. The Canadians recommend cutting white spruce at room temperature but using a microbevel to produce a 30° angle at the extreme tip of the knife.

Commercial veneer producers generally heat the bolts of white and red spruce prior to cutting. Vat temperatures are 50° to 55° C. (120° to 130° F.), and heating is long enough to bring the core temperature to about 30° C. (90° F.). Commercial producers of sliced, knotty spruce heat the flitches to about 60° C. (140° F.) prior to slicing. Overheating will increase the incidence of fuzzy surfaces and shelling.

The springwood of all the spruces is very soft and so is sensitive to any dullness of the knife. If the knife edge is not maintained in a very keen condition, tearing and rough surfaces occur in the springwood portion of rotary–cut veneer. The edge of the pressure bar should be slightly eased and set very accurately to the edge of the knife to produce moderately tight and smooth veneer. Spinout of bolts may be a problem when peeling spruce veneer. Use of retractable chucks and a roller nosebar will help minimize this problem.

Veneer Drying

The sapwood of the spruces is often over 100 percent in moisture content, while the heartwood has a moisture content of about 40 percent. In this respect the spruces are similar to Douglas–fir. Sapwood and heartwood veneer thus should be segregated for drying. The bulk of the veneer is heartwood and requires about the same drying time as heartwood of the same thickness of Douglas–fir. Most spruce veneer dries flat. Pronounced compression wood causes a small percentage of spruce veneer to buckle during drying. Spruce is low in strength in tension perpendicular to the grain and must be handled carefully to prevent development of splits.

The Canadian Laboratory at Vancouver has found that white spruce veneer darkened by high drying temperatures is difficult to glue.

Veneer Uses

Clear, old–growth Sitka spruce may be quarter–sliced and used for very high–grade products such as aircraft veneer. Some Engelmann spruce with small, tight red knots is sliced for decorative, knotty veneer. The bulk of the veneer produced from all of the spruces is rotary–cut and made into construction plywood. The very high incidence of knots, including many loose and encased knots which fall out during drying, makes this the most logical use for the spruce species. Spruce is particularly adaptable for some types of containers because of its light weight, its fine light color, and its freedom from odor and taste. The resonance of spruce makes it well suited for musical instruments.

Pinus

More species of the Pinus genus grow to veneer–log size than any other softwood genus in the United States. For convenience in discussing them, they are broken into the three regions––southern, western, and northeastern––in which they grow, and further subdivided into the soft pine and the hard pine groups. The soft or white pines, subgenus Haploxylon, have a more gradual transition from springwood to summerwood than the hard pines, subgenus Diploxylon. The soft pines have needles in clusters of five and the hard pines in clusters of two or three.

Southern Pine Group

Common Name	Botanical Nane	Soft or Hard Pine
Loblolly pine	P. taeda	Hard pine
Shortleaf pine	P. echindta	Hard pine
Longleaf pine	P. palustris	Hard pine
Slash pine	P. elliottii var. elliottii	Hard pine
Spruce pine	P. glabra	Hard pine
Pond pine	P. serotina	Hard pine
Virginia pine	P. virginiana	Hard pine
Pitch pine	P. rigida	Hard pine
Sand pine	P. clausa	Hard pine
Table-Mountain pine	P. pungens	Hard pine

Western Pine Group

Western white pine	P. monticola	Soft pine
Sugar pine	P. lambertiana	Soft pine
Limber pine	P. flexilis	Soft pine
White bark pine	P. albicaulis	Soft pine
Ponderosa pine	P. ponderosa	Hard pine
Jeffrey pine	P. jeffreyii	Hard pine
Lodgepole pine	P. contorta	Hard pine
Knobcone pine	P. attenuata	Hard pine
Digger pine	P. sabiniana	Hard pine

Northeastern Pine Group

Eastern white pine	P. strobus	Soft pine
Red pine	P. resinosa	Hard pine
Jack pine	P. banksiana	Hard pine
Pitch pine	P. rigida	Hard pine

SOUTHERN PINE GROUP

The southern pines grow principally in the Southeastern States of the United States bordering the Atlantic and the Gulf of Mexico. They are all hard pines. The four major species in this group are loblolly, shortleaf, longleaf, and slash pine. Slash and longleaf pine are denser, stiffer, and stronger than shortleaf and loblolly pine. However, there is considerable variation in the wood of any one species of southern pine. For example, loblolly

may be as heavy as typical longleaf or as light as typical shortleaf. Associated with these four major southern pines are six species considered minor southern pines. In general, they represent a relatively small volume of timber; and they are all lower in stiffness and other strength properties than shortleaf pine, the weakest of the major pines.

Tree and Log Characteristics

The four major southern pines are medium- to large-sized trees. They may reach a diameter of 24 inches (60 cm.) or more at maturity. Typical southern pine logs available for veneer production are 12 to 16 inches (30 to 40 cm.) in diameter. In general, the southern pines are moderately tolerant or intolerant to shade. The four major southern pines have good natural pruning so that logs 12 inches (30 cm.) or more in diameter often have a large percentage of clear material. Shortleaf, longleaf, and slash pine generally have straight boles, while loblolly often has sweep. Logs up to 16 inches (40 cm.) in diameter generally have relatively small log end splits and are free from shake and decay. Comments on specific species follow.

Loblolly.--There is more volume of loblolly pine than any of the other southern pines. It grows over a wide range from the Atlantic Coast to the Piedmont. Loblolly occurs in pure stands on old fields and also in mixed stands with hardwoods. Because it is a light-seeking tree, it sometimes develops a pistol butt or sweep in the bole. Thinning of managed stands tends to eliminate trees with poor form before they reach a size suitable for veneer.

Shortleaf.--Shortleaf is next in volume to loblolly among the southern pine group. It has the widest range of the southern pines, growing in 22 states. Shortleaf grows on upland: and in the foothills. It occurs in pure or mixed stands with hardwoods. Shortleaf is the slowest growing of the major pines and tends, therefore, to have a more uniform texture. Shortleaf may reach a diameter of 36 inches (90 cm.) and is the largest of the southern pines. The littleleaf disease has caused loss in some stands of shortleaf pine. Shortleaf will sprout if it is cut back or burned early in life. Shortleaf is resistant to fire after it reaches a diameter of 4 to 10 inches.

Longleaf.--Longleaf grows in pure, open stands. Longleaf is very intolerant to shade and naturally prunes at an age of about 10 years. Longleaf is resistant to fire as a seedling in the grass stage and after the tree is 3 feet tall. However, with fire protection, other southern pines and hardwoods tend to take over land formerly occupied by longleaf.

Slash.--Slash pine grows on poorly drained soils from South Carolina to Florida. It is the heaviest and strongest of the southern pines. Slash pine is susceptible to fire damage. Consequently, it is preferably managed in even-aged stands so that prescribed burning can be used. Slash pine grows best on poorly drained soils such as the margins of ponds. Mature stands of slash pine may develop red heart disease. Older trees may also be attacked by bark beetles.

Spruce.--Spruce pine is a medium-sized tree that grows on riverbanks and swamps in small groups or scattered among hardwoods. When grown singly, the bole is frequently crooked, In pure stands, it may develop a clear bole.

Pond.--Pond pine grows in swamps and upland bogs. Over 50 percent of the volume is in North Carolina. The tree may occur in pure or scattered stands. The bole is frequently short and contorted. Adventitious buds cause knots 1/4 inch in diameter or less in veneer cut from the species. Older stands may be damaged by fire and beetles. Loblolly sometimes will cross with pond pine.

Virginia.--Virginia pine grows in pure and mixed stands with over 50 percent of the volume in Virginia. The stands are subject to wind and ice damage. Stands over 60 years of age may develop heart rot. Virginia pine sometimes takes over old fields.

Pitch.--Pitch pine grows on poor soils such as sand and gravel. Typically, it occurs mixed with hardwoods. The tree can reproduce vegetatively and will recover after damage by fire

or deer browsing, However, this results in deformed trees. Since most trees grow in the open, they often have large branches. Trees grown in closed stands that later have the stand opened will develop sprouts along the bole. Fire tends to maintain stands of pitch pine.

Sand.--Sand pine occurs as two types. In north-central Florida, it grows in dense, even-aged, pure stands resulting from fire. In western Florida, sand pine grows in uneven-aged stands. Sand pine rarely exceeds a diameter of 12 inches (30 cm.) and grows on sandy, infertile soil.

Table-Mountain.--Table-Mountainpine is a small tree seldom over 18 inches (45 cm.) in diameter. It produces a short bole with many branches, resulting in very knotty veneer, Table-Mountain pine may occur as a scattered mountain tree or in pure stands.

Wood Characteristics

Veneer from any of the southern pines cannot be distinguished by species. There is a sharp contrast in density between the springwood and the summerwood, with the summerwood being two to three times as dense as the springwood. This characteristic, plus the very wide range in growth rate for southern pine and the very wide range in the percent of summerwood in any one annual ring, makes the wood of the southern pines highly variable in quality, The dense summerwood is more difficult to glue than the springwood. Typically, longleaf and slash are the denser of the southern pines. For structural purposes, it is sometimes specified that dense southern pines must have six rings to the inch and be at least one-third summerwood. Shortleaf is the slowest grown and the least dense of the four major southern pines. Loblolly often approaches shortleaf in these properties, but it may be as dense and fast grown as slash pine. The six minor pines are less stiff and strong than the four major pines. Therefore, the minor pines are not as desirable for structural plywood as the major pines.

The sapwood of the southern pines is frequently 6 to 8 inches (15 to 20 cm,) in width. As a result, most of the veneer cut from the second growth is sapwood. The sapwood is yellowish-white, and the heartwood reddish-brown in color. Each annual ring is made up of a band of dark summerwood and a band of light-colored springwood. This makes a very pronounced pattern in rotary-cut veneer. The grain of southern pine is generally straight. All of the southern pines contain resin, but the sapwood has less resin than the heartwood. Slash, longleaf, and pond pine are reported to have higher resin content than the other southern pines. Longleaf and slash pine trees are frequently tapped for resin and turpentine. Southern pine is free of hard deposits.

Compression wood is very common in southern pine in leaning trees or trees having poor form. Compression wood cuts satisfactorily into veneer, but the veneer tends to buckle during drying and may cause warping of the plywood panels.

The sapwood of southern pine is very permeable. Logs stored in warm weather in a pond or under a sprinkler system often are attacked by bacteria. The bacteria attack makes the wood even more permeable but apparently does not have a noticeable effect on the strength properties of the wood. The very high permeability of bacteria-attacked sapwood can cause problems in gluing.

Veneer Cutting

In laboratory experiments, bolts of southern pine heated to 60° to 70° C. (140° to 160° F.) cut well. In industrial practice, some manufacturers prefer limiting the heating to 50° C. (120° F.) to keep spinout of the bolts to a minimum. Other manufacturers use a cold-water spray at the ends of the bolts after heating and just prior to rotary-cutting as the means of reducing spinout. Some plants cut southern pine at room temperature, 20° C. (70° F.).

Very high heating temperatures such as 95° C. (200° F.) tend to cause fuzzy surfaces in the springwood and shelling or separation of the springwood from the summerwood during rotary-cutting. Southern pine bolts at a temperature of 50° to 70° C. (120° to 160° F.), and cut using moderately high nosebar pressure, yield suitable smooth veneer of uniform thickness. Flitches for quarter-slicing were heated to 80° C. (180° F.) prior to slicing at the Forest Products Laboratory. These flitches cut well.

Veneer Drying

The moisture content of southern pine sapwood varies from 70 to 180 percent and heartwood from 25 to 50 percent, Southern pine sapwood requires about the same drying time as Douglas-fir sapwood of the same thickness. Since most southern pine veneer is sapwood, while most Douglas-fir veneer is heartwood, a greater drying capacity is needed for a southern pine veneer plant.

Most southern pine veneer can be dried flat. However, sheets containing compression wood will often buckle out of the dryer. Fast-grown southern pine having three to four rings to the inch and a high percentage of summerwood frequently will develop fine checks, particularly over the summerwood bands. This does not affect the use of the veneer for structural purposes but is a problem where the panel is intended for decorative purposes.

Veneer Uses

Before 1962, less than 1 percent of southern pine harvested in the United States was used for veneer. Starting in 1963, southern pine has become a major supplier of raw material for construction plywood. Plywood made from the four major southern pines is used equivalently with Douglas-fir plywood.

Southern pine veneer and plywood are also used for containers. Slow-grown, lower density southern pine has been used successfully for backs of decorative panels. Because of the contrast in density between springwood and summerwood, southern pine is generally not recommended as inner plies of decorative panels. Plywood faced with quarter-sliced southern pine has been used successfully as decorative paneling and as a flooring material in laboratory experiments.

WESTERN PINE GROUP

Of the nine pines listed in the western pine group, four are soft pines--western white, sugar, limber, and white bark. Western white pine and sugar pine are the more important. The hard pines are ponderosa, jeffrey, lodgepole, knobcone, and digger. Ponderosa pine is by far the most important veneer species in this group. Jeffrey pine is similar to ponderosa and is sold interchangeably with it.

Tree and Log Characteristics

The western pine species differ so much that each will be described separately.

Western white,--Western white pine grows principally in the Inland Empire and has its best growth in northern Idaho. It is typically a mountain-grown tree. Western white pine grows to 30 to 40 inches (75 to 100 cm.) in diameter, but most trees available for veneer are 12 to 30 inches (30 to 75 cm.). Mature trees may be as tall as 150 to 180 feet (45 to 55 m.). Western white pine has excellent form and generally develops a tall, cylindrical bole.

Western white pine may occasionally occur in pure stands, but generally is found in mixed stands. Western white pine is intermediate in tolerance to shade, being more tolerant

than western larch and lodgepole, and less tolerant than Engelmann spruce and western hemlock. However, it does not prune well even in dense stands. As a result, most second-growth western white pine will contain knots.

Like eastern white pine, western white pine is subject to the white pine blister rust, This disease, if left unchecked, will kill the trees. Western white pine is also subject to attack by bark beetles, and decay may occur in old-growth stands.

Sugar.--Sugar pine is the largest and the most valuable of the western pines. It is a wind-resistant, fast-growing tree that prefers cool, wet sites in the mountains of Oregon and California. It typically occurs in scattered, mixed stands. Sugar pine may reach a diameter of 2 to 3 feet (60 to 90 cm.) at an age of 300 years. Old-growth trees as large as 10 feet (300 cm.) in diameter and 250 feet (75 m.) tall have been recorded. Most trees available for veneer cutting are 24 to 48 inches (60 to 120 cm.) in diameter.

Sugar pine is intermediate in tolerance to shade and cannot compete with Douglas-fir and white fir. Sugar pine does not prune well, and there are many small, dead limbs on 60-year-- old trees. Probably it will be necessary to prune sugar pine if it is desirable to produce clear wood on a 100-year rotation.

Like eastern white pine and western white pine, sugar pine is attacked by blister rust and is also subject to beetle damage. The seeds of sugar pine are eaten by squirrels and other rodents. As a result, there is relatively little natural reproduction of sugar pine. Large, old-growth trees of sugar pine have excellent form and produce a high percentage. of clear veneer.

Limber.--Limber pine is a small tree with a short, tapered bole. Maximum diameter may be from 15 to 24 inches (38 to 60 cm.). It grows in high altitudes of the east slope of the Rocky Mountains on dry, gravely soils. Limber pine grows slowly and is intolerant to shade throughout life. The drooping branches frequently form a crown from the tip to the ground. It occurs in pure and mixed stands. The wood is reportedly similar to western white pine.

White bark.--White bark pine, like limber pine, is a small alpine tree that may reach a maximum diameter of 12 to 24 inches (30 to 60 cm.). On open sites at timberline it may be a shrub. White bark pine typically has a short, tapered bole. White bark pine is very slow grown and has upward-pointing branches that often extend the length of the trunk.

Ponderosa.--Ponderosa pine is the most important pine that grows in the Western United States. It is also the most widely distributed pine in the United States, growing in every state west of the Great Plains and British Columbia. On good sites ponderosa pine will reach a diameter of 36 to 48 inches (90 to 120 cm.). Most ponderosa trees available for use as veneer are 14 to 36 inches (35 to 90 cm.) in diameter. Ponderosa pine is generally considered intolerant to shade; it is more tolerant than western larch but less tolerant than Douglas-fir and sugar pine.

Ponderosa pine is wind-resistant and on good sites has a clear, symmetrical bole. In closed stands it will develop a considerable amount of clear wood. However, on drier sites old-growth stands are invariably open grown due to root competition for moisture. These open stands often have large limbs which in turn cause large knots in the veneer. Ponderosa pine is relatively free of Log end splits and shake. Root and butt rot attack ponderosa trees of all ages. The ponderosa pine tree is also subject to beetle damage. While older ponderosa pine is resistant to fire, butts of the trees may be fire scarred.

Jeffrey.--Jeffrey pine is very similar to ponderosa pine and at one time was considered the same species. It grows primarily in the coastal ranges in southwest Oregon and California Mature trees may reach a diameter of 36 inches (90 cm.). Jeffrey reportedly endures greater climate extremes than ponderosa pine, including drier summers and colder winters.

Lodgepole.--Lodgepole pine grows from Alaska to California and east to the Black Hills of South Dakota, but only the mountain form is important now. On the Pacific Coast the

tree is small and has poor form and so has little economic use. The mountain form of lodgepole pine grows into straight pole sizes, hence, the name lodgepole, The mountain form may reach diameters of 12 to 24 inches (30 to 60 cm.), with most veneer logs 10 to 14 inches (25 to 35 cm.) in diameter. Lodgepole pine is intolerant to shade but does not prune well. It is often found in pure, even-aged stands that originate after a fire. It may also be found in mixtures with other conifers. Lodgepole pine generally is slow grown. In the past, thousands of acres of stagnated stands of lodgepole pine have been killed by the mountain pine bark beetle. Lodgepole pine is also subject to damage by snow and wind.

Knobcone.--Knobcone pine grows on dry, mountain slopes in southwest Oregon and California. It may occur in pure or mixed stands. In the north it reaches a maximum diameter of 12 to 24 inches (30 to 60 cm.); and in the south 6 to 15 inches (15 to 38 cm.). Like lodgepole pine, knobcone pine often comes in after a fire. A characteristic of the tree is to have unopen cones growing in circles about the trunk. The bole of the tree often is forked about halfway from the ground to the tip of the tree.

Digger.--Digger pine occurs on very dry sites in California. On the best sites it may reach a diameter of 12 to 24 inches (30 to 60 cm.). Digger pine has a short bole that is often forked. The tree is intolerant to shade but open grown so that it is typically very limby. As a result, veneer cut from digger pine has a high percentage of large, solid knots.

Woad Characteristics

Western white.--Western white pine is moderately low in specific gravity and is correspondingly moderately low in hardness and other strength properties. Like eastern white pine the wood is considered easy to work and very useful. The cream to yellow-white sapwood is typically 1 to 3 inches (2 to 8 cm.) in width. The heartwood is cream to light red-brown in color and darkens on exposure to air. Wide zones of springwood merge gradually to narrow bands of darker summerwood. The wood is typically straight grained. Rotary-cut or flat-sliced veneer has a mild figure of ellipses caused by the darker bands of summerwood. Like eastern white pine, western white pine has relatively little resin. Leaning trees of western white pine may develop compression wood. The wood is free of hard deposits and relatively free of odor and taste.

Sugar.--Sugar pine is similar in density and other properties to eastern white pine and western white pine, The narrow to medium-wide sapwood is creamy white. The heartwood is buff to light brown but does not darken with age as much as eastern or western white pine. Large resin canals in sugar pine exude small quantities of a sugary substance. Like the other white pines, sugar pine has fairly distinct annual rings with the springwood merging gradually with the summerwood. The wood is straight grained and relatively free of taste and odor.

Limber and white bark.--The wood of limber pine and white bark pine is reportedly somewhat similar to eastern white pine and western white pine. Both are very slow grown so the texture of clear wood is fine. However, both tend to produce primarily knotty material. The tangential surface of wood of white bark pine shows dimpling.

Ponderosa,--Ponderosa pine is classified as a hard pine. Because of the very wide range of growth conditions, ponderosa pine wood actually varies from fast-grown, rather dense material that superficially looks like southern pine to extremely slow-grown, light material that seems similar to the wood of white pine. The white to pale yellow sapwood is typically 3 to 6 inches (8 to 15 cm.) in width. The sapwood may contain as many as 80 annual rings. The heartwood is yellow to light red or orange-brown. Transition from springwood to summerwood is typically abrupt. Ponderosa pine generally has straight grain, but occasionally it has a slight spiral. Most ponderosa pine has relatively little resin, but some logs have streaks of massed pitch. Occasional leaning trees of ponderosa pine develop compression wood. Ponderosa pine does not have hard deposits and is relatively free of odor and taste. It does have a slight resin odor when first cut.

The sapwood of ponderosa pine stored in log ponds in warm weather is susceptible to bacterial attack that makes it extremely permeable. Presumably this would also be true for the sapwood of all pines.

Jeffrey.--The wood of jeffrey pine is almost identical to ponderosa pine. It differs from ponderosa pine in that the heartwood has a pinkish cast, and the wood has a faint pineapple or lemonlike odor when first cut.

Lodgepole.--The wood of lodgepole pine is also very similar to the wood of ponderosa pine. The narrow sapwood is white to pale yellow. The light yellow to pale brown heartwood is not distinct from the sapwood. Like ponderosa pine, the contrast from springwood to summerwood is more or less abrupt but is not as conspicuous as in the southern pine group. Lodgepole pine has a small amount of resin like ponderosa pine. Leaning trees of lodgepole pine develop compression wood. Lodgepole pine is free of hard deposits and has relatively little odor or taste.

Knobcone.--Knobcone pine has a thick, creamy sapwood and pale yellow-brown heartwood. The wood is described as coarse grained and may have unopened cones embedded in the wood.

Digger. --Digger pine has light cream sapwood and dark yellow-brown heartwood tinged with red. Most of the trees are open grown; as a result, the wood cut from them is described as coarse grained. Industrial veneer trials showed that the veneer was rough, brashy, cross grained, and pitchy. A high percentage of the veneer contained large, solid knots. A smaller percentage contained open defects.

Veneer Cutting

This will be discussed for the soft pines and then the hard pines in the western pine group.

Laboratory tests indicate that the soft pines (western white, sugar, limber, and white bark) can be rotary-cut into veneer from bolts that are at room temperature, that is, 15° to 30° C. (60° to 90° F.). Use of high heating temperatures such as 80° C. (180° F.) resulted in very fuzzy surfaces when cutting the soft pines and also increased shelling, the separation of springwood from summerwood. The sapwood of western white pine may have as much as 200 percent moisture content. Such material is particularly prone to shell during rotary-cutting. Cutting at room temperature, use of a very sharp knife, and flushing the nosebar with water reduced fuzzy veneer surfaces, In laboratory tests, satisfactory veneer 1/8 inch (3 mm.) thick was cut from the western soft pines that had been heated to 30° C. (120° F.). One commercial veneer producer uses a conditioning temperature of 50° C. (120° F.) for cutting clear white pine flitches and 55° C. (132° F.) for cutting knotty white pine flitches. Knotty white pine is flat-sliced to produce decorative knotty face veneer.

The hard pine group (ponderosa, jeffrey, lodgepole, knobcone, and digger) can all be heated the same for good cutting. Thin veneer such as 1/16 inch (1.5 mm.) or less can be satisfactorily cut from these species at room temperature, 15° to 30° C. (60° to 90° F.). However, it would be necessary to put a slight back bevel or microbevel on the knife to prevent knots from nicking the knife edge. In laboratory tests, we found that these species cut very well when the bolts had been heated to about 60° C. (140° F.). This was particularly advantageous when cutting thick veneer such as 1/8 inch (3 mm.) or greater. The slow-grown material of these species cut particularly well for a softwood. Satisfactory veneer was produced throughout a wide range of knife angles and pressure bar settings. Fast-grown material also cut satisfactorily but tended to be rougher than the slow-grown material. In slicing tests, satisfactory veneer was produced from flitches heated from 60° C. (140° F.) to 80° C. (180° F.)

Veneer Drying

The moisture content of the sapwood of the western pines is apparently always much higher than the heartwood. For example, with western white pine the sapwood may have a moisture

content as high as 200 percent, while the heartwood is at about 50 percent. For ponderosa pine, the moisture content of the sapwood varies from about 120 to 150 percent and the heartwood from 30 to 40 percent. The sapwood of lodgepole pine varies from 150 to 175 percent and the heartwood from 35 to 80 percent.

Because of these large differences in the moisture content of the sapwood and heartwood, it generally pays to separate the sapwood for drying. In general, the sapwood of these pines requires about as much time as the sapwood of Douglas–fir. The heartwood of ponderosa pine dries about as fast as the heartwood of Douglas–fir, while the heartwood of white pine and lodgepole pine takes slightly longer. Normal, clear veneer of all of these species dries rapidly and without developing any defects. Sheets of veneer containing compression wood tend to buckle during drying. Sheets containing many large knots also tend to distort locally in the short–grain areas around the knots.

Sound, intergrown knots up to 4 and 5 inches in diameter remained in the veneer through the drying process. Checks in sound, intergrown knots up to about 1-1/2 inches in diameter are small. In contrast, the checks in larger knots become sizable during drying. The sapwood of all of the pines is highly susceptible to blue stain and mold. Consequently, this material must be processed reasonably soon after cutting or mold and blue stain may develop.

Veneer Uses

Large, old–growth western white pine, sugar pine, ponderosa pine, and jeffrey pine have been used commercially to make clear, decorative faces for plywood for such products as kitchen cabinets and wall paneling. Western white pine flitches containing intergrown knots up to 1–1/2 inches in diameter have been used extensively in sliced veneer for decorative, knotty paneling. Western white pine has been rotary–cut for matches. In laboratory experiments, the small, tight knots in lodgepole pine, together with the dimples typically seen on the tangential surface, added to the species potential for decorative, knotty paneling.

The lower grades of all of the western pine group have long been preferred for containers. Their light weight, light color, ready nailability, and relative freedom of odor and taste have made them well suited.

Second–growth timber of all of these species could be used for construction plywood. The lower specific gravity, stiffness, and strength of these species would require them to be used in greater plywood thicknesses to be equivalent to the more common structural plywood species. In this respect they are like the spruces and northeastern pines.

NORTHEASTERN PINE GROUP

Of the four pines that grow in the Northeast, eastern white pine is a soft pine, and the other three (red, jack, and pitch pine) are hard pines.

Tree and Log Characteristics

White pine, red pine, and jack pine are sometimes found in the same stand. Of these three species white pine is the most tolerant to shade. Ked pine is intermediate, and jack pine is the least tolerant to shade. Of the three species, jack pine is most tolerant of poor, dry soil. Ked pine is next in tolerance to poor soil, and white pine is least tolerant of poor, dry soil. Logging and fire may create conditions suitable for jack pine to take over a stand that had been primarily red or white pine. When the humus is gone, jack pine often replaces red and white pine on dry, sandy soils. As the humus builds up, red pine invades the jack pine stands; and if the soil is good enough, white pine in turn will replace the red pine.

White.--White pine is the largest of the eastern conifers and may reach a diameter of 36 to 40 inches (90 to 100 cm.). Most trees available for veneer are 12 to 16 inches (30 to 40 cm.) in diameter. On good sites in the Lake States and in the Northeast, white pine may occur in pure stands. On dry sites in the Lake States, it is frequently mixed with red and jack pine.

In the Northeast white pine may occur in old fields or with red spruce and hemlock. In closed stands the limbs on white pine die in about 15 years, but they persist for another 25 years. Consequently, a stand must be 50 years old before it begins to produce clear wood. White pine is subject to blister rust which attacks the bark and kills the tree, and to white pine weevil which damages the terminal bud and deforms the tree.

Red.--Red pine may reach a diameter of 36 inches (90 cm.) and, like white pine, has a good straight bole. Typical logs are 12 to 14 inches (30 to 35 cm.) in diameter. Red pine occurs in pure and mixed stands. Red pine will grow on light sandy soil too poor for white pine. White and red pine have been used to reforest areas in New England and the Lake States. In these dense stands, it requires at least 40 years before natural pruning begins to occur on red pine. Red pine is free from attack by blister rust and the white pine weevil which causes so much damage to white pine.

Jack.--Jack pine is mainly a Canadian species that grows in very cold areas and very poor soil. It reaches a maximum diameter of about 12 to 15 inches (30 to 38 cm.) but usually is much smaller. It is typically 8 to 10 inches (20 to 25 cm.) in diameter at an age of 60 years. Jack pine is a short-lived tree. The branches die early but persist. Frequently, there are two to three whorls a year. As a result, almost all veneer that could be cut from jack pine will be knotty. Jack pine is very intolerant to shade and grows in pure stands or open mixtures with scrub oak, aspen, and white birch.

Pitch.--In the northern part of its range, pitch pine grows on poor sandy, sterile soil. Best development of pitch pine occurs in Pennsylvania where it may reach a diameter of 24 inches (60 cm.). Typical logs are 12 to 14 inches (30 to 35 cm.) in diameter. Pitch pine often has very poor form. It develops two to three whorls of branches per year and associated false annual rings. It is very intolerant to competition from hardwoods.

Wood Characteristics

Eastern white.--Eastern white pine is moderately low in density. It is a soft pine and is considered one of the best working and most useful of the woods that grow in the United States. The sapwood is commonly 2 to 3 inches (5 to 7 cm.) in width. The sapwood is white to pale yellow-white, and the heartwood is cream to light brown. The heartwood darkens to a reddish-brown on exposure to the air. White pine is generally straight grained. The earlywood is wide and the transition from earlywood to latewood is gradual with the latewood being narrow. White pine is the least resinous of all the pines. However, it does have a slight resinous odor. Leaning trees of white pine may develop compression wood.

Red.--Red pine is denser than white pine and correspondingly harder and stiffer. The sapwood of red pine may be 2 to 4 inches (5 to 10 cm.) in width. The sapwood is nearly white to yellowish; the heartwood is a light red to orange-brown to reddish-brown. The grain of red pine is generally straight but occasionally spiraled. The transition from springwood to latewood is more or less abrupt, and the latewood may be narrow or wide. While red pine is sometimes sold with white pine as northern pine, red pine is coarser in grain and texture and has more contrast in the annual rings and more resin than white pine. Leaning trees of red pine may develop compression wood.

Jack.--Jack pine is intermediate in density between white pine and red pine. The sapwood of jack pine is wide, and trees up to 40 or 50 years of age may be entirely sapwood. The heartwood is light orange to light brown. The earlywood and latewood are variable in width and there is an abrupt change in density from earlywood to latewood. The wood has a resinous odor. Leaning trees of jack pine may develop compression wood.

Pitch.--The wood of pitch pine is described under the southern pine group.

Veneer Cutting

With a careful setup of the knife and pressure bar, it is possible to cut good quality veneer from both white and red pine.

Eastern white.--Bolts of white pine can be cut into veneer at room temperature, 20° C. (70° F.); but in laboratory evaluations, white pine cut better when heated to 50° C. (120° F.). A heating temperature of 50° C. (140° F.) is recommended for cutting decorative, sliced knotty veneer. In laboratory evaluations, the main problem in cutting white pine veneer was a tendency to shell between the springwood and summerwood. Moisture contents in excess of 200 percent in some white pine sapwood make it very sensitive to nosebar pressure. Consequently, low nosebar pressure and slow cutting speed are suggested when cutting white pine. Some commercial veneer producers recommend white pine be steamed rather than heated in hot water to reduce moisture in the wood and so aid cutting.

Red.--"Shelling"was less of a problem when cutting red pine under laboratory conditions. Red pine sapwood may have a moisture content as high as 150 percent. If shelling should be a problem with red pine, we recommend using the same procedures as for white pine. At the U.S. Forest Products Laboratory we found the conditioning temperatures used with white pine were also suitable for red pine.

Evaluations with red pine at the Canadian Forest Products Laboratory at Ottawa indicate the species cuts satisfactorily at 10° to 40° C. (50° to 100° F.). The Canadians recommend the use of a roller bar and a knife having a microbevel when cutting red pine. They report spinout of the bolts was reduced by using a roller bar rather than a fixed solid bar.

Jack.--No veneer cutting studies have been made with jack pine. With its many knots and a specific gravity between red and white pine, we recommend heating bolts and flitches the same as for white pine.

Pitch.--The cutting of pitch pine is described under the southern pine group.

Veneer Drying

In laboratory experiments, most of the veneer produced by rotary-cutting or slicing red pine and white pine dried satisfactorily. There was slight buckle around the knots in rotary-cut veneer, and similarly, there was some buckle in veneer containing pronounced bands of compression wood.

The sapwood of white pine and red pine requires about the same drying time as sapwood of Douglas-fir of the same thickness. The heartwood has much lower moisture content than the sapwood and can be dried in a shorter time, much like Douglas-fir heartwood of the same thickness. For this reason, it would pay to separate the sapwood from the heartwood of white pine and red pine prior to drying. Jack pine will be almost entirely sapwood and so requires more drying capacity for a given volume of veneer.

Veneer Uses

Old-growth white pine is satisfactory as a decorative, flat-sliced veneer for interior paneling. Knotty white pine having sound intergrown knots not over 1-1/2 inches in diameter is frequently used for decorative paneling. Rotary-cut white pine has been used for matches. Because of white pine's light color, ease of nailing, low shrinkage, and moderately light weight, it is a preferred material for boxes and crates.

Red pine is coarser in grain and texture and has more contrast between the springwood and summerwood and more resin than white pine. Nevertheless, it has been used for much of the same end products as white pine.

Experiments with both red and white pine demonstrate that a much higher percentage of yield of clear material will be obtained if the stands are pruned when the trees have a diameter of 3 to 4 inches. This clear, rotary-cut veneer could be used for a paint-grade or natural-finish-grade of panel. Knotty, rotary-cut veneer produced from white pine, red pine, jack pine, and pitch pine could be used for Construction grade plywood. The limitation would be that all of these species are less stiff and strong than the species more commonly used for construction plywood.

Pseudotsuga

There are two varieties of Douglas-fir that grow in the Western United States from Canada to the mountains in Mexico. These are the coast variety, P. menziesii var. menziesii, and Rocky Mountain Douglas-fir, P. menziesii var. glauca. These are sometimes further divided into four subdivisions as shown in the tables. For use as veneer and plywood, coast Douglas-fir, interior west Douglas-fir, and interior north Douglas-fir are all given the same classification. Interior south Douglas-fir is slightly lower in specific gravity, stiffness, and strength and so is given a lower classification for use as structural plywood

The differences in the coastal and Rocky Mountain varieties of Douglas-fir are relatively minor. The coast type has yellow-green needles, while the Rocky Mountain type generally has blue-green needles. Sapwood on the coast-type Douglas-fir is generally wider than the sapwood on the Rocky Mountain type. Trees of the coast-type Douglas-fir also reach a larger size, Once veneer is cut from the trees, it is not possible to distinguish the varieties.

Tree and Log Characteristics

Coast-type Douglas-fir is found west of the Cascade Range in Washington and Oregon, west of the coast range in British Columbia, and west of the Sierra Nevadas in northern California The giant sequoias are the only trees native to the United States that are larger than Douglas-fir, Douglas-fir on the Coast may reach a diameter of 10 feet (3 m.) and a height of 300 feet (90 m.). In the old-growth forest, trees with a diameter of 6 feet (1.8 m.) were common. In contrast, the Rocky Mountain Douglas-fir may reach a diameter of 18 to 36 inches (45 to 90 cm.). Most trees in the second-growth forest will probably be harvested at a diameter of about 18 to 24 inches (45 to 60 cm.).

Both varieties of Douglas-fir are moderately tolerant to shade when young but intolerant of shade when they are old. Best growth is reached in areas of high rainfall, preferably 40 inches or more per year. Douglas-fir grows in dense, even-aged stands. At an age of 100 years, the trees may be 2 feet (60 cm.) in diameter with 115 trees to the acre. Later, the stands may become mixed with other species. There is little attack from fungi and insects in second-growth Douglas-fir. However, the second-growth forest contains primarily knotty material up to an age of about 150 years. Old-growth Douglas-fir may be attacked by the Douglas-fir beetle and by a heart rot decay known as Fomes pini. Old-growth trees also may develop ring shake and frequently have pitch pockets and bark pockets.

Wood Characteristics

Douglas-fir is moderately hard and heavy and quite stiff. The sapwood may be 1 to 3 inches in width with coast-type Douglas-fir generally having wider sapwood than Rocky Mountain Douglas-fir. The sapwood is whitish to pale yellow while the heartwood varies in color from yellowish to orange-red or deep red. The grain of Douglas-fir is generally straight but occasionally has a slight spiral. Like southern pine, Douglas-fir has a sharp contrast in density from springwood to summerwood. The earlywood zone is usually several times wider than the band of darker colored latewood. Transition from earlywood to latewood is generally abrupt. When the trees are young, they are generally fast grown and have a coarse texture. In old-growth the annual rings are quite fine and the wood has a much

softer texture. Douglas–fir has occasional pitch pockets and areas of massed pitch. Compression wood occurs in leaning trees but is not common in Douglas–fir. The wood has a characteristic resinous odor when fresh.

The heartwood of Douglas–fir grown inland from the coast is relatively impermeable.

Veneer Cutting

in Laboratory tests we found it advantageous to heat Douglas–fir peeler blocks at a temperature of 50° to 60° C. (120° to 140° F.). In commercial practice bolts may be heated to 50° C. (120° F.), or they may be cut at room temperature. Flitches for quarter–slicing heated at 80° C. (180° F.) sliced well in laboratory trials. The sapwood of Douglas–fir may have a moisture content from 120 to 160 percent. This wood is quite sensitive to nosebar pressure and light pressure must be used or mashed grain may result. Higher nosebar pressure can be used to advantage to improve the smoothness and tightness of the drier heartwood. Use of a back bevel when rotary–cutting unheated Douglas–fir blocks is common practice in the veneer industry. Researchers at the Canadian Forest Products Laboratory at Ottawa have demonstrated in Laboratory tests the advantage of the use of a microbevel when cutting unheated Douglas-fir.

Veneer Drying

Douglas–fir veneer dries with little degrade. Temperatures as high as 200° C. (400° F.) are commonly used in mechanical dryers when drying rotary–cut veneer of Douglas–fir. The sapwood, which has moisture contents well above 100 percent, requires about twice as long to dry as the heartwood, which has moisture contents from 30 to 40 percent. Consequently, the sapwood is generally separated from the heartwood for drying. The veneer generally dries flat, although sapwood and wood containing compression wood may have slight buckle after drying.

Veneer Uses

Douglas–fir has long been the main species used for construction plywood in the United States. Recently a limited amount of Douglas–fir containing Fomes pini has been permitted in standard structural plywood panels. Quarter–sliced, old-growth Douglas–fir has been used for doors and other millwork. Douglas–fir plywood is sometimes used as a base panel that is covered with a decorative hardwood face veneer and used for wall paneling. Douglas-fir veneer and plywood is well suited for use as containers. A very limited amount of Douglas–fir containing white pocket has been used as decorative paneling. Douglas–fir from the Interior South, that is, from the States of Nevada, Utah, Colorado, Arizona, and New Mexico, has a lower specific gravity, stiffness, and strength than coast Douglas–fir and, hence, is in a lower classification for use as Construction plywood.

Sequoia

The two sequoias that grow in California are the only members of this genus in the world. They are S. gigantea, giant sequoia, and S. sempervirens, redwood. Mature giant sequoias are the most massive that grow in the world, and mature redwoods are the world's tallest trees.

Tree and Log Characteristics

Giant sequoias occur in isolated groves on the west slope of the Sierra Nevada range in central California. Mature trees nay reach a diameter of 10 to 15 feet (3 to 4.5 m.) and a height of over 250 feet (75 in.). Some of these trees are over 3,000 years old. Growth

is fast in youth but becomes slow in mature timber. The species is moderately tolerant to drought but relatively intolerant to shade. Severtheless, trees 100 years in age maintain most of their branches. Mature trees may be free of branches for the first 100 feet (30 m.) of the bole. Fire is an enemy to the young trees but old trees have bark as thick as 2 feet (60 cm.) and are relatively immune to fire damage. This species has no other enemies. Because of their aesthetic value, old-growth giant sequoias are not cut for timber; most are in national parks.

Redwood grows in the fog zone from the southwest corner of Oregon along much of the coast of California. Mature redwood trees may reach a diameter of 5 to 15 feet (1.5 to 4.5 m.) and a height in excess of 300 feet (90 m.). Second-growth redwood is a fast-growing tree; at a rotation age of 60 years, stands may be from 16 to 36 inches (40 to 90 cm.) in diameter. They may reach a height of 200 feet (60 m.) at an age of 100 years. Most trees available for veneer cutting are 24 to 50 inches (60 to 150 cm.) in diameter. Redwood is considered tolerant to very tolerant to shade but grows best in full light. Second-growth material produces mainly knotty wood.

Redwood reaches its best growth on alluvial flats. In some cases, it occurs in pure stands; but it may also be mixed with other western softwoods, particularly Douglas-fir. Redwood is one of the few softwoods that sprouts readily from stumps. Sprouts grow faster than seedlings when they are young and may develop somewhat eccentric trunks. If the crown of redwood is damaged, it may sprout almost the entire length of the trunk. Probably related to this ability to sprout is the frequent occurence of burls at various heights of the trunk. Young redwood trees may be damaged by fire and heart rot may enter at the fire scar. The bark of redwood is tough, thick, and fibrous. Because of the large size of the trees and the brittle nature of the wood, felling damage or breakage in redwood is often from 5 to 20 percent of the merchantable volume.

Wood Characteristics

Redwood is low in specific gravity and correspondingly soft and low in most mechanical properties. The nearly white sapwood of redwood is generally 1 to 2 inches (2.5 to 5 cm.) in width. The heartwood is light red to deep red-brown. Redwood is straight grained but frequently has burls. The springwood of the annual rings is considerably less dense than the summerwood. The heartwood of redwood contains estractives that make the wood highly resistant to decay. Compression wood occurs in some redwood trees, but it is not a major problem in the use of this species. Redwood is free of hard deposits, odor, or taste. Some redwood has small distortions caused by adventitious growths. These distortions are sometimes called "birds-eye," but they are not identical with "birds-eye"found in hardwoods such as maple.

The wood of the giant sequoia closely resembles that of redwoood. However, the wood of the giant sequoia generally is softer and the heartwood is darker, often with a purplish cast. Any second-growth of giant sequoia that may be used commercially would probably be marketed as redwood.

Veneer Cutting

The sapwood and the outer heartwood of butt logs of redwood may have moisture contents in excess of 200 percent. This material is difficult to cut without rupturing or mashing the grain. Consequently, the second log of old-growth timber is generally preferred to the first log for use as veneer. Clear redwood can be rut at room temperature, 20° C. (70° F.). Intergrown, black knots in redwood are much harder than the clear wood. Unheated knots will sometimes turn the edge of a sharp knife.

In laboratory tests we found that bolts heated at 70° C. (160° F.) until the temperature at the core had reached 50° C. (120° F.) could be cut without damage to the knife by the knots. In addition, veneer from the heated bolts was tighter than veneer cut from unheated bolts. Flitches heated to 70° to 80° C. (160° to 180° F.) were well conditioned for slicing.

Large, old-growth redwood bolts often have large splits radiating from the pith. Use of retractable chucks and a roller nosebar helps reduce the likelihood of spinout due to the splits in the bolts and the soft nature of the wood. Redwood is somewhat brittle. The green veneer must be handled carefully or it may split. Redwood stains readily if the wet wood contacts iron or steel for a short period of time. High moisture content in flitches that were quarter-sliced did not appear to have much effect on the cutting of the wood.

Veneer Drying

The sapwood and the wet heartwood should be separated from the drier heartwood for drying. The sapwood and wet heartwood take slightly longer to dry than the sapwood of Douglas-fir. The drier heartwood requires about the same drying time as heartwood of Douglas-fir. Rotary-cut veneer containing wet streaks may develop slight buckle at the streaks during drying. In general, however, redwood veneer, both sapwood and heartwood, dries flat and without any visible drying defects.

Veneer Uses

Redwood plywood is generally considered a specialty item. Rotary-cut veneer with textured and rough-sawn surfaces has been used for both exterior and interior paneling. Attractive paneling is also made from flat-sliced and quarter-sliced redwood. Second-growth redwood is mainly knotty and would probably be limited to a rustic-type finish. The rating of redwood for construction plywood in table 8 is A for use as a decorative exterior siding and B where strength properties are the primary concern.

Taxodium

Two species of the Taxodium genus grow in the United States. They are T. distichum, baldcypress, and T. distichum var. nutans, pondcypress.

Tree and Log Characteristics

Baldcypress is a large tree that grows in the swamps and lowlands in the Southeastern United States. Pondcypress grows in much the same area but is limited to shallow ponds and wet areas of the Coastal Plain. It is very similar to baldcypress but is slower growing and not as large. Baldcypress may reach a diameter of 36 to 60 inches (90 to 150 cm.) and an age of 1,000 years. However, most of this old-growth material has been cut, and most trees now available for veneer cutting are 12 to 16 inches (30 to 40 cm.) in diameter. Second-growth cypress is relatively fast growing and may reach a diameter of 20 inches (50 cm.) at an age of 100 years. Cypress typically grows in pure stands. It is rated as intermediate in tolerance to shade so that fully stocked stands develop a clear stem above the butt swell. Poorly stocked stands are very limby. Old-growth cypress often develops a swelled butt and considerable taper. Old-growth trees may develop brown rot. Wood from infected trees has been marketed as pecky cypress.

Wood Characteristics

The wood of baldcypress is moderate in weight, hardness, and stiffness. Cypress heartwood varies from a reddish-yellow color, referred to by the trade as tidewater red cypress, to a light yellow color known as white or yellow cypress. Some of the trees have both dark and light streaks in the heartwood. Inland-grown cypress is lighter in color than cypress grown in tidewater areas. The sapwood is about 2 inches thick and nearly white. The wood of cypress is straight grained and has distinct growth rings. The transition from springwood to summerwood is more or less abrupt. Cypress develops false growth rings and so may appear to be older than it actually is. The wood has a greasy feel and a faint rancid odor. It is free of gum and hard deposits.

Veneer Cutting

The sapwood of cypress may have a moisture content of 170 percent or higher. The heartwood has a moisture content of about 120 percent. This high moisture content, particularly in the sapwood, makes the wood subject to shattering if high pressure is used by the nosebar during rotary cutting or slicing. Cypress can be cut at room temperature. Flitches are sometimes heated to a temperature of about 60° C. (140° F.) prior to slicing.

Veneer Drying

Because of the high moisture content in the sapwood and the heartwood, cypress takes a slightly longer drying time than Douglas–fir sapwood and heartwood. The veneer dries without apparent defects.

Veneer Uses

There is relatively little volume of cypress cut into veneer. Sliced cypress is used as faces for decorative paneling and siding, Plywood made from all heartwood is suitable for use in boats. The lower grades should be suitable for containers. The rating fur cypress for construction plywood in table 8 is A for use as a decorative exterior siding and B where strength properties are the primary concern.

Taxus

Three species of Taxus are native to the United States, but only T. brevifolia (Pacific yew) is of any commercial importance.

Tree and Log Characteristics

Pacific yew grows on the Pacific Coast and also eastward into Idaho and Montana. It is usually a small tree with a diameter from 12 to 15 inches (30 to 38 cm.). It is found in mixed coniferous stands with other western softwoods. The species is very tolerant to shade, and even forest trees produce limby trunks. The trunk of the tree is often fluted and occasionally contorted. Butt logs of old–growth trees often are decayed.

Wood Characteristics

Pacific yew is heavy and hard. The narrow sapwood is light yellow and the heartwood is bright orange to rose–red in color. The grain may be straight or spiraled and is often quite irregular. This results in highly figured veneer caused by irregular grain. The wood is slow grown, even, and fine textured. The growth rings are distinct, having relatively narrow and darker latewood. The transition from earlywood tu latewood is very gradual, and the latewood is dense. The wood is free of gum or resin and is without odor or taste.

Veneer Cutting

No data are available on the cutting of yew. Based on its density, we suggest heating to 80° to 90° C. (180° to 200° F.).

Veneer Drying

We do not have data on the drying of this species. Based on the density of the wood and the irregular grain, we expect that it may tend to buckle during drying.

Veneer Uses

A small amount of yew veneer has been produced and used for decorative accents of fine furniture. Laminates made from straight-grained yew veneer are suitable for archery bows. The species is of limited commercial importance because of its scarcity and small size.

Thuja

Two species of the genus Thuja grow to commercial size in the United States. They are T. occidentalis (northern white-cedar) and T. plicata (western redcedar). The two species are similar in that they both prefer moist sites, both are moderately tolerant of shade, and both are slow grown. They differ in the size of the mature trees and are completely separate by geographic range.

Log and Tree Characteristics

Northern white-cedar grows in Southeast Canada, the New England States, and the northern Lake States. Mature trees may reach a diameter of 12 to 36 inches (30 to 90 cm.). Northern white-cedar grows in pure and in mixed stands. On very wet sites, such as swamps and stream-banks, it is exceptionally slow growing and may require 150 years to reach a diameter of 12 inches (30 cm.). Most trees available for veneer cutting are 14 inches (35 cm.) or smaller in diameter.

The trunk of full-growth northern white-cedar is often fluted and buttressed. Logs are typically knotty and may be crooked and hollow. In some areas, as much as 80 percent of the old-growth trees have heart rot. Rot is not much of a problem with second growth. Older trees of this species are subject to shake. Over 50 varieties of northern white-cedar have been developed for use as ornamentals.

Western redcedar grows from the southern coast of Alaska to Oregon and rarely in northern California. It also occurs in the Inland Empire from Idaho to British Columbia. Mature trees of western redcedar may reach a diameter of 8 to 16 feet (2.4 to 4.8 m.). It occurs primarily in mixed stands where there is abundant rain and atmospheric humidity. Western redcedar is very tolerant to shade so that most second growth is quite knotty. Growth is generally slow, and in 80 years trees may reach a diameter of about 10 to 18 inches (25 to 45 cm.). Most cedar logs cut into veneer are 24 to 48 inches (60 to 120 cm.) in diameter, The bulk of old-growth redcedar is buttressed, fluted, and tapered. The main enemy of western redcedar is fire. Small trees may be damaged by cold following a warm spell in the spring.

Wood Characteristics

The wood of northern white-cedar is very lightweight, soft, and weak. It splits readily. The white sapwood is narrow and is rarely over 1 inch (2.5 cm.) in width. Heartwood is light brown. The grain is generally straight, and the texture is fine and uniform. Growth rings are distinct, and the transition from earlywood to latewood more or less gradual. The wood has a pleasant aromatic odor. It is free of gum and hard deposits, The wood has a faint bitter taste. The heartwood is relatively impermeable to liquids, but the sapwood is permeable.

Western redcedar is lightweight and a moderately soft wood. The wood of western redcedar is slightly heavier than the wood of northern white-cedar and is correspondingly harder and stiffer. Both species are low in strength in tension perpendicular to the grain, which makes them rather easy to split. The sapwood of western redcedar is white and narrow, generally 1 inch (2.5 cm.) or less in width. The heartwood is red-brown and may be dark brown in the butt logs or a lighter pink-brown in other sections of the tree. The grain is typically straight. Western redcedar has distinct and conspicuous growth rings grading

from the lower density springwood to narrow, dense, darker latewood, The wood is uniform in growth, frequently having about 10 rings to the inch, but is described as coarse in texture as seen on a tangential surface. The wood has a pungent characteristic sweet cedar odor. The wood is free of hard deposits and gum.

Veneer Cutting

We have no data on cutting of veneer from northern white-cedar. Based on the log characteristics, we expect it to be prone to shelling. The small logs available for veneer would probably yield mainly knotty material. Based on the density of the wood, this species could be cut at room temperature. However, because of the knots, it would probably be desirable to heat the wood to 50° to 60° C. (120° to 140° F.) prior to cutting.

Western redcedar is both rotary-cut and sliced into veneer. When rotary-cut or flat-sliced, the veneer has a tendency to shell. Clear rotary-cut veneer can be cut from wood at room temperature. However, it is recommended that bolts be heated to 60° to 70° C. (140° to 160° F.) to soften the knots. In Laboratory tests we found that heating to 80° C. (180° F.) improved the tightness of sliced veneer.

Veneer Drying

Rased on the moisture content in the heartwood, we expect veneer of these two cedars to require about the same drying time, or slightly longer, than Douglas-fir heartwood. Western redcedar veneer dries flat. Both cedars are somewhat brittle and will readily split if rough handled,

Veneer Uses

Western redcedar is used for exterior and interior siding. Because the wood is subject to shelling, it is suggested that rotary-cut faces be used as a rough or textured surface. Quarter-sliced faces should be satisfactory as sanded or as a textured surface. The wood can be readily stained. Knotty cedar and etched cedar are specialty face veneers. The rating for western redcedar for construction plywood in table 8 is A for use as a decorative exterior siding and B where strength properties are the primary concern.

We do not know of any veneer operations with northern white-cedar. Based on the properties of the wood, it could be used in the same manner as western redcedar. The lower grades of both species could be used for containers.

Tsuga

Three species of Tsuga reach commercial size in the United States. They are T. canadensis (eastern hemlock), T. heterophylla (western hemlock), and T. mertensiana (mountain hemlock). Western hemlock is the most important of these three species, both in terms of volume and quality of timber. Eastern hemlock is completely separated from the other two species by geographic range. While mountain hemlock tends to grow in the higher altitudes, it does intermix somewhat with western hemlock. Veneer from the three species of hemlock is difficult to distinguish once it is cut.

Tree and Log Characteristics

Eastern hemlock grows in the Eastern United States and adjacent areas of Canada. On good sites trees may reach a diameter of 24 to 36 inches (60 to 90 cm.). Most trees available for use as veneer are 12 to 20 inches (30 to 50 cm.) in diameter. Eastern hemlock generally grows in mixed stands but occasionally occurs in pure stands. Eastern hemlock is very

tolerant to shade and tends to keep its branches until old age. Open-grown trees often have a rough bole with marked taper. Eastern hemlock is generally slow growing so that trees 100 years old may be only 10 inches in diameter. Old-growth eastern hemlock logs frequently have ring shake and occasionally have spiral grain. Eastern hemlock is subject to damage by fire and old-growth trees often have butt rot and may be attacked by bark borers. Insect and disease are not important factors in second-growth eastern hemlock.

Western hemlock grows from Alaska to northern California along the Pacific Coast. It also occurs in northern Idaho, eastern Washington, and southeastern British Columbia. Western hemlock may reach a diameter of 24 to 48 inches (60 to 120 cm.). Typical veneer logs are 24 to 36 inches (60 to 90 cm.) in diameter. Western hemlock is rated as very tolerant to shade. Pure, dense, even-aged stands of western hemlock develop long, clear, symmetrical boles, but upen-grown trees and trees of western hemlock grown in the understory generally have poor form and many branches. Western hemlock grows best on well-drained soil in areas of high rainfall.

Old-growth western hemlock develops a slight amount of shake and a slight amount of compression wood and occasional bark pockets. The frequency of these three factors is not great enough to limit the use of this species for veneer. The sapwood of western hemlock is subject to damage by Lyctus beetles if the trees are not processed in a reasonably short time.

Knots are the most important characteristic of this species affecting its use as veneer. The second most important characteristic is dark streaks caused by a fly maggot. This characteristic is sometimes referred to as bird peck (or turkey tracks). Western hemlock may also develop light areas termed "floccosoids." These have no apparent effect on the use of the wood. Wind and snow may damage smaller trees, and butt rot is a common defect in older trees. Western hemlock is highly susceptible to damage by fire.

Mountain hemlock grows from Alaska to California in much the same geographical area as western hemlock. Typically, mountain hemlock is found at timberline throughout its range. In Alaska mountain hemlock grows at sea level, while in California it occurs at 6,000 to 11,000 feet. Alpine trees may be prostrate while trees growing on the best sites may be 30 to 40 inches (75 to 100 cm.) in diameter. Over most of its range, typical diameters for mountain hemlock are 10 to 20 inches (25 to 50 cm.). Mountain hemlock is very tolerant to shade. Consequently, it is poor in natural pruning and contains many knots unless it has been close grown for a long period. Mountain hemlock is subject to fire damage and to snow damage on steep slopes, which may result in abnormal log form referred to as pistol butt .

Wood Characteristics

The three hemlocks have many similar characteristics. All are moderate in specific gravity. In the dry condition the western species are slightly stronger than eastern hemlock. The hemlocks are free of resin and gum. Compression wood occurs in eastern and western hemlock but is not a limiting factor in using these species for veneer. The narrow sapwood of the hemlocks is not distinctly different from the buff to light brown heartwood. The summerwood, particularly of eastern hemlock, has a pink or roseate color. The growth rings of hemlock are distinct with a gradual transition from springwood to summerwood. All of the hemlocks have a somewhat sour odor when first cut but this odor disappears when the veneer is dried. Black, encased knots in the hemlocks are hard enough to nick a sharp lathe knife. The heartwood of the hemlocks is more permeable than the heartwood of Douglas-fir and so may require different gluing techniques.

Most eastern hemlock has straight grain but occasional logs have spiral grain. The wood of eastern hemlock is coarse and uneven in texture and is inclined to splinter under tools. Shake is common in eastern hemlock.

Western hemlock has straighter grain, a more uniform texture, and machines better than eastern hemlock. Butt logs of old-growth western hemlock reportedly have some shake. Black streaks caused by a fly maggot are fairly common in western hemlock.

Veneer Cutting

Based on its specific gravity and reported hardness of knots, we suggest heating eastern hemlock bolts to 50° to 70° C. (120° to 160° F.) prior to cutting veneer. The Canadian Forest Products Laboratory at Ottawa reports that satisfactory veneer can be cut from eastern hemlock at room temperature providing a microbevel is put on the knife edge. The Ottawa Laboratory also recommends the use of a roller bar as eastern hemlock has a considerable amount of shake and tends to develop splinters which jamb between a rigid bar and the bolt and degrade the veneer.

Western hemlock heated to 50° to 70° C. (120° to 160° F.) cut well in trials at the U.S. Forest Products Laboratory. The smoothest veneer was cut from bolts at 50° C. (120° F.), 'This species has areas in the sapwood and heartwood where the moisture content exceeds 200 percent. These areas are subject to shelling if excessive nosebar pressure is used. High conditioning temperatures such as 95° C. (200° F.) increased the incidence of shelling.

We would expect mountain hemlock to cut much the same as western hemlock.

Veneer Drying

The Ottawa Laboratory reports moisture content in eastern hemlock sapwood from 180 to 270 percent and in the heartwood or inner areas from 90 to 180 percent moisture content. At Madison it was found that the sapwood of western hemlock varied from 80 to 230 percent moisture content, averaging about 150 percent, and the heartwood varied from 30 to 220 percent moisture content, averaging about 60 percent. The sapwood of the hemlocks requires about the same drying time as the sapwood of Douglas-fir. However, the heartwood of these species requires as much as 60 to 75 percent more drying time than Douglas-fir. Splits sometimes develop at very wet streaks in the heartwood during drying. In other respects, the veneer dried well and without defect.

Veneer Uses

Western hemlock is a well-established veneer species used for construction plywood. It is also used for container veneer and plywood.

Eastern hemlock and mountain hemlock yield much less clear veneer than western hemlock. With this lower grade recovery in mind, mountain hemlock and eastern hemlock could be used for veneer and plywood in much the same way as western hemlock.

MAIN REFERENCES

American Woods (series of leaflets covering individual species). Forest Service, U.S.D.A.

Fine Hardwoods Selectorama, by Burdett Green, Fine Hardwoods Assoc., Chicago, Ill. 1956.

Identification of Furniture Wood, U.S.D.A. Misc. Circ. 66.

Reference Manual for Principal U.S. Woods, by Louis W. Powell and Marvin F. Bengelsdorf, American Plywood Association, Jan. 1969.

Silvics of Forest Trees of the United States, Agr. Handb. No. 271, Forest Service, U.S.D.A. 1965.

Textbook of Dendrology, by Harlow and Harrar, McGraw-Hill Book Co., New York, 1937.

Textbook of Wood Technology, Vol. 1, by Panshin, DeZeeuw, and Brown, McGraw-Hill, Inc., 1964.

Wood Handbook, Agr. Handb. 72, U.S. Forest Prod. Lab., Forest Service, U.S.D.A. 1955.