

# Characteristics Of Alaska Woods

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## SUMMARY

This paper is a compilation of information relating to the characteristics, distribution, and utilization of some Alaska woods. A brief description is given of Alaska's timber resources along with a general discussion of mechanical properties, pulp and paper-making characteristics, seasoning data, and preservative treatment of the various woods. Additional information also is presented for the specific species of western hemlock, mountain hemlock, Sitka spruce, white spruce, Alaska-cedar, western redcedar, lodgepole pine, paper birch, black cottonwood, balsam poplar, and quaking aspen.

Summary tables contain data on strength properties, pulp processes and yields, and drying schedules.

**COVER:** Sitka spruce and western hemlock frame the natural beauty of Auke Lake and Mendenhall Glacier near Juneau.

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# Characteristics Of Alaska Woods

Forest Products Laboratory,<sup>1</sup> Forest Service  
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## INTRODUCTION

The wise utilization of Alaska's timber resources and the development of wood-using industries are vital factors to the economy of the young State. To stimulate and encourage such activities requires specific and reliable information on the various properties and characteristics of the predominant species growing in Alaska. This report, based on previously published material from many sources, was compiled to provide a convenient reference on Alaska woods. The principal source, especially for the information on the mechanical properties, was "The Distribution and the Mechan-

ical Properties of Alaska Woods," by L. J. Markwardt, U.S. Department of Agriculture Technical Bulletin 226 . Results of individual research studies conducted at the Forest Products Laboratory provided, primarily, the data on pulping and papermaking, preservative treatment, and seasoning characteristics. In the Appendix, data relating to the mechanical properties of the Alaska species are presented in tables 1 through 5, information on pulping and papermaking is contained in tables 6 through 10, and data on seasoning are given in tables 11 through 14.

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<sup>1</sup>Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

## ALASKA FOREST TYPES

The Alaska forests are of two distinct kinds, the coastal forests and the interior forests. Because of its higher density of stand and its accessibility, the coastal type, as found in the national forests, is of the greater commercial importance, and is the principal source of material under consideration in this report.

The Chugach and Tongass National Forests are under the administration of the Forest Service, U.S. Department of Agriculture. Most national-forest business is handled locally by resident officers, The chief administrative officer is the regional forester who is headquartered at Juneau.

The remaining forest-covered land, largely the interior forest, is administered by the Bureau of Land Management and the State of Alaska.

### Coastal Forests

The coastal forests of southern Alaska form a part of the coniferous forest type that occupies a belt, usually less than 50 miles wide, along the shore line of the Pacific Northwest from southern Oregon to the northern tip of Kodiak Island. In Alaska, this coastal forest is predominantly a mixed stand of western hemlock and Sitka spruce, with a small percentage

of Alaska-cedar, and western redcedar in some localities (fig. 1). The forest here is almost tropical in density. The main cover is western hemlock with some cedar. This is overtopped by scattered trees of the more light-demanding spruce, while underneath is a second story of somewhat suppressed saplings of the more shade-resistant hemlock and cedar. At a still lower level are great clumps of blueberry, false azalea, the devilsclub, and other woody shrubs. Fallen timber, which decays slowly in this region, is abundant, and the ground surface is usually covered with a carpet of moss. The ground surface is rough, for the top soil is relatively shallow and bedrock is exposed in many places.

The forest occurs as a relatively narrow ribbon or band along the sinuous coastline of the mainland and the hundreds of islands, and extends from the edge of tidewater to an elevation varying from approximately 1,000 feet in the more northerly and westerly sections of the region to 2,000 and 3,000 feet in southeastern Alaska. Because of the mountainous character of the country, the entire area of tree growth is usually within sight of tidewater and rarely extends more than 5 or 6 miles inland. Three-fourths of the commercial timber by present standards is estimated to be within 2-1/2 miles of the coastline,

## Tongass National Forest

Included in the Tongass National Forest is 70 percent of the area and most of the commercial timberlands of southeastern Alaska. Because of the elaborate system of sea channels in this area, the timber is more accessible than that in the more northerly and westerly sections of coastal Alaska.

Of the 16,073,000 acres that make up the Tongass National Forest, some 10 million acres is within the altitudinal limits of tree growth. Approximately 4 million acres carries timber of present commercial quality; another 1 million acres has timber of marginal quality; and still another 1 million acres has timber of such low quality that it is wholly disregarded

in all timber management planning. The remaining 4 million acres within the limits of the timbered zone is barren rock or is covered with muskeg, brush, or icefields.

As part of the coastal forest area, the Tongass Forest consists of a mixture of 73 percent hemlock and 21 percent spruce with scattered small stands of western redcedar and Alaska-cedar, totaling about 3 percent for each species (37). Mature hemlock trees average between 3 and 4 feet in diameter, are usually quite clean boled and well formed, and are sound until maturity is reached. After maturity, dead tops and butt rot develop rapidly. Sitka spruce, on the other hand, is a larger tree than the hemlock, reaching at maturity an average diameter of 5 to 6 feet.

Figure 1.--Timbered slopes of South Tongass National Forest containing western hemlock and Sitka spruce interspersed with western redcedar.

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## Chugach National Forest

The northern section of the coastal forest includes the important timbered areas extending from the Prince William Sound region to Cook Inlet. Practically all of the merchantable timber in this section is included within the Chugach National Forest. This forest also includes a small amount of the type of timber found in the interior of Alaska as represented by white spruce and Alaska paper birch, which reaches tidewater at the head of Cook Inlet. The forest is quite similar to that of southeastern Alaska, except that no redcedar is found, some additional species are present, and the trees are smaller and on the whole contain less clear lumber.

The principal species in the Chugach National Forest occur in the following percentages: Western hemlock, 65 percent; Sitka spruce, 22 percent; white spruce, 11 percent; cottonwood, 1 percent; and Alaska paper birch, 1 percent (37). Some mountain hemlock also is to be found. The total stand of commercial timber on the 4.8 million acres of the Chugach Forest is estimated at approximately 6.3 billion board feet.

## Interior Forests

The interior forests are the westward extension of the subarctic type found throughout northern Canada. They are found in extensive stands on the low valley benchlands and as narrow belts of timber along all of the stream

courses. These forested areas are moderately to heavily interspersed with wet muskeg areas, lakes and ponds of varying sizes. Timberline lies generally between 1,500 and 2,000 feet, with occasional instances of 3,000 feet and many less than 600 feet. Extensive stands of spruce timber are found north of the Arctic Circle, on the south slopes of the Endicott Mountains.

About 35 percent of Interior Alaska's total land area is forested. Of the 120 million acres of forest land, about 40 million acres, or 33 percent of the forested area and 12 percent of the total land area, might be classed as commercial forest land. This commercial forest land supports an estimated 32 billion cubic feet of timber, including 180 billion board feet of sawtimber, with an estimated annual net growth of about 4 billion board feet. About 95 percent of the commercial forest land is in public ownership.

Three forest species dominate the interior stands; white spruce (*Picea glauca*), aspen (*Populus tremuloides*), and paperbirch (*Betula papyrifera*), and its Alaska varieties. The spruce-birch forest is found throughout the interior and is believed to be the climax type on the well-drained soils of the lower benchlands and valley bottoms. Immature birch is often found in pure stands but upon nearing maturity there is usually an advent of white spruce (fig. 2). Pure spruce stands, however, are found throughout Alaska and are found at the limits of tree growth in latitude, longitude, and altitude.



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Figure 2. --Paper birch with some white spruce understory typical of Alaska's interior forests.

Over extensive areas, the spruce will probably average 6 to 8 inches in diameter (at breast height). Many large areas, however, have spruce averaging 12 to 16 inches with 24 to 32 inches not uncommon. Average height of the spruce to a 6-inch top is 40 feet over much of Interior Alaska, with the better stands attaining 70 to 75 feet. The spruce has a rapid taper, is usually limby nearly to the ground, is relatively free of fungus and disease and produces little clear lumber. White spruce, although producing low grades of lumber, is the most important commercial species in the interior, primarily because it is growing where needed for consumption. This is highly important in a land with few transportation routes and high freight costs, for importing lumber products would

be so excessively expensive as to prohibit normal development \*

The birch in mixed stands is usually small (5 to 7 inches in diameter), of poor form, and highly defective. In the better, more nearly pure stands, the birch averages 10 to 13 inches in diameter, is columnar in form and may average 50 feet to a 6-inch top. Immature birch is usually healthy, but it quickly deteriorates upon reaching maturity. The birch of Alaska, though little used to date, has a high potential export value both as veneer stock and as lumber, flooring, paneling, trim, and other allied uses.

Black cottonwood and balsam poplar are found along stream banks and on bottom lands subject to flooding. The cottonwood is mostly commonly found south of the Alaska Range and the poplar in the Yukon Valley, but admixtures are frequent. These trees vary greatly in size, but at maturity may average 30 to 40 inches in diameter, with heights to an 8-inch top of 80 feet. Little commercial use has been made of these species to date. The related aspen is found throughout the interior.

It is a typical cover crop after a fire. It matures rapidly, attains sizes of 7 to 9 inches in diameter and has at present but a limited utilization.

Black spruce and tamarack are found on the cold, poorly drained muskeg areas. Both species average 3 to 5 inches in diameter and seldom exceed 6 to 8 inches. Neither species is used extensively and is of comparatively little importance.

## PULP AND PAPERMAKING CHARACTERISTICS

At present, the two pulp mills in Alaska, (38)<sup>2</sup> both located in the south-eastern coastal areas, produce sulfite dissolving pulp from the two major wood species in the coastal forests--western hemlock and sitka spruce. In addition to the hemlock and spruce in the coastal forests, however, several minor species, mountain hemlock, western redcedar, Alaska-cedar, lodgepole pine, and black cottonwood, are suitable for pulp and paper. The interior forests, generally referred

to as the spruce-birch forests, are made up mainly of white spruce, paper birch and its varieties, balsam poplar, and quaking aspen. All of these species produce good pulp and are potentially capable of supporting a pulping operation (fig. 3).

Most of the literature on the pulpwoods common to Alaska concerns work done on like species grown in Oregon, Washington, other northern States, and Canada.

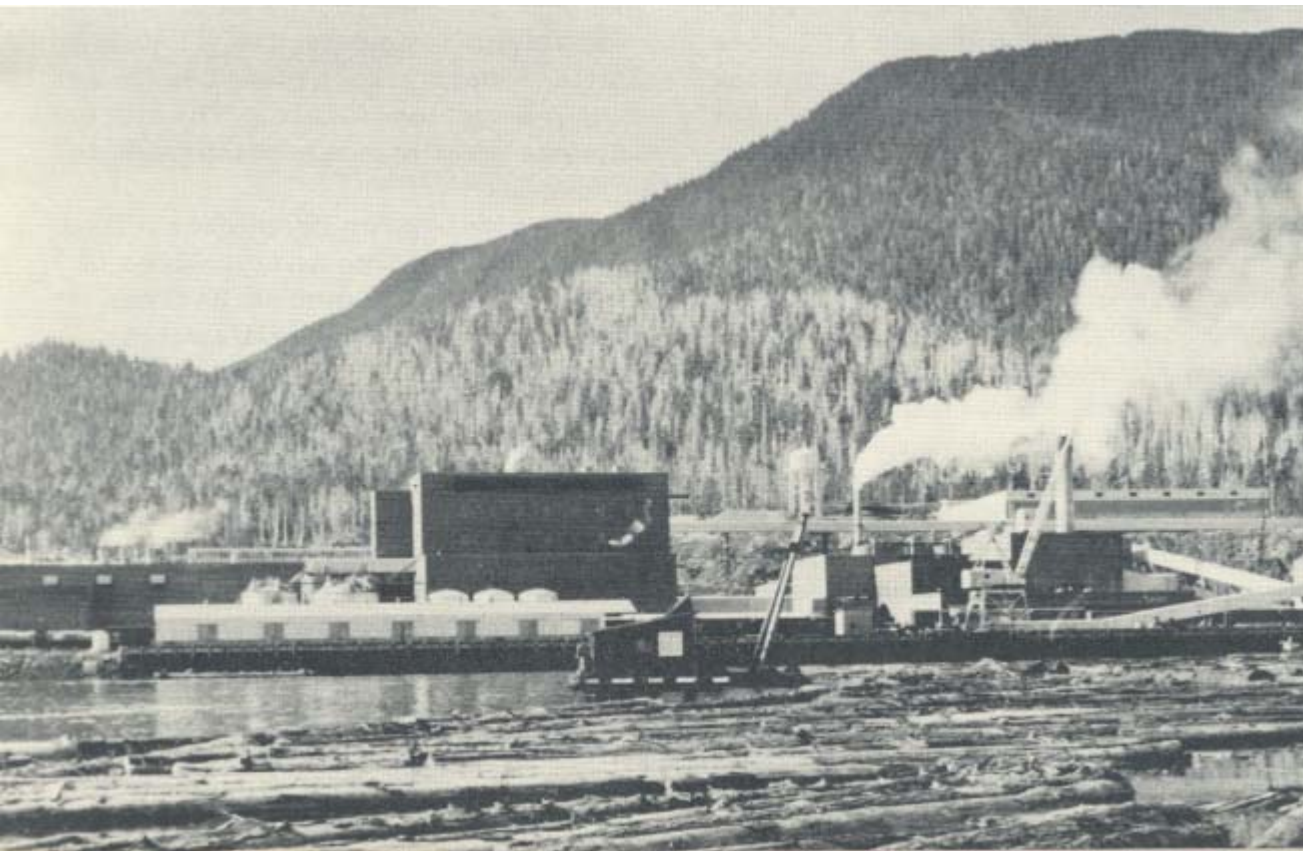
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<sup>2</sup>Underlined numbers in parentheses refer to references listed at the end of this paper.

The timber quality of Alaska's hemlock-spruce forests is generally considered poorer than the forests of

Figure 3.--Western hemlock and Sitka spruce logs produce alpha-cellulose dissolving pulp in Alaska pulp mills.

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Oregon and Washington, because trees tend to be shorter and produce lower grade logs best used for pulpwood. On the other hand, both commercial practice and experimental work have shown that western hemlock and Sitka spruce, when processed for pulp, are equivalent to the same species grown in Oregon and Washington (35).

Practical experience and experimentation have proved that mixed species can produce good pulp whether the mixture is exclusively of softwoods or hardwoods, or in combination—a fact that should be kept in mind when considering the availability of raw material for pulp and paper production. Cooking hardwoods with softwoods is not an uncommon practice. The properties of the finished paper can often be controlled by the quantity of any one species in the mixture.

The pulp industry has at least one competitive advantage in that it can use logging, sawmill, and veneer mill residues as sources of raw material. Studies (26, 33) have shown that pulps produced from sawmill chips when free from mechanical, thermal, biological damage and deterioration are generally considered as good or better than pulp made from round logs.

#### Wood Pulp from Softwood Species

The softwoods of the coastal regions that are suitable for pulping include western hemlock, Sitka spruce, and minor species, such as western red-

cedar, Alaska-cedar, mountain hemlock, and lodge pole pine. The only softwood of pulpwood quality in the interior forests is the white spruce.

In general, western softwoods have good fiber length (table 6), which contributes to good pulp strength, particularly tearing resistance, but makes papers somewhat more bulky and porous, which may or may not be an advantage, depending on the grade of paper and its use. There is a tendency for western softwoods to be more resistant to refining treatments and to fibrillate more than pulps from other regions. With proper refining, these pulps are known for their excellent strength (35).

#### Wood Pulp from Hardwood Species

In the coastal regions, black cottonwood is suitable for pulpwood, while available from the interior forests are paper birch and its varieties, quaking aspen, and balsam poplar.

Hardwoods have shorter fibers than softwoods. They differ chemically from softwoods (table 7) by higher pentosans and other hemicelluloses, frequently lower lignin contents, and often high alpha cellulose contents. The extractives contain more gums and waxes, whereas the extractives from softwoods contain more oleo-resins and terpenes (35).

Hardwoods are generally considered more dense than softwoods, but this

is not true of all hardwood pulpwoods, especially the poplars (Populus spp.).

Hardwoods can be handled in mixtures and in mixtures with softwoods, but facilities for separate handling are desirable to permit optimum processing conditions to obtain uniformity of product. Separate handling, however, is not often possible in present day mill practice (35).

Hardwoods are pulped by traditional pulping processes, but are more versatile than most softwoods in that the semichemical and the chemimechanical processes, such as chemigroundwood and cold soda, produce good pulps from many species. These pulps are generally suitable for a wide variety of products from bright papers to various types of boards.

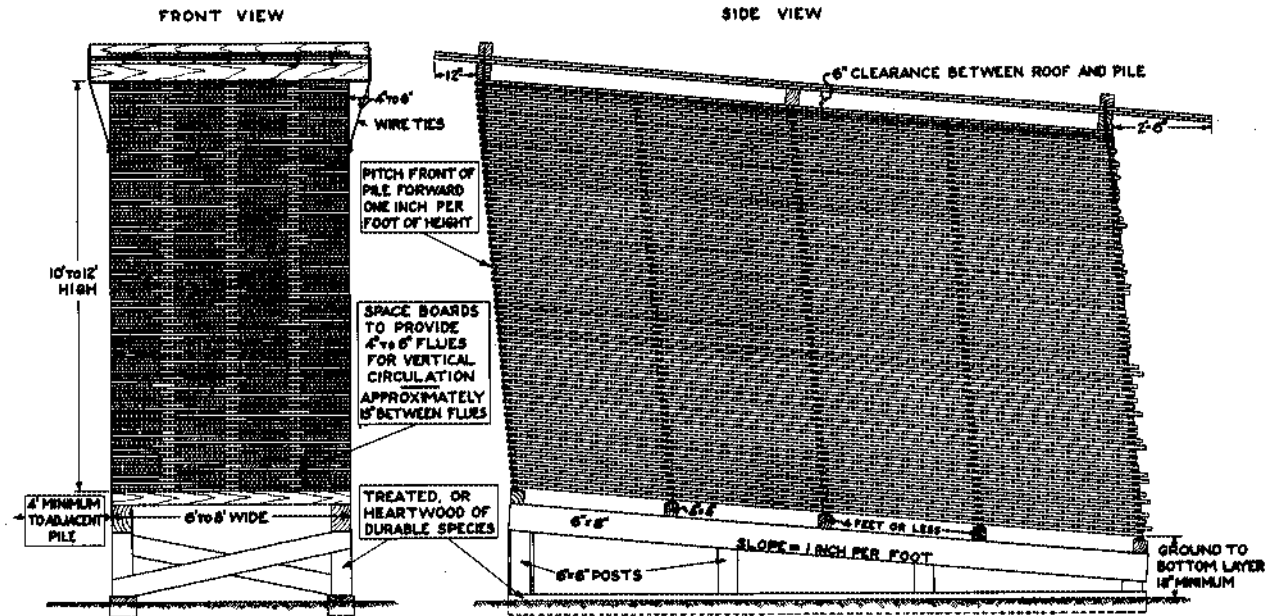
## SEASONING CHARACTERISTICS

The seasoning information in this report is based on a general knowledge of the seasoning of wood, together with available data on Alaska woods and more extensive data on the same or very closely related woods grown in the other states. Generally, the seasoning characteristics of any wood do not vary with geographical location. Major differences are related to differences in the quality of the growing site, particularly soil moisture. The extreme range of climate in Alaska, however, will affect the rate of air drying. Extremely low temperature or very high humidity tends to decrease the drying rate.

Since drying is an operation that should be started as soon as possible after sawing and often requires greater-than-average care to produce best results, some suggestions on drying procedures and kiln schedules are included in this report.

Lumber can be dried to a low final moisture content by kiln drying directly from the saw or by air drying, followed by kiln drying or drying in a heated room. Thorough air drying will make the lumber dry enough for shipment or for exterior uses but not dry enough for use in heated buildings. For faster and better quality drying, a dry kiln should be used. By close control of drying conditions, shrinkage defects can be prevented and drying stresses relieved so the lumber will not warp when resawed or machined to smaller sizes or irregular shapes. The Dry Kiln Operator's Manual (32) contains general information on shrinkage and, other properties of wood related to drying.

To facilitate seasoning, the material generally should be sawed into lumber or flitches slightly thicker than the size that will be used for the end purpose, because there is considera-



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Figure 4. --Essential features in piling Alaska woods for rapid and uniform air drying,

bly less danger of developing checks and honeycomb in thin stock than in thick stock. Very thin stock, however, must be piled with stickers closely spaced and the pile weighted down to control warping.

### Air Drying

Air drying is a comparatively simple process, but careful attention should be paid to the details of piling to obtain fastest drying and avoid damage to the lumber. Essential features of handpiling lumber for rapid and uniform air seasoning are illustrated in figure 4. The pile foundation should be well constructed and sufficiently high to keep the lumber well off the ground. The stickers should be made of dry material and perfectly alined above the foundation supports in tiers that pitch forward at the same angle

as the front of the pile.

Only a portion of each year is considered to be an active drying period. The character of the weather conditions during this period is considerably less favorable for drying in Alaska than in the other States, and the length much shorter. Thus, to take best advantage of the goodweather, considerable attention should be given to laying out the air -drying yard with ample lateral space between piles and rows of piles, and with the alleys or roadways and lateralspaces at right angles to each other and in good alinement across the whole yard (30).

A considerable difference in air -drying rates exists between Interior Alaska and the coastal region. While the active drying period in the coastal region extends from about the first of May to the end of August, the relative humidity and equilibrium moisture con-

tent of wood are SO high that very wet 1-inch lumber of the coastal species may not dry to 25 percent moisture content or less in one drying season. Piling the lumber openly and as far away from or above the water as possible should be helpful. The lumber will not dry much between the first of October and May 1. In the interior, the active drying period is from about June 1 to August 30, but moderate drying will occur between May 1 and October 1. The humidity is lower and the drying faster in this region, so that 1-inch lumber of species growing there probably will dry to 25 percent moisture content or less in one active season. Weathertight covers are desirable on top of each pile or a shed roof may be installed over the entire drying area.

In areas where relative humidity is high, it may be advantageous to use the method known as end racking for rapid surface drying of the boards. A sturdy ridge-pole type of support is used. The boards are leaned on edge against the ridge pole, crossing each other at the top. The lower end of the boards should be supported at least 6 inches above the ground by hewed poles, timbers, or boards on blocks. Lumber that is likely to warp should be taken from such end racks and flat piled before warping starts.

At mills where forklift trucks are available for handling the lumber, sticker guides should be used to build the packages at ground level. Sturdy pile supports should be used under all tiers of stickers. Bolsters between packages should be perfectly aligned above the stickers. For such package

handling, the piles are usually built with no slope or pitch, but it is advantageous to use panel roofs on top of the top packages in the pile (30).

### Kiln Drying

Kiln drying, a complex process that requires considerable skill and equipment, is thoroughly explained in the Dry Kiln operator's Manual (32). For convenience, an abbreviated set of kiln schedules and an index of suggested schedules for Alaska woods are given in tables 11, 12, and 13. Table 14 illustrates how the separate dry-bulb temperature and wet-bulb depression schedules are assembled with a few examples for some of the more common Alaska woods. Since these schedules are not based on experience with the species as they are grown in Alaska, the kiln operator should proceed with caution. The dry-bulb temperature schedules are expected to be reasonably satisfactory, but the operator may wish to adjust the stage at which he makes the first change in wet-bulb depression in accordance with the green moisture content of the wood. This first change should be made when about one-third of the total moisture content of the wood has been dried out. Thus, for woods that have a green moisture content of 100 percent or over, the F wet-bulb depression schedules would be used. For those that have a green moisture content of 60 to 70 percent, the C schedules would be used. Kiln schedules for some of the woods are recommended by the Canadian Forest Products Laboratories (18).

The final moisture content to which wood is dried depends upon the temperature and the humidity of the air to which it will be exposed during fabrication and use. Wood will lose moisture to, or take up moisture from, the surrounding air until its moisture content reaches equilibrium. Charts showing the relationship between temperature, relative humidity, and equilibrium moisture content (E.M.C.) are contained in the Dry Kiln Operator's Manual (32). Lumber for manufacture into furniture and flooring for most parts of the United States is generally dried to an average moisture content between 6 and 8 percent. In Alaska these values probably should be 5 to 6 percent, provided the interiors are considerably sheltered from high-humidity summer air. This is because heating coldwinter air to 65°F. or higher greatly reduces relative humidity and E.M.C. Where average outdoor temperature is around 30°F., the interior E.M.C. is lowered to about 5 percent even though outdoor relative humidity may be 95 percent. Where the outdoor temperature is 0°F. and relative humidity 75 percent or lower, the interior E.M.C. goes down to 2 percent.

In areas where there is considerable exposure to such humid conditions, the higher average of 8 percent may be advisable. How to determine the moisture content of wood by the oven-drying method or by electrical moisture meter and to test the wood for presence of residual drying stresses or casehardening are described in the Dry Kiln Operators's Manual.

Living trees contain tremendous amounts of water. If wood is to be used to its greatest advantage, almost all of the water must be removed before the wood is cut to final size or manufactured into a product. During removal of the water, chemical changes can cause undesirable changes in color, insects or stain and decay fungi can attack the wood, or shrinkage can cause such defects as checking and warping. A number of defects that can sometimes occur in the drying of Alaska woods are described below.

Extractives in wood undergo chemical changes during drying that may cause discolorations--or chemical stains, as they are generally called. If pitch fails to harden or set during drying, trouble may result, particularly with products to which sealers, varnishes, and paints are applied.

Brown stain is a chemical stain that occurs in many softwoods, particularly western hemlock. Its color varies from light to very dark brown. While it affects appearance of the wood, it does not impair strength. The stain can be reduced considerably by (1) cutting the logs into lumber as soon as possible after the tree is felled; (2) drying the lumber without delay; and (3) using an initial dry-bulb temperature that does not exceed 130°F., with a relative humidity as low as the stock will tolerate without excessive surface and end checking, and a wet-

bulb temperature that does not exceed 120° F. throughout the drying.

Sticker marking is discoloration that may occur on and beneath the surface of the board under the sticker or appear as narrow, dark streaks on the surface at the edges of the sticker. Sometimes it can be removed by surfacing or sanding. No means of preventing the discoloration is known, but certain seasoning procedures will lessen it. These include the use of dry, narrow stickers or of grooved stickers to reduce the contact area, and starting the drying of the green lumber as soon as possible.

Blue stain and incipient decay caused by fungi have sometimes been problems in bulk shipment of green lumber or during air seasoning in warm climates elsewhere in the United States. If they develop in Alaskan operations, relatively cheap, highly effective chemicals are available for their control. Two such chemicals are sodium pentachlorophenate and a combination of borax and sodium pentachlorophenate. If stain or decay organisms have infected green wood during storage or air drying, the temperatures normally used at the start of kiln drying are usually high enough to stop their growth. A temperature of 110° F. stops the growth of these organisms and 150° F. will kill major wood-destroying fungi in green wood in 75 minutes.

Collapse is a severe distortion or flattening of wood cells. A slight amount of this defect may be difficult, if not impossible, to detect. When severe,

it often shows up as grooves or corrugations on the wood surfaces. This defect is generally associated with excessively high dry-bulb temperatures in the early stages of drying, and these temperatures should be lowered on subsequent kiln charges if collapse occurs.

Splitting and checking are lengthwise separations of the wood. End checks generally occur in the wood rays on end-grain surfaces. They also occur in the initial stage of drying, and can be minimized by using a higher relative humidity. End splits usually result from the extension of end checks.

A boxed-heart split results when the pith falls entirely within the four faces of a piece of wood anywhere in its length and the difference between tangential and radial shrinkage of the wood surrounding the pith causes such severe stresses in the faces that the wood is split. It is virtually impossible to prevent this condition.

Ring failure occurs parallel to the annual ring either within the ring or between rings. In appearance it is similar to shake, which takes place in standing trees or in trees when they are felled. Ring failure can be kept to a minimum by end coating stock and by using higher initial relative humidities and low dry-bulb temperature schedules.

Honeycomb is an internal void caused by tensile failure across the grain, and it usually occurs in the wood rays. It is produced by the use of excessively high temperatures for too long a

time while free water is still present in the cell cavities. Honeycombing can be held to a minimum by avoiding excessively high dry-bulb temperatures until all the free water has been evaporated from the piece.

Warping is the distortion in shape and form caused by differences in radial, tangential, and longitudinal shrinkage of wood as it dries. Warping is also aggravated by irregular or distorted grain and the presence of abnormal types of wood. Various types of warp are cup, bow, crook, and twist. Cup is a distortion of a board in which there is a deviation flatwise from a straight line across the width of the board. It is caused by greater shrinkage parallel to than across the annual rings. A flat-sawed board cut near the bark tends to cup less than a similar board cut near the pith. The thinner the lumber, the greater is its tendency to cup. The best method to control cup is by good piling or stacking practices.

Bow is a deviation flatwise from a straight line drawn from end to end of a board. This characteristic is associated with longitudinal shrinkage in wood adjacent to the pith of the tree, compression or tension wood that occurs in leaning trees, and cross grain in wood. It can be controlled by the same procedures used to diminish cupping.

Crook is a deviation edgewise from a straight line drawn from end to end of a board. The causes of crook are the same as those for bow. It is more difficult to prevent than cup or bow.

Twist is the turning or winding of the edges of a board so that the four corners of any face are no longer in the same plane. It occurs in wood containing spiral, wavy, diagonal, distorted, or interlocked grain. Lumber containing these grain characteristics can sometimes be dried reasonably flat by using proper piling procedures. Checked knots are often considered defects. The checks appear on the end grain of knots in the wood rays. They are the result of differences in shrinkage parallel to and across the annual rings within the knots. They occur in the initial stages of drying and are aggravated by using too low a relative humidity. Knot checking can be controlled by using higher relative humidities and by drying to a higher moisture content, but is almost impossible to prevent.

Encased knots invariably loosen during drying. This is due to the fact that they are not grown to the surrounding wood, but are held in place only by bark and pitch. They shrink considerably in both directions of the face of the lumber, whereas the board shrinks considerably in width but very little in length. Consequently, the dried knot is smaller than the knot-hole, and frequently falls out of the lumber during handling and machining. Nothing can be done, however, to prevent the loosening of dead knots during drying.

Casehardening is the inevitable result of the drying stresses associated with shrinkage--the stresses persisting when the wood is uniformly dry. Whether or not it is considered to be

a defect depends on the final use of the dried material. Casehardened lumber may cup or distort if resawed or machined unevenly. Ripsawing may result in crook. Casehardening can be relieved in a compartment -type dry kiln by a conditioning treatment.

All of the spruces, pines, Douglas-fir, and western larch have resin canals or pockets. As these woods dry, some of the volatile substances in the pitch evaporate, causing it to harden somewhat. If the pitch is not hardened sufficiently, it will ooze or bleed to the surface of the wood during use. Pitch can be thoroughly set by using a temperature of 160° F. or higher.

Some species of wood contain zones of unusually high moisture content,

commonly called water pockets. This water moves out very slowly during the drying process. Woods such as western hemlock and true firs frequently contain water pockets.

Lumber manufacturers and kiln operators must be especially alert to overcome the following drying defects,

Alaska -cedar- -failure to set resin.

Western redcedar --collapse and honeycomb, particularly in sinker stock.

Western hemlock--water pockets; chemical stain.

Aspen--collapse in "wet wood;" water pocket.

Paper birch--end checks, brownish chemical stain.

## TREATING WITH PRESERVATIVES

Until the establishment of a commercial wood preserving plant in Whittier, Alaska, in 1961, treated products, such as crossties, poles, piling, and construction timbers, were mostly of Douglas-fir and western hemlock produced in Oregon and Washington. There has therefore been limited commercial experience in the treatment of Alaska woods. This limited experience, along with that in treating similar or related species from the States farther south, indicates that it should be possible, with careful conditioning and treatment of such Alaska species as west-

ern and mountain hemlock, Sitka spruce, Alaska-cedar, white spruce, paperbirches, and cottonwood to obtain preservative retentions and penetrations approaching those of minimum requirements of recognized standards for ties, poles, piling, and construction timbers. As in the case of similar species, incising may be necessary to meet preservative penetration requirements, particularly with ties and sawed timbers with heartwood faces. Western redcedar is very resistant to penetration and is seldom treated except in the round form for which incising is required.

Graham and Miller (13) have reported on the importance of seasoning of round western hemlock and indicate drying to an average moisture content below 30 percent to obtain adequate retentions and penetrations. Conners and Bramhall (8) have shown erratic penetrations following conditioning by Boultonizing of round green western hemlock poles and the need for long pressure periods, also the tendency of the wood to collapse under a pressure of 150 pounds per square inch.

A study at the Forest Products Laboratory on the pressure treatment of kiln-dried western hemlock 2- by 6-inch lumber showed higher retentions and more uniform penetration of preservative than that obtained in Pacific Coast type Douglas-fir treated in the same charge. In treating pieces 3.5 by 4.5 by 48 inches cut from air-seasoned ties with a preservative oil, Graham (12) reported deep penetrations in unincised western hemlock

with high retentions of 20 to 30 pounds per cubic foot but incising necessary with lower retentions; irregular penetration in incised and unincised mountain hemlock; and penetration in Sitka spruce limited mostly to summerwood bands with improvement in penetration and retention on incised material. Although the preservative penetrations are not known, cottonwood treated with 8 pounds and western hemlock with 6.75 pounds of creosote-coal tar solution per cubic foot have shown an average life of 37 years and 30 years in the Northern Pacific Railroad test tracks in Montana, and birch ties treated with 7 pounds of creosote petroleum solution have shown an average life of 50 years (11).

Limited evidence has indicated untreated ties in Alaska to perform about as follows: Mountain hemlock, 11 to 12 years; Douglas-fir, 10 to 11 years; western hemlock, 9 to 10 years; Sitka spruce and white spruce, 6 to 7 years.

## DESCRIPTION OF SPECIES

A general description of the characteristics, properties, uses, and range (fig. 5) of several of the Alaska species is presented. In referring to the various physical and mechanical properties, a graduated set of descriptive terms, each corresponding to a certain numerical range of the property under consideration, is used to permit a more accurate evaluation of the property, and to afford a uni-

form basis of comparison between species. These terms are used in connection with the following properties: Weight, strength in bending and compression, stiffness, hardness, shock resistance, and shrinkage. Descriptive terms are also given for ease of kiln drying, ability to stay in place, workability, nail-holding ability, ease of gluing, and resistance to decay, although for

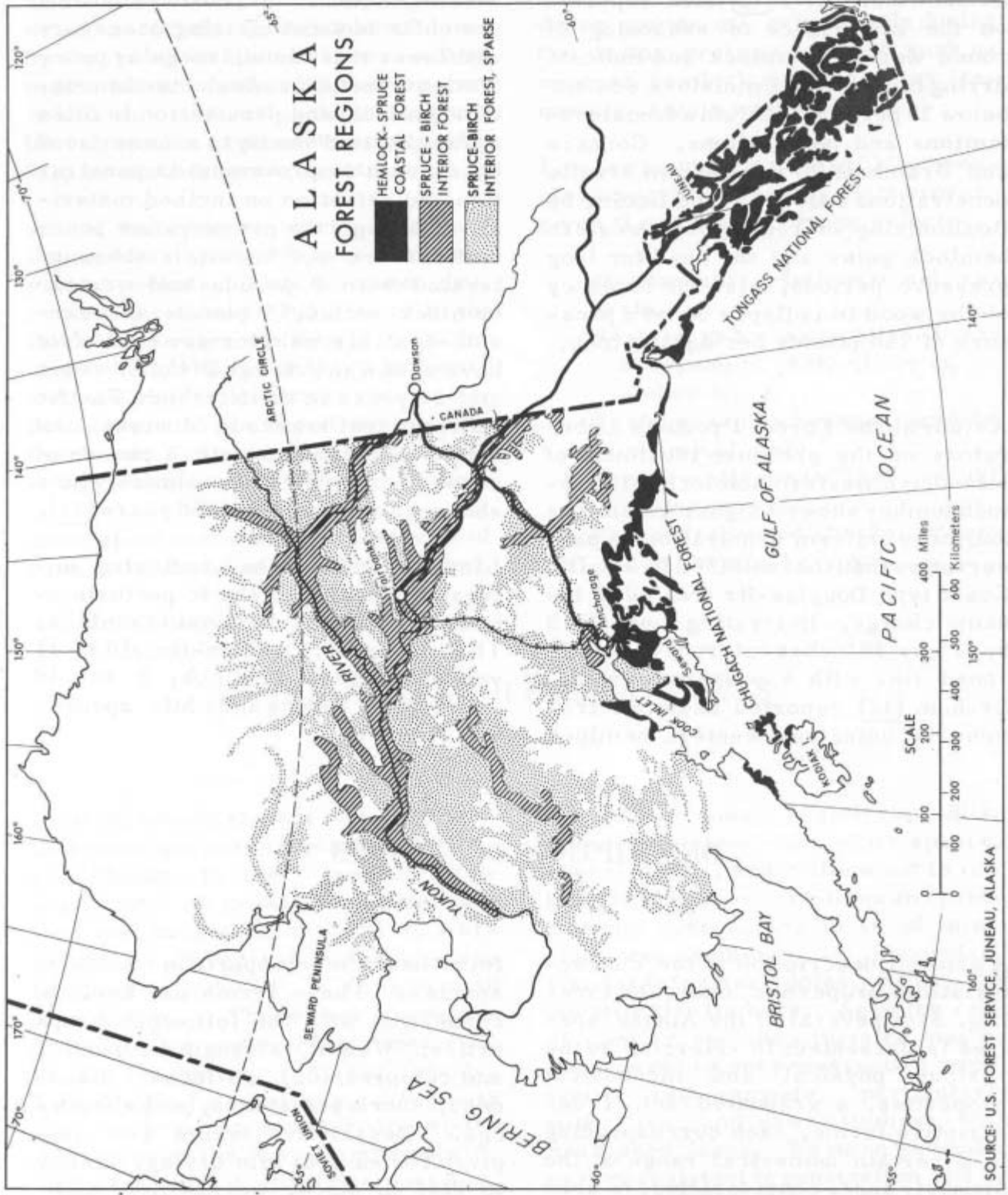


Figure 5. ---Location of Alaska forests and range of species.

these properties sufficiently complete information is not available on most species to permit as accurate a classification as is desired.

The complete set of terms for the above properties, applicable to all species, is presented in table 1. An examination of this table will give a background for appraising the relationship of each term to that of the others. The index figures in column 1 of table 1 are suggested as a numerical scale for expressing the degree to which a species possesses each of the various properties, and thus might be employed in lieu of the corresponding descriptive term. In the species descriptions which follow, however, only the descriptive terms are used. The classification limits given in table 1 apply to specific gravity only, although other classification limits have been set up and used for shrinkage and the mechanical properties.

## WESTERN HEMLOCK (Tsuga heterophylla (Raf.) Sarg.)

Western hemlock is also known as west coast hemlock and Pacific hemlock.

### General Description

Western hemlock is related botanically to eastern hemlock (Tsuga cana-

densis (L.) Carr.), but differs from it in appearance, ingrowth characteristics, and to a lesser extent, in its mechanical properties. The general color of the wood is a pale reddish brown, with the sapwood very similar and generally not easily distinguishable from the heartwood when dry. The summerwood bands, although marked, do not contrast decidedly with the lighter-colored springwood. The contrast is less pronounced than in Douglas-fir and southern pine, but more so than in Sitka spruce and northern white pine. The grain is quite distinctive, and it is highly regarded for interior finish and decoration. The wood has a moderately fine and moderately even texture and is normally nonresinous, a factor of importance for certain kinds of boxes. It has a sour odor when green, but is odorless and tasteless when dry. The annual growth rings are usually comparatively uniform in width. Western hemlock from Alaska, however, appears to have a somewhat slower average growth than that from Washington and Oregon, and to the extent that this is true the Alaska-grown material should exhibit a more even texture.

### Distribution and Growth

Western hemlock grows in the Pacific Coast region of North America from southern Alaska to northern California and western Montana. In Alaska the stands of mature trees of about 200 to 250 years in age range from 2 to 4 feet in diameter and are about

150 feet in height. The tree has a long slender bole, and a short narrow crown. The trees are clear of limbs well to the top. They are commonly sound when young, but when mature and overmature at diameters of 3 to 3-1/2 feet, heart rot is very prevalent; many of these old overmature trees are so defective as to be classed as unmerchantable. The stands vary from almost pure to admixtures of Sitka spruce, western redcedar, and Alaska-cedar. Western hemlock is the most prevalent species in the mature and overmature forests of southeast Alaska (fig. 6). It reproduces prolifically, grows well on a variety of soils, and is very tolerant of shade. In Alaska, hemlock trees on the poorest sites and occurring as scattered trees in pure spruce stands frequently have deeply fluted lower trunks. The lumber from these fluted

trunks often contains many large bark pockets and decay spots. In the commercial forests as a whole, however, fluting is not considered an important factor.

### Properties

The wood of western hemlock is moderately light in weight, moderately weak in bending and compression, moderately stiff, moderately hard, moderately low in shock resistance, and has a moderately large shrinkage. Although not so strong as Douglas-fir, western hemlock can be used for many of the purposes for which Douglas-fir is employed. Western hemlock is estimated to rank as moderate in ease of kiln drying, moderate in ability to stay in place, moderate in nail-holding ability, and is less inclined to split in nailing than is Douglas-fir. It is very easy to glue, and very low in resistance to decay, being comparable with spruce in most situations\* Western hemlock takes paint satisfactorily, and in this respect is about equal to eastern hemlock and the spruces.

Figure 6. --Mature stand of western hemlock and Sitka spruce.

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Moderate in workability, western hemlock works readily in all hand and machine operations and has little dulling effect on cutting edges. The relative softness of the springwood requires the use of sharp tools for clean cutting, and in end-grain working, for example scribing and mortising, the material must be properly supported at the tool exit to obviate chipping out. There is a tendency to chipbruising in

planing and for the best finish, the waste removal system must be efficient and the cutters should be honed free from wire edge.

### Pulping and Papermaking

Western hemlock, which accounts for about 73 percent of the softwood species growing in the coastal forests, is one of the best pulpwoods for overall quality; it is nonresinous, and has good density and fiber length. The wood can be pulped by almost any process, and it produces good yields of chemical pulp. Typical values for fiber length, density, and yields of chemical pulps appear in table 6.

When pulped by the sulfite or kraft processes, western hemlock reduces readily and gives normal yields. The pulps are dark and slightly red in color, but offer no resistance to bleaching. The pulps have good strength, particularly tearing resistance, and are well balanced as to burst and tear (35). This species is one of the principal pulpwoods for the production of dissolving pulp in Alaska.

For groundwood pulp, western hemlock reduces readily to yields of about 87 percent and requires about 10 to 15 percent more power than spruce. The pulp has fair color and is of standard strength. The groundwood pulps, however, tend to discolor easily in contact with iron because of the presence of tannins (36), but they are readily bleached for use in papers requiring brighter pulps,

The various kinds of papers made from these pulps are listed in table 8.

### Seasoning

Western hemlock is generally not a difficult wood to dry, except greater care and longer times are required for sinker stock. Little information is available on drying the related species, mountain hemlock, but the better quality material from lower elevations may dry about the same as this species. These woods probably would air dry faster than the cedars in good air drying locations during the active air-drying period.

Recommended kiln drying schedules use initial dry-bulb temperatures of 150° and 160° F. and wet-bulb depressions of 7° to 10° F. The Canadian Laboratories recommend about the same temperatures and wet-bulb depressions, except a 17° F. depression is recommended for 4/4 and 5/4 box and commons. No special schedules are suggested for sinker stock, but best results should be obtained by sorting it out and either air-drying first or kiln drying separately on the same schedule as recommended for regular stock. Even if such methods are used, water pockets may result in wet spots, remaining in the lumber if final drying is not continued long enough. Estimated drying time can vary from 2 to 10 days, depending upon the thickness and final moisture content sought.

Western hemlock is subject to occa-

sional brown stain. Care should be taken to start kiln drying within 3 days of sawing or to pile the material for rapid air drying if kiln drying is not immediately available.

### Principal Uses

The most important uses of western hemlock include lumber for general construction, railway ties (treated), pulp for paper and paperboard, dissolving pulp for the manufacture of such products as rayon, enameled furniture, broom handles, poles and cross arms (treated), marine piling (treated), interior finish, boxes and crates, kitchen cabinets, and flooring and ceiling (decking). Veneer cut from western hemlock logs is also used to make plywood.

### MOUNTAIN HEMLOCK (Tsuga mertensiana (Bong.) Carr.)

Mountain hemlock is also known as black hemlock.

### General Description

Mountain hemlock is a near relative of western hemlock (Tsuga heterophylla (Raf.) Sarg.), and is somewhat similar in appearance, but the tree is smaller and the trunk has more taper and is less clear of branches and knots. The heartwood is a pale red-

dish brown, the sapwood is moderately thin. The summerwood is quite pronounced, and is distinguishable from the lighter appearing springwood. The wood has a moderately fine and moderately even texture. The mountain hemlock from Alaska tested at the Forest Products Laboratory averaged 29 growth rings per inch,

### Distribution and Growth

Mountain hemlock grows in the mountains of the Pacific coast region of North America from southern Alaska to the high Sierras of California, extending as far eastward as Idaho and Montana. It is mainly a timber-line tree, but in Alaska it also grows near the sea level on rocky sites. Mountain hemlock at its best occasionally reaches a height of 100 to 125 feet and a diameter of 30 to 40 inches. Such trees, however, are uncommon. At the other extreme, it sprawls among the rocks to but a few feet in height on bleak windswept crests.

### Properties

Mountain hemlock is one of the few species in which shrinkage and the principal strength properties all closely and uniformly correspond to what would be expected for its density. Most species have at least one property which differs from the general law. The wood of mountain hemlock is slightly above the median of the different species, and may be classed as

moderate in its properties. Hence it is moderately heavy, moderately strong in bending and compression, moderately stiff, moderately hard, moderately high in shock resistance, and has a moderately large shrinkage. The heartwood of mountain hemlock, however, is low in decay resistance.

Experience with mountain hemlock is very limited, but a few samples were machined satisfactorily and finished smoothly. The wood is quite similar to western hemlock in its characteristics, but is somewhat more dense. In recent years, with the expansion of logging operations, more of this wood is reaching the market. It is usually marketed with western hemlock and is used for the same purposes.

#### Pulping and Papermaking

Moderately fine and even textured, mountain hemlock has good fiber length and density. The lignin content is within the range of most softwood pulpwoods, but it is comparatively low in cellulose content.

Experimental work has shown that mountain hemlock pulps readily by the sulfite process, but is lower than western hemlock in bursting strength and tearing resistance. When pulped by the kraft process, the wood reduces readily, providing a pulp with excellent bursting and tensile strength, and fairly good tearing resistance (25).

#### Seasoning

Because of the similarity of the two species, the information relating to the seasoning of western hemlock is also applicable to mountain hemlock.

#### SITKA SPRUCE (*Picea sitchensis*

(Bong.) Carr.)

Sitka spruce is also known as tideland spruce, coast spruce, and yellow spruce.

#### General Description

Commercially Sitka spruce is one of the more important species in Alaska. While related botanically to the white spruce, it is much larger in size. The heartwood is light reddish brown, the sapwood nearly white. The wood is classified as nonporous and has a fine, moderately uneven texture. The tree, except in overmaturity, is of moderately rapid growth in Alaska. The test material from Girdwood averaged 23 rings per inch, and the large trees from near Ketchikan averaged 17.

#### Distribution and Growth

Sitka spruce is found along the Pacific coast region from Alaska to northern California, extending in-

land about 50 miles. It is reported to occur from sea level to as high as 5,000 feet, but grows mainly at altitudes of less than 1,500 feet. It forms pure forests, but also occurs in mixed stands. In the usual mixed forest the faster-growing and more light demanding spruces are larger in diameter than the western hemlock with which they are associated and exceed them in height.

The tree is ordinarily 80 to 125 feet high and from 3-1/2 to 6 feet in diameter. In the Tongass National Forest the average mature tree is about 160 feet high and 5 feet in diameter, but trees with a height of 200 feet and a diameter of 7 feet are common. The trees from which test material from the Tongass National Forest were selected ranged from 4-1/2 to 5-3/4 feet in diameter at the stump, with an average of 5 feet, and from 147 to 228 feet in height, with an average of 197 feet. The oldest tree was 757 years of age; the youngest 248. The trees selected for test from the Chugach National Forest were much smaller, averaging 17 inches in diameter, 80 feet in height, and 203 years of age.

Sitka spruce is commonly sound and straight grained, but on exposed sites is subject to spiral grain. The most common defect of overmature trees is butt rot.

### Properties

The wood of Sitka spruce is moder-

ately light in weight, moderately weak in bending and compression, moderately stiff, moderately soft, and moderately low in shock resistance. It does not splinter or shatter easily on impact. It has a moderately large shrinkage and is easy to kiln dry. It may be classed as good in ability to stay in place, easy to work, very easy to glue, and very low in resistance to decay. It takes nails without splitting and holds them well, takes paints and enamels well and is practically tasteless and odorless. It is a nonporous wood and has a fine, moderately even texture.

Because of the great size of the tree and its clear trunk, it produces a large proportion of clear timber (figs. 7 and 8). Knots, when present, are usually sound. The wood contains small resin ducts, the direction of which on a flat-sawed surface indicates the direction of the grain, and is a useful guide in inspection for such uses as airplanes and ladders where strength is the controlling requirement.

Figure 7.--Felling Sitka spruce using spring-board to get above swell.

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Figure 8.--Rafting Sitka spruce logs at an Alaska sawmill.

Sitka spruce, in common with other softwood species, frequently contains compression wood. Compression wood is characterized by high density, wide rings, and a large percentage of summerwood. Although such material, because of its density and large amount of summer wood, superficially presents certain external characteristics of the strongest and most desirable material, it is, nevertheless, unreliable as to strength and has an appreciable longitudinal shrinkage which causes it to warp and twist badly, particularly when present with normal wood. Fortunately, compression wood is not excessive in amount, is easily recognized, and, because of its warping tendencies, is likely to be culled before it reaches the finished product.

Sitka spruce is seldom used for ordinary plywood, but sliced veneers have been employed in special laminates for aircraft. Usually very

straight grained, the wood works easily in all hand and machine operations with little dulling effect on cutting edges. A clean finish is obtained in machining, provided that sharp tools are used and normal care is taken to prevent grain raising.

### Pulping and Papermaking

Sitka spruce, which comprises about 21 percent of the hemlock-spruce southeastern coastal forests and also occurs in pure stands (37), is an excellent pulpwood with exceptionally long fibers and good density. It can be pulped by almost any process and produces good yields of pulp. The chemical pulps are coarser and of lower quality than those from western hemlock or white spruce and about 10 percent lower in strength. It probably has about the highest pulp color of any of the common pulpwoods and

is used extensively for sulfite and mechanical pulping. Sitka spruce is the principal source of dissolving pulp in Alaska, Sitka spruce and western hemlock, also suitable for dissolving pulp, are processed together with spruce comprising the greater portion of the mixture.

The groundwood pulp of Sitka spruce has the highest strength of those from common pulpwoods, while the strength of the chemical pulps is the lowest,

The various kinds of papers made from these pulps are listed in table 8.

### Seasoning

Sitka spruce is easy to dry and 1-inch stock possibly could be air dried in the coastal region during a good summer season. The high quality stock merits the greater care of kiln drying, however. Upper grade material responds well to kiln schedules starting with 150° to 160° F. dry-bulb temperature and 5° to 10° F. wet-bulb depressions. A lower temperature schedule that starts at 130° F. with a 10° F. wet-bulb depression is recommended for 4/4 lower grade material. For aircraft material requiring the greatest strength, lower temperatures are required throughout the run.

Kiln drying times vary from 48 hours to 10 days.

A small amount of Sitka spruce has spiral grain, and some has compress-

ion wood. Both of these will lead to warping during drying or when dried stock is resawed. Both can be recognized and sorted out when the spruce is to be used for particular products.

The difficulty encountered from stain and mold in shipping green spruce by water through hot, humid zones may be overcome by air seasoning for from 30 to 60 days before shipment or by dipping the green lumber in a toxic antistain chemical.

### Principal Uses

Because of its high strength to weight ratio, Sitka spruce is used specially for airplane and glider construction, oars, ladders and scaffolding, and the building of boats, particularly racing sculls. It is one of the best pulpwoods in Alaska. It is also employed for sounding boards in pianos, organ pipes, food containers, shelving, kitchen furnishings, and general construction.

### WHITE SPRUCE (Picea glauca (Moench) Voss)

White spruce is also known as skunk spruce, eastern spruce, Canadian spruce, and Black Hills spruce.

### General Description

White spruce is a softwood species that has long been in popular favor and

use. It is related botanically to several other species, the more important of which are Sitka spruce, red spruce, and Engelmann spruce. Of these, red, Sitka, and white spruce are very similar in their mechanical properties and may be used on a like basis in airplane construction.

The heartwood and the sapwood are practically white; consequently they are not readily distinguishable when dry. The wood in common with that of other coniferous species is classified as nonporous. It has a fine, moderately uneven texture, and can be machined and worked easily. In Alaska, the tree is of relatively slow growth; the test material obtained from near Matanuska averaged 22 rings per inch.

### Distribution and Growth

White spruce grows over a wide area extending from Labrador to Hudson Bay and to northwest Alaska, extending southward to the Great Lakes region and the States adjoining Canada to the east (fig. 9).

In Alaska, white spruce is typically a tree of the interior, rather than of the coastal region, although it extends to tidewater in a few places. It is found in forests of the woodland type, principally along the valley floors of the great rivers.

White spruce is rarely more than 60 to 70 feet in height, and 2 feet in diameter. The trees selected for test from near Matanuska averaged 56 feet



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Figure 9.--White spruce stand, principally found in interior forests.

in height and 97 years of age, the age ranging from 83 to 113 years. The diameter at the stump was 12 to 15 inches.

### Properties

The wood of white spruce is moderately light in weight, weak in bending and compression, moderately limber, moderately soft, moderately low in shock resistance, and has moderately large shrinkage. It is ranked as easy to kiln dry, good in ability to stay in place, low in nail-holding ability, and very easy to glue. It gives good service in ordinary construction, although it is classed as very low in decay resistance. The wood is easy to work in all hand and machine operations and has little dulling effect on

cutting edges. A clean finish can generally be obtained if sharp tools are used, but knots are apt to give trouble,

When white spruce is seasoned, it is almost tasteless and odorless, making it especially well suited for food containers. It takes paint and varnish well and can be easily stained. The wood is readily sliced to a smooth silky finish, which is advantageous for the manufacture of veneers and plywood. It has a long slender, colorless fiber that is especially desirable in making pulp and paper.

### Pulping and Papermaking

White spruce is a common forest tree in interior Alaska. It is the only softwood of pulpwood quality in the interior forest areas (37) and is usually found with paper birch or in pure stands. White spruce is the foremost pulpwood in Canada and can be pulped by any process to produce pulps of good strength for a wide variety of papers,

Pulps from white spruce are of high quality and brightness. Groundwood pulp yields excellent bright-colored pulps for many uses.

When pulped by the sulfite process, the wood reduces readily; the pulp is strong and of fine texture, although occasionally it may be somewhat pitchy. It bleaches easily to white for use in high-grade printing paper.

White spruce is easily pulped by the kraft process to produce normal yields of pulp, which are strong and fine textured.

Various kinds of papers made from these pulps are listed in table 8.

### Seasoning

White spruce is generally easy to dry and can be air seasoned to some extent in the interior region where it grows. Kiln schedules are slightly milder than those for Sitka spruce. Kiln drying times vary from 60 hours to 6 days.

Stock containing spiral grain or compression wood is subject to twisting, crooking, and bowing. This wood also can be expected to cup more than Sitka spruce during drying because of the high degree of growth-ring curvature found in smaller trees.

### Principal Uses

Because of its resilience, white spruce is a favored wood for ladder stock, scaffolding planks, paddles and oars, and similar uses. It has good resonance properties, a desirable feature for sounding boards in musical instruments. Other uses include pulp, shop fittings, agricultural implements, kitchen cabinets, light and medium construction, food containers and boxes, cooperage, and shelving.

ALASKA-CEDAR (Chamaecyparis  
nootkatensis (D. Don. ) Spach)

Alaska-cedar is also known as yellow-cedar, Sitka cypress, yellow cypress, Nootka false-cypress, Alaska cypress, and Alaska yellow-cedar.

General Description

Alaska-cedar is a little-known softwood which is closely related botanically to southern white cedar and Port-Orford cedar. The heartwood is a bright clear yellow; the sapwood is noticeably lighter in color, particularly when green, and forms but a comparatively narrow band. The wood contains a natural volatile oil, which gives it a distinctive odor and seems to add a slight gloss to a newly cut smooth side-grain surface. It has a fine, even texture, and is relatively straight-grained. The virgin trees are of slow growth, as shown by the average of 23 rings per inch for the specimens tested from Alaska.

Distribution and Growth

Alaska-cedar grows in the Pacific coast region of North America from southeastern Alaska southward to a northern Oregon. It is widely distributed in southeastern Alaska and reaches the best development at elevations between 500 and 1,200 feet. It generally reaches a height of about

80 feet and a diameter of 2 to 3 feet. Trees 4 to 5 feet in diameter and 100 feet high are common. Trees 15 to 20 inches in diameter are generally 200 to 300 years old.

Alaska-cedar grows in southeastern Alaska in combination with western redcedar, in pure stands, and as scattered trees in the spruce-hemlock forests. The best trees are found in the spruce-hemlock forests, and are logged in connection with saw timber and piling operations. To obtain any considerable quantity, however, it is necessary to log the cedar stands which are usually in patches of one-half million feet or less. These patches are most frequently found on steep slopes some distance inland from tidewater so that the cost of logging is consequently high. While Alaska-cedar lumber is very resistant to decay, the overmature trees are inclined to be defective, many containing as much as 25 to 30 per cent rot at the center.

Properties

The wood of Alaska-cedar is moderately heavy in weight, moderately weak in bending and compression, moderately stiff, moderately hard, moderately high in shock resistance, and has a small shrinkage. On the basis of approximate classifications Alaska-cedar is estimated to rank as very easy to kiln dry, good in ability to stay in place, very easy to work, low in nail-holding ability, easy to glue, and very high in resistance to

decay, The heartwood of Alaska-cedar appears to have moderate capacity for resisting decay when serving in contact with the ground, but its decay resistance in above-ground situations is indicated to be high. Thus the heartwood might be expected to be less durable than that of western redcedar or redwood in ground contact, but comparable in length of service given above ground., Alaska-cedar is resistant to acids, is highly resistant to teredo attack in seawater, and only moderately resistant to termites or other insects,

Alaska-cedar and Port-Orford-cedar differ from western redcedar and most other species in that the springwood is firmer and consequently they have a much more uniform texture which makes them admirably adapted for such purposes as carving, veneers, high-class joinery, and where smooth wear is desirable. It works readily by hand and machine tools, has a very slight dulling effect on their cutting edges and usually finishes excellently. Where the grain is wavy, there is a slight tendency to pick up in planing and moulding.

Alaska-cedar is reputed locally not to hold paint well, particularly on boat hulls but experiments on dry samples at the Forest Products Laboratory have not shown any unusual difficulty. Like other species, it would not be expected to take' paint satisfactorily if not well dried, and it is possible that any difficulty encountered may be due to this cause.

The static and impact bending specimens of Alaska-cedar exhibited dur-

ing test an evidence of toughness not usually found in a softwood species of its density, Some of the 2- by 2- by 30-inch bending specimens when green deflected 6 inches without complete failure, the compression tending to distribute itself as in some of the hardwoods, rather than sharply localizing as is more characteristic of the softwoods, This indicates that Alaska-cedar may be adapted to uses where bending to form is required, and its properties are otherwise suitable, but additional tests would be necessary to determine whether or not this is a species characteristic, or merely of occasional occurrence. The behavior observed is contrary to reports that Alaska-cedar is inclined to be brash,

### Pulping and Papermaking

Alaska-cedar can be pulped, although this is not considered as one of its primary uses. It has good density and in this respect is like mountain hemlock, but it has shorter fibers. The pulping qualities of this cedar, however, would be expected to differ from those of western redcedar because of the shorter fibers and the much higher density, The distinctive sulfur-yellow color of the heartwood may have some effect on the bleachability of pulp made from Alaska-cedar,

### Seasoning

Alaska-cedar seasons readily, It air dries slowly in the coastal region, but

can be dried more rapidly in the inland areas during the summer, Kiln drying schedules given in table 11 for 4/4 and 8/4 upper grade stock have starting temperatures of 160° and 150° F., respectively. The Canadian Laboratories recommend for 4/4 and 5/4 stock a schedule starting at 170° F. with a 7° F. wet-bulb depression. For wide 2-inch material, Canada recommends a milder schedule starting at 130° F. with a 2° F. wet-bulb depression. Estimated drying time in a modern forced-air circulation kiln varies from about 72 hours for 4/4 stock to 168 for 8/4.

Alaska-cedar may develop some longitudinal shrinkage because of streaks of compression wood. High temperature schedules and an intensive conditioning treatment would be somewhat helpful in relieving the resultant longitudinal stresses when the material that contains compression wood is dried. Such stresses usually are not fully relieved, however, and Alaska-cedar with pronounced compression wood streaks should not be ripped into long narrow cuttings. This wood also may be subject to pitch exudation in use unless the pitch is set by kiln drying with a final temperature of 160° F. or higher.

#### Principal Uses

Its very low shrinkage factor, combined with its high durability in situations favoring decay, makes Alaska-cedar valuable for window frames and exterior doors, the better class of

boat construction, and other similar uses. It is used also for poles, piles, interior finishing in houses, cabinet work, patterns, and furniture,

#### WESTERN REDCEDAR

(Thuja plicata Donn)

Western redcedar is also known as canoe cedar, arborvitae, shingle-wood, giant-cedar, Pacific redcedar, and giant arborvitae.

#### General Description

Western redcedar is a moderately slow-growing, long-lived tree that is closely related to the well-known northern white-cedar (Thuja occidentalis L.). The heartwood is a reddish brown; the narrow sapwood is white. The reddish color of the heartwood is thought to be due partly to certain extractives, which appear to be responsible for the high resistance of the wood to decay. The wood has a distinctive odor characteristic of the cedars. The narrow summerwood bands are distinctly darker and harder than the adjacent springwood. The wood has a fine, moderately even texture.

#### Distribution and Growth

Western redcedar grows principally in a belt along the western coast of North America, extending from the

southern half of southeastern Alaska to northern California, In Alaska it reaches its best development below an elevation of 500 feet.

Western redcedar has a characteristic buttressed base, tapering trunk, and conical crown; it sometimes grows in small pure stands but generally in mixture with other species, by which it is frequently overtopped. The tree is capable of enduring shade but under such conditions the rate of growth is reduced. Large trees in southeastern Alaska are from 100 to 130 feet high and 3 to 6 feet in diameter. The mature trees are limby, heavily tapered, and are subject to severe heart rot, but trees of pole size are well formed and sound. In Alaska, the best trees are those occurring as scattered individuals or in small groups in stands of hemlock and spruce. The trees of the pure cedar type of forest average somewhat poorer in quality but are sufficiently good to be classed as merchantable. The open stands of cedar and other species found so commonly on the swamp soils are uniformly poor in quality and are not considered merchantable, the trees being short, limby, and defective.

### Properties

The wood of western redcedar is light in weight, weak in bending and compression, moderately limber, moderately soft, low in shock resistance, and has a very small shrinkage. It is straight grained and splits readily and uniformly. On a basis of approx-

imate classification, western redcedar is estimated to rank as moderate in ease of kiln drying, good in ability to stay in place, very easy to work, very low in nail-holding ability, moderate in ease of gluing, and takes stains and paints satisfactorily. It is very high in decay resistance when used in contact with the soil or in other situations favoring decay. In decay resistance, the heartwood ranks with that of redwood and old-growth baldcypress. In resistance to insect attack, the seasoned timber is not immune from damage by furniture beetles. The wood is resistant to but not immune from termite attack.

The wood of western redcedar works easily in all hand and machine operations and has little dulling effect on tools. A good finish is generally obtainable, provided that sharp cutters are used. It is somewhat brittle and may splinter to a certain extent when worked on end grain, as in mortising, and end moulding. In planing and moulding, particularly of fast-grown material, dulled or thickened cutters tend to compress the soft springwood, which later expands and produces ridged surfaces. Western redcedar belongs to the class of timbers that is subject to chip-bruising under certain machining conditions. This difficulty can generally be overcome by improving the efficiency of the waste-removal system and by having the cutters free of all wire-edge.

The wood has acidic properties and tends to accelerate the corrosion of metals in contact with it. In contact with unprotected iron, the wood de-

velops a black stain and the iron corrodes. Suitable precautions should be taken, either by applying protective coatings to the metals in contact with the wood, or by selecting metals that are relatively resistant to corrosion.

### Pulping and Papermaking

Western redcedar, a minor softwood species, is usually scattered in groups in the hemlock-spruce coastal forests. It has stringy bark that causes removal problems. Compared to western hemlock and Sitka spruce, it has low density, average fiber length, and high water extractives (table 7). The lignin content, 29 to 32 percent, is high compared to 26 to 30 percent found in most softwoods. These wood properties adversely affect pulp yield and color. The high extractives may cause corrosion problems (44), so the pulp is usually cooked with other woods to prevent corrosion from becoming a problem,

Western redcedar is pulped mainly by the kraft process, since it is not only difficult to reduce by the sulfite process, but it also results in dark-colored shivey pulps that are difficult to bleach. Kraft pulps develop the highest bursting strength of the Pacific coast species (10).

The exceptional uniformity in overall fiber size of this cedar and the fineness of its fibers result in good sheet formation where the pulp is used in paper machine furnishes for printing and other high-grade papers (table 8).

It generally contributes to good fiber bonding, close structure, smoothness, and opacity of papers. For those requiring exceptional smoothness, large amounts of cedar should be considered (27).

Western redcedar is not suitable for the generally acceptable grades of groundwood pulp because of its poor color,

### Seasoning

The seasoning properties of western redcedar vary with its initial moisture content and weight. Light wood of low moisture content (below 90 percent) dries easily with little defect hazard. Very heavy, high-moisture content sinker stock from the butts of large trees is slow to dry, and subject to collapse and honeycombing. Such wood probably should be air dried to 50 percent moisture content or less before being kiln dried. Moderately heavy material, which may contain small streaks of very wet wood, can be kiln dried from the green condition using moderate kiln schedules. Air drying is generally slow in the coastal region, but when it is practiced, the very best drying site should be used,

Recommended kiln drying schedules for upper grade light stock start at 140° F. with 5° to 10° F. wet-bulb depressions. Lower grade, knotty stock uses a larger initial wet-bulb depression and finishes with a lower final dry-bulb temperature. Recommended kiln schedules for somewhat heavier stock start at 120° F. with

5° to 7° F. wet-bulb depressions.

## General Description

The Canadian Laboratories recommend higher starting temperatures and considerably larger wet-bulb depressions for lightweight western redcedar. Commercial time schedules used in Washington and Oregon have large depressions at the moderate temperatures of the recommended schedules.

Kiln drying time can vary from 50 hours for light 4/4 stock to 22 days for heavy 5/4 siding stock.

## Principal Uses

Because it retains its size and shape exceptionally well after being properly seasoned, western redcedar is much favored in canoe and boat construction. Its durability has made it the most widely used wood in America as shingles for roofing. It is also used for telegraph and telephone poles, fence posts, light construction, pulp, clothes closets and chests, and conduits.

Lodgepole pine, Alaska's only pine, is a low, scrubby tree with a trunk that becomes gnarled with age. Because of its size, it does not produce much high-grade lumber, but it yields a good grade of small, tight-knotted stock, somewhat similar in quality to that of Engelmann spruce or jack pine. The heartwood of lodgepole pine varies in color from a light yellow to a yellow brown. The narrow sapwood is nearly white. The wood is generally straight grained with narrow growth rings in which the darker bands of summerwood are distinct.

Lodgepole pine contains resin ducts which may be fairly numerous, but are not distinctly visible without a lens. These ducts are often indicated by exudations of resin. On the surface under the bark or on split tangential surfaces numerous slight indentations may be seen which give the surface a dimpled appearance.

## Distribution and Growth

### LOGEPOLE PINE (Pinus contorta Dougl.)

Lodgepole pine is also called black pine, scrub pine, shore pine, coast pine, and tamarack pine.

Lodgepole pine extends through the Rocky Mountain and Pacific Coast regions from Alberta to Yukon, and south through southeastern Alaska, British Columbia, and western United States. The tree varies considerably in size in different districts. The dwarfed coastal type, ranging from 6 to 20 inches in diameter and 20 to

40 feet in height, is common in open muskegs of peat moss and on benches near lakes. The tree is able to survive for long periods where it is crowded or shaded, then recover and make increased growth if conditions are improved.

Lodgepole pine is susceptible to severe insect attack and to damage from fungi and mistletoe. Trees killed by fires or insects generally decay very slowly as long as they remain standing but often check so badly that merchantable lumber cannot be sawed from them. Dead trees may remain standing for 20 or 30 years.

### Properties

In strength properties, lodgepole pine rates as weak in bending and compression, moderately stiff, moderately soft, and moderately low in shock resistance. It is not considered durable when used under conditions favorable to decay, but can be satisfactorily treated with a preservative by proper methods, although the heartwood is difficult to penetrate. In ability to hold paint, the wood ranks below the white pines but above southern pine and Douglas-fir. Small sound knots are characteristic of the lumber.

Lodgepole pine is moderately light in weight and fairly easy to work with machine and hand tools, but resin exudation may sometimes be trouble-

some. Clear material has little dulling effect and that caused by the knots is not unduly severe, as they are usually sound. It finishes cleanly, takes nails satisfactorily, and can be readily glued. Lodgepole seasons easily and uniformly and has moderately large shrinkage compared with the majority of softwoods.

### Pulping and Papermaking

Tests on lodgepole pine (24) grown in the Rocky Mountain regions indicate that it has excellent papermaking properties. Wood from these regions contains comparatively little pitch and can be pulped readily by the sulfite or sulfate processes. Sulfite pulp is easily bleached, strong, and of excellent color, suitable for the manufacture of such papers as newsprint, book, and high-grade printing (table 8). The sulfate pulp is strong and especially suitable for wrapping and bag papers and container boards.

The wood with comparatively little pitch can also be ground readily by the mechanical process to yield a pulp of satisfactory color and strength, but the power required is about 20 percent more than for white spruce—a wood long used for groundwood pulp. When pulped by the sulfate process, which can be applied satisfactorily to woods containing considerable pitch, lodgepole pine produces a very strong, dark-colored pulp suitable for making high-grade kraft wrapping papers and fiberboard.

## Seasoning

Straight-grained lodgepole pine from the interior areas should season very readily during the active drying periods. Material from scrubby trees along the coast and from interior trees containing much spiral grain would not be expected to dry straight. With such a species as lodgepole, complete seasoning before use is essential to eliminate pieces that are likely to warp excessively.

The kiln drying schedules for lodgepole pine start at 140° F. for upper grade stock, and at 120° F. for low grade material. The wood has small knots and a high luster, so that it makes an excellent paneling. Some manufacturers of 1-inch paneling use a maximum dry-bulb temperature of 145° F. to prevent the resin around the knots from flowing out and turning dark on the surface. Kiln drying time for 1-inch stock varies from 3 to 5 days. The time for thicker stock would be somewhat longer, depending upon the width and degree of dryness required.

## Principal Uses

Lodgepole pine is used principally for lumber, railroad ties, mine timbers, and poles. Less important uses include pulpwood, posts, and fuelwood. The ties and poles are nearly always treated with a preservative to increase their life. The lumber is used mostly for local rough construction and occasionally for boxes. It is also

used in increasing amounts for siding, finish, and flooring, especially where the lumber of other species is not readily available,

## PAPER BIRCH (Betula papyrifera Marsh. and varieties)

Paper birch is also known as Alaska paper birch, Alaska birch, white birch, canoe birch, Alaska white birch, silver birch, Kenai paper birch, black birch, and red birch,

## General Description

Paper birch is one of the few hardwood species found in Alaska, and has the densest wood of the Alaska tree species. The heartwood is light reddish brown; the moderately wide sapwood is practically white. The wood has a fine even texture, and finishes well. The trees are of relatively slow growth; the material from 10 trees of one site near Whitney averaged 29 rings per inch. The birch trees of Alaska have a distinctive, smooth, thin, creamy white, slightly red, or brown bark that peels off in papery strips.

## Distribution and Growth

The general range of paper birch is widespread across North America from western Alaska east to Labrador and Newfoundland. Western paper birch (Betula papyrifera, var. com-

mutata) is found along the mainland coastal river drainages and lakes in the northern part of southeast Alaska and is separated from other Alaska tree birches that grow in the interior (37). Alaska paper birch (B. papyrifera, var. humilis) occurs mainly in the interior forests and south to the Pacific coast. Kenai birch (B. papyrifera, var. kenaica) grows in the interior and southern Alaska, except in the southeast portion.

The most extensive birch forests in Alaska are those of the upper Cook Inlet region. The paper birch-white spruce type is the typical forest of this region. It occupies the rolling benchland above the bottoms and extends up the lower slopes of the foothills to an elevation of about 800 feet. Here the paper birch is associated with white spruce and aspen. Trees 80 to 100 years old on the more favorable sites attain a height of 60 to 70 feet and a diameter of 12 to 14 inches, although the average diameter breast high is from 8 to 10 inches. Occasionally a diameter of 24 inches is reached (fig. 10).

In trees over 8 inches diameter breast high, the heartwood for varying distances from the pith is commonly stained, and frequently advanced stages of decay are present.

### Properties

The wood of paper birch is moderately heavy, moderately strong in bending and compression, stiff, moderately



M 122 736

Figure 10.- Paper birch is a predominant species in interior forests.

hard, high in shock resistance, and has a very large shrinkage. Observations on the material tested for strength indicate that paper birch may be ranked as moderate in ease of kiln drying, good in ability to stay in place, high in nail-holding ability, difficult to glue, and low in resistance to decay. Like the other species of birch, it is diffuse-porous in structure. It has a fine, even texture, and takes finishes and stains satisfactorily. The wood works easily and the uniformity of grain is a distinct advantage in the manufacture of veneers and plywoods.

### Pulping and Papermaking

Paper birch and its varieties growing in Alaska forests have suitable char-

acteristics for pulping and paper-making. Paper birch has short fibers, typical of hardwoods, and good density (table 6) thus producing more pulp per cord of wood than spruce. It can be pulped by any process and various types of papers can be made from it (table 8). It reduces easily in sulfite pulping and produces normal yields of pulp of rather poor color but which are easily bleached. The strength is considered almost equal to that of hemlock sulfite pulp and about 75 percent as strong in burst and 90 percent in tear as spruce sulfite (35). The use of green wood may cause papermaking troubles because of excessive wax, but this difficulty is usually eliminated by using seasoned wood (17).

When pulped by the kraft process, the wood reduces readily, producing pulps of high yield and with strength about 75 percent of that from spruce (17). It seems to have the best overall strength properties in the hardwood group.

Paper birch, when pulped by the soda process, reduces with some difficulty. The yield is normal and the pulp is fairly easy to bleach (17),

Neutral sulfite semichemical pulp from birch is particularly bright and strong. It has use as a partial substitute for chemical pulps in a number of papers, including newsprint and other groundwood-sulfite papers. Newsprint paper has been successfully made at the Forest Products Laboratory using 20 to 60 percent birch neutral sulfite semichemical pulp to-

gether with varying amounts of spruce and birch groundwoods. This pulp may also be used in corrugating and coarse wrapping paper furnishes (35), and it has been found to produce lithographic paper of good quality.

Groundwood pulp from paper birch is short fibered and lacks the strength of spruce, but even so, it can be used as filler stock in the manufacture of book and newsprint papers. It is absorbent, a quality required in paper toweling, and light colored, showing a tinge of pink (17).

Chemigroundwood pulp from birch is moderately low in strength and is usually used in mixtures with softwood groundwood and sulfite pulps for newsprint paper.

Pulped by the cold soda process, birch is comparatively low in strength, but has its use in mixtures for furnishes for boxboards and book and newsprint papers.

Paper birch is used in mixtures with other hardwoods for pulping, but mixtures may require longer cooking times. Birch and spruce may be cooked together in sulfite cooking.

### Seasoning

The varieties of paper birch growing in Alaska all should be relatively easy to air dry or kiln dry. Air drying of 1-inch material to 25 percent moisture content or less should be accomplished in one summer season. Rec-

ommended kiln drying schedules begin with dry-bulb temperatures of 130° to 140° F. and wet-bulb depressions of 5° to 7° F. Somewhat more severe wet-bulb depressions can be used when drying squares. Kiln drying times in modern forced circulation kilns vary from 3 to 10 days, depending on thickness.

In material cut from small trees or from near the pith of larger trees, some cupping may be expected, and longitudinal warp may result from tension wood in some trees. End checking is somewhat of a problem and thick lumber or large squares probably should be end coated. Birch shows a tendency to brown slightly when dried at high temperatures, and manufacturers of spools and some other products prefer the whitest stock produced by air drying prior to kiln drying or low temperature kiln drying.

#### Principal Uses

Near cities of Interior Alaska, paper birch has been an important source of fuel. The wood has been used locally for mine props also. It is satisfactory for pulp, furniture, cabinetmaking, veneer and plywood, handles, boxes and crates, clothes pins, spools, and bobbins. Paper birch is also used for turned and carved articles, tooth-picks, and toys. The bark was used by northern Indians for canoes and various small articles.

## BLACK COTTONWOOD (Populus trichocarpa Torr. & Gray)

Black cottonwood is also known as California poplar, cottonwood, balsam cottonwood, and western balsam poplar.

#### General Description

Black cottonwood is a lightweight hardwood (broadleaved) species of the Pacific Northwest, which is closely related to the aspens and poplars. The wood is grayish white to light brown. It is diffuse porous, and has a fine, even texture. It is generally straight grained, although cross grain is not uncommon. The annual rings are scarcely noticeable. The sapwood is wide and not clearly defined, but merges gradually into the heartwood. It has a characteristic sour odor when moist but is odorless when seasoned. Black cottonwood is a tree of normally rapid growth, but in maturity and overmaturity the rate of growth is much slower.

#### Distribution and Growth

Black cottonwood occurs from southern Alaska to California and extends inland into western Montana. It grows best at lower levels on river bottoms and sandbars. In Alaska it occurs in quantity only on the valley floors of a few large mainland streams, principally the Chilkat, Stikine, and Taku



M 122 747

Figure 11.--Black cottonwood stand averaging 90 feet in height and 33 inches in diameter.

rivers. It is the largest broadleaf tree in Alaska, reaching 125 feet in height and 3 to 5 feet in diameter (fig. 11). Though black-heart and black knots are common in mature trees, extensive areas of immature trees of excellent quality are found.

### Properties

Black cottonwood is light in weight, weak in bending and compression, moderately limber, soft, moderately low in shockresistance, and has a moderately large shrinkage. It is estimated to rank as moderate in ease of kiln drying, poor in ability to stay in place, easy to glue, and very low in resistance to decay. Cottonwood is rather difficult to work with tools without producing chipped or fuzzy grain. It is low in nail-holding ability, but does not split easily in nailing. The wood has a good reputation for holding paint, although care must be

taken in selecting a suitable priming paint.

### Pulping and Papermaking

The fiber length of black cottonwood is good for hardwoods, and the density, about 20 pounds per cubic foot, is slightly lower than for aspen (P. tremuloides), which is 23 pounds per cubic foot.

Blackcottonwood reduces fairly readily when processed mechanically. The groundwood pulp has excellent color with strength about equal to that of groundwood from western hemlock (25).

This species pulps easily by the sulfite process, producing a high yield of low strength pulp (17). It reduces readily by the soda process too.

When pulped by the kraft process, black cottonwood produces comparatively high yields of pulp with adequate strength. In a recent study (10), black cottonwood bleached kraft pulp was used successfully in furnishes for high-quality printing papers. Furnishes for mimeograph papers contained 55 percent of the pulp, and for offset book papers, 40 percent. Western hemlock or western redcedar bleached kraft pulps were used with the cottonwood in some of these furnishes.

Black cottonwood would be expected to pulp satisfactorily by the neutral sulfite semichemical and by chemi-

mechanical processes, such as cold soda and chemigroundwood.

The various kinds of papers made from these pulps are listed in table 80

### Seasoning

Cottonwood, aspen, and balsam poplar are relatively easy to dry and require about the same drying conditions. Recommendations are given for cottonwood, and the manufacturer can use somewhat more severe conditions for aspen as his experience develops. One-inch lumber of all species should air dry to 25 percent moisture content or less in one summer season in interior locations. Kiln drying schedules start at 130° to 140° F. dry-bulb temperature with 7° to 10° F. wet-bulb depressions.

Aspen or cottonwood that contains wet streaks near the sapwood-heartwood line is subject to collapse and should be air dried to 25 percent moisture content or less before kiln drying if the wood is to be used for an exacting purpose, such as core stock. The water pockets may end up as wet spots in the finished lumber if the final drying is not continued long enough.

Cottonwood that contains interlocked grain or tension wood shows a tendency to crook or bow upon ripping or resawing, and it may warp excessively during kiln drying. Close sticker spacing is desirable for such stock, and it may be necessary to air dry the wood before kiln drying if the warping is severe.

### Principal Uses

Cottonwood is used largely for lumber, veneer, pulpwood, excelsior, and fuel. The lumber and veneer go mostly into boxes and crates. The light weight of the wood and its ability to take nails without splitting, combined with a good color for stenciling, and lack of odor, make it suitable for a wide variety of containers. In Alaska, the small supply of black cottonwood provides a possible source of pulpwood for the manufacture of paper.

### BALSAM POPLAR (Populus balsamifera L.)

Balsam poplar is also known as tacamahac poplar, cottonwood, hackmatack, and tacamahac.

### General Description

Balsam poplar is a hardwood species of light weight, which is closely related botanically to the aspens and cottonwoods. It should not be confused with yellow-poplar (Liriodendron tulipifera L.), to which it bears no botanical relation.

The heartwood of balsam poplar is a light brown; the moderately thick sapwood nearly white. The wood is diffuse porous, and consequently has a fine, even texture. The tree is normally of rapid growth; the trees col-

lected for test from Girdwood, Alaska, averaged 14 rings per inch.

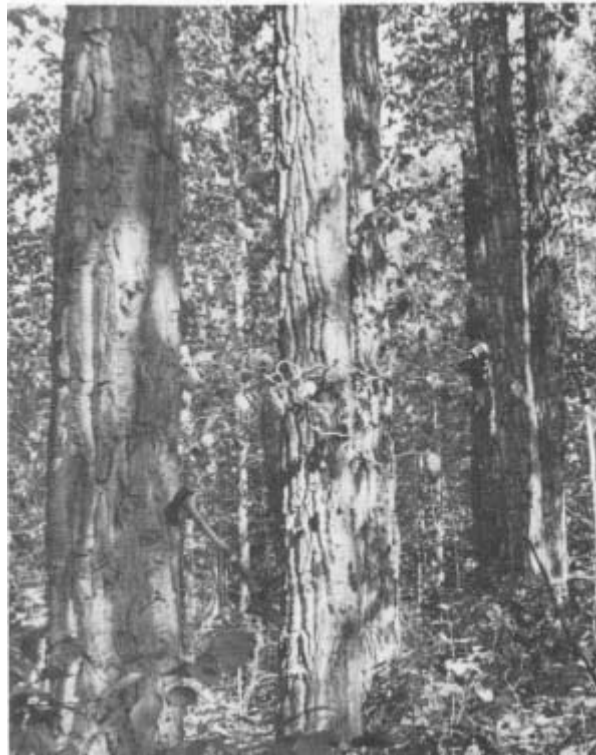
When cut into lumber, balsam poplar is frequently sold in mixture with aspen and cottonwood under the name "cottonwood." When cut for pulpwood, it is commonly included with aspen and both are classed as "popular."

### Distribution and Growth

Balsam poplar grows principally in Alaska and Canada. Its range extends from Alaska to Hudson Bay and Newfoundland and southward to the northern United States along the Canadian border from Maine to Oregon. It is distinctly a northern tree and parts of its range are characterized by a short growing season and long severe winters; conditions too severe for the existence of most other trees. It is confined mainly to alluvial bottomlands and to the borders of streams and swamps in moist, sandy, and gravelly soils. Seeds are abundant and are scattered widely by the wind. The trees secured for test from Girdwood averaged 88 feet in height and ranged from 78 to 98 feet. They averaged 23 inches in diameter and 162 years of age (fig. 12).

### Properties

The wood of balsam poplar is light in weight, exceedingly weak in bending and compression, limber, soft, low in shock resistance, and has a moder-



M 122 748  
Figure 12.--Mature stand of balsam poplar ranging from 170 to 235 years of age.

ately small shrinkage. It is considered to rank as moderate in ease of kiln drying, poor in ability to stay in place, easy to work, easy to glue, and very low in resistance to decay. The wood shows little tendency to split in nailing, but is very low in nail-holding ability. Balsam poplar is reported to require considerable care in seasoning to overcome a tendency to twist and warp. The wood has excellent pulping qualities and is well suited for papermaking, both by the sulfite and soda processes.

### Pulping and Papermaking

Balsam poplar, along with quaking

aspen, is found in small numbers mainly in the interior forests. Balsam poplar has slightly shorter fibers than the aspen. The lower density of balsam poplar results in slightly lower yields of sulfite and kraft pulps than those made from aspen (table 6), but the yields of soda pulp are about the same.

Balsam poplar reduces with exceptional ease by the sulfite process, and the pulps are of excellent color, and they bleach very easily for use in printing papers. The woodpulp satisfies by the neutral sulfite semi-chemical process, and would be expected to be suitable for chemimechanical pulping.

This species is also easily made into groundwood pulp, but the pulp does not respond to bleaching as easily as does that from aspens. The various kinds of papers made from these pulps are listed in table 8.

### Seasoning

Balsam poplar can be seasoned in accordance with the recommendations given for cottonwood.

### Principal Uses

Balsam poplar is used principally for box and crate lumber and for pulpwood in the manufacture of paper. Some of the high-grade logs are cut into veneer from which various kinds of fruit baskets are made. A small amount of

balsam poplar is also used for making excelsior.

## QUAKING ASPEN (Populus tremuloides Michx.)

Quaking aspen is also known as quaking asp, aspen, golden aspen, mountain aspen, trembling aspen, Vancouver aspen, poplar, trembling poplar, popple, and alamo blanco.

### General Description

Quaking aspen is a small tree with a conspicuous whitish, smooth bark, straight trunk, and leaves with such long, slender leaf stalks that the least wind causes the foliage to turn and tremble. The heartwood of the aspens is grayish white to light grayish brown. The slightly lighter colored sapwood varies in thickness and generally merges gradually into the heartwood without being conspicuous. The wood is generally straight grained, and the texture is fine and uniform. Aspen has a characteristic disagreeable odor when moist. This odor disappears in seasoned material which does not impart odor or flavor to foodstuffs.

### Distribution and Growth

Quaking aspen is the most widely distributed species in North America, ranging in the West from the northern

limit of trees in northwestern Alaska and the Yukon south to the northern end of southeastern Alaska British Columbia; southern high mountains of western United States from Washington to southern California, Arizona, and New Mexico.

A small tree, quaking aspen averages 8 to 12 inches in diameter and 50 to 60 feet in height, but occasionally attains a diameter of 24 inches and a height of 90 feet. The trees are fast growing but short lived, 60 to 80 years, and highly susceptible to decay. They must have sunlight to live and are often suppressed and killed by slower-growing but longer-lived species. The tree reproduces both by seed and by root sprouts. It usually occurs as a temporary type following a fire, and is often associated with white birch and white spruce in Alaska (fig. 13).

Figure 13.--Quaking aspen is one of the more abundant species found in the interior forests.

M 122 740



## Properties

The wood of quaking aspen is light in weight, weak, soft, moderately limber, moderately low in resistance to shock, and has a moderately large shrinkage. It has the reputation of being somewhat difficult to season without warping, but can be dried successfully by modern methods. The wood can be easily glued with a variety of glues and under a wide range of gluing conditions. Aspen ranks low in nail-holding ability but has little tendency to split in nailing. When seasoned properly, it works well with both hand and machine tools and has only a slight dulling effect on their cutting edges. It finishes cleanly in most operations, but sharp, thin-edged tools are required. A tendency for woolly surfaces to be produced in planing and for the wood to crumble in end-grain cutting was observed with aspen when dulled cutters were used. The wood takes paints satisfactorily, providing care is taken in selecting a suitable priming paint.

### Pulping and Papermaking.

Quaking aspen is quite versatile in the kinds of pulp it will produce, since it can be pulped by six different methods (table 8).

In sulfite pulping, aspen reduces readily, the pulp has high yield, hydrates rapidly, and has excellent color, except for small black specks that disappear on bleaching. The pulp is easily bleached, resulting in strength

of about 50 percent that of spruce pulps. The opacity or bulk characteristics are lower than those of aspen soda pulp. It is used in small amounts for newsprint, various printing papers, and tissues (17).

The soda pulp from aspen is weak, bleaches easily, and imparts opacity, bulk, softness, and absorbency when used in papers. It is principally used with bleached sulfite pulp in book paper furnishes, and some is used for facial tissues.

In kraft pulping, the wood reduces readily, produces good yields of pulp, hydrates easily, and is about 65 percent as strong as kraft pulp of spruce,

Aspen neutral sulfite semichemical pulps are bright and strong. Corrugating board medium has good resistance to crush, and the pulp is used extensively for container boards. A bleached grade is used in book papers and food boards, and should be suitable for glassine. The pulp is readily bleached by chlorine or sodium peroxide.

Cold soda pulps, which are relatively strong and possess comparatively high resistance to crush, are suitable for use in furnishes for corrugating medium. When bleached, the pulp loses some of its original opacity (6), but has possible use as part of the furnish for newsprint and lower-grade book papers.

Aspen reduces readily in groundwood pulping; the strength is somewhat lower than that of spruce groundwood pulp. It has good color and bleaches readily for use in book papers and

tissues. The unbleached pulp can be used in newsprint paper because of its bright color and for heavy structural boards. Aspen can be included in hardwood mixtures and with certain softwoods for pulping.

### Seasoning

Aspen can be seasoned in accordance with the recommendations given for cottonwood. As his experience develops, the manufacturer can use somewhat more severe kiln conditions for aspen.

### Principal Uses

Aspen is used principally for pulpwood, lumber, excelsior, and matches. The wood is generally pulped by the soda process and the pulp used in the manufacture of book and magazine paper. The lumber goes principally into boxes and crates, including small boxes for shipping foods, for which the light color and light weight of aspen and its freedom from taste and odor make it a very satisfactory wood. For the manufacture of high-grade excelsior, aspen has long been one of the preferred woods on account of its light weight and color and the toughness and resilience of the thin strands. Aspen logs in limited quantities are cut into veneer by the rotary process and used in the manufacture of matches. In Canada, a considerable amount of aspen is cut for lumber, especially in localities where other species are not plentiful.

# MECHANICAL PROPERTIES

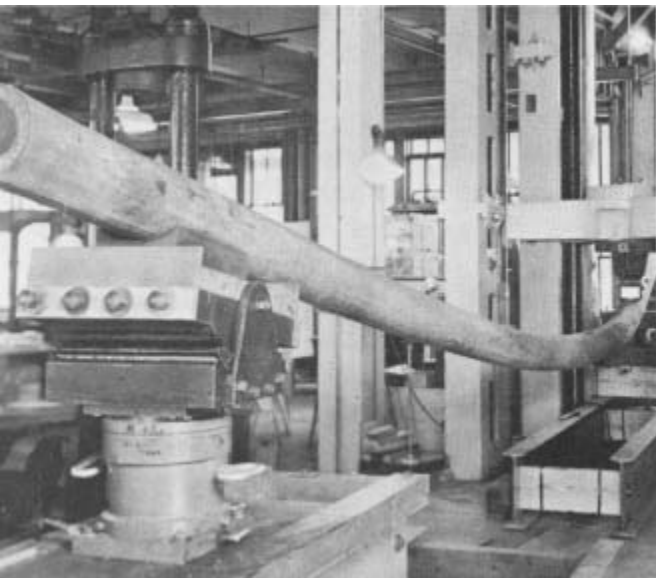
## Nature of Studies

A study was made by the Forest Service on the mechanical properties of Alaska woods that included standard tests on small, clear specimens of eight species, comprising paper birch, Alaska-cedar, western red-cedar, mountain hemlock, western hemlock, balsam poplar, Sitka spruce, and white spruce.

In considering the mechanical properties of woods grown in Alaska in connection with utilization requirements, two questions that arise are (1) What are the strength properties of the species found in Alaska? and (2) How do the properties of Alaska-grown timber compare with those of the same and other species grown elsewhere?

Figure 14.--Full-sized lodgepole pine pole under load at Forest Products Laboratory.

M 105 113



The results of the strength studies together with other data available furnish a basis for obtaining definite answers to these pertinent questions (fig. 14).

## Standard Tests of Small,

### Clear Specimens

## Selection of Material

The material used for determining the average properties of a wood from any one locality consisted of logs 5 feet or 9 feet in length taken from each of five or more representative trees, the upper part of the section usually being 16 feet above the stump. The Alaska species for test in the form of small, clear specimens were obtained from eight locations all of which were less than 400 feet above sea level.

The material collected in the Chugach National Forest near the Alaska railroad was transported by train to Seward, Alaska, and then by steamship to Seattle, Wash. The logs from the Tongass National Forest were rafted to Ketchikan, Alaska, for boat shipment to Seattle. The tests were made at the Forest Products Laboratory, Madison, Wis.

## Character of Tests

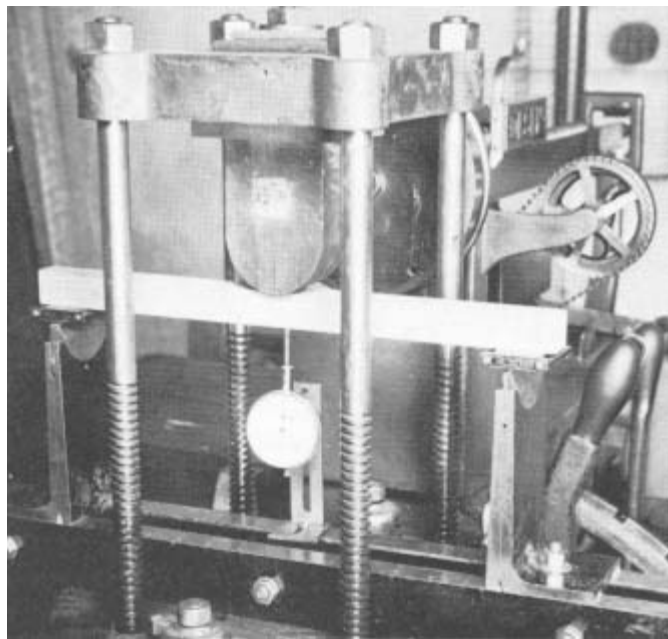
The standard tests, such as were made on small, clear specimens of

Alaska woods as well as for similar studies of other species, serve as a basis for comparing and substituting species, promoting the use of unknown and little-used woods, aiding in the determination of safe working stresses for design, determining the influence on strength of such factors as locality of growth, position in tree, rate of growth, and seasoning, grouping of species into utility classes for individual uses, such as boxes and ladders, developing specific gravity-strength laws, comparing virgin-growth and second-growth timber, determining the effect of growth conditions on properties, and studying the variability of wood.

The tests were made in accordance with Specification D-143 of the American Society for Testing and Materials. The tests included both green and air-dried material. The air seasoning was accomplished by open piling the stock in a covered shed, open at the sides to permit circulation. The specimens were 2 by 2 inches in cross section, except the specimens used for radial and tangential shrinkage, which were based on width measurements of pieces 1 inch thick, 4 inches wide, and 1 inch along the grain. Bending specimens were 30 inches long; others were shorter, depending on the kind of test (fig. 15). The results obtained on Alaska woods are consequently directly comparable with those of tests reported in Wood Handbook (41).

#### Explanation of Tables 2, 3, and 4

Table 2 presents the average test results of the Alaska woods for each lo-



M 542 85

Figure 15.--Small, clear specimen undergoing standard static bending test.

cality from which specimens were obtained. In a few cases this permits comparing material from two sections of Alaska. Table 3 presents similar data on some of the same species grown in other parts of the United States, and thus, in conjunction with table 2, affords a basis for comparing the strength of Alaska-grown wood with that of the same species from other regions.

Table 4 presents the average results of all comparable tests made by the Forest Products Laboratory on woods that grow in Alaska, and in addition, other data on well-known species. Previous studies by the Laboratory have shown that the average results for material from all localities tested is a better criterion of the properties of material from any untested site than are the results of tests from

seemingly similar sites, as appraised by the usually recorded characteristics, Table 4 represents the best estimate of the true average for each of the species, and accordingly affords the best basis for comparing the various species.

The first line of figures for each species in tables 2, 3, and 4 are the results of tests on green material; those in the second line are from tests of seasoned material adjusted to an average air-dry condition of 12 percent moisture.

### Precautions to be Observed in the Use of Data

The test results obtained in studying the properties of clear wood are dependent on the size and form of test specimens, the rate of loading, and other factors entering into methods of testing, and in seasoned material on the moisture content. Care should accordingly be used in attempting to compare the data with that from other sources in which a different test procedure has been used.

The data in tables 2, 3, and 4 are primarily for the comparison of species in the form of clear lumber.

### Variation in Strength of Wood

Variability is a characteristic of all materials, although there may be wide differences in its magnitude. The

living tree is subjected to numerous influences that have a bearing on the wood produced, and it is not surprising as a result that even the clear wood is often regarded as a variable product. The influences acting on the tree include the amount of sunlight, type of soil, temperature, rainfall, heredity, and the like. Fortunately, the variations in the properties of wood usually bear a relation to the specific gravity or density, and in some cases to physical characteristics, such as proportion of summerwood or rate of growth, so that in cases of importance, selection methods can be used to secure wood of desired properties to meet any given requirements. Accordingly, the variability which is usually thought of as a liability may actually become an asset, particularly inasmuch as a range in properties permits adaptation to a range of uses.

### Basic Stresses

Basic stresses recommended by the American Society for Testing and Materials for clear lumber of the more common domestic structural species are presented in table 5 (1). These are applicable to long-time loadings and since factors of safety are included in their derivation, they require only application of the grade strength ratio to become working stresses for design,

The strength ratio of a grade represents the remaining strength after making allowance for the maximum effect of the permitted knots, cross grain, shakes, and the like on a green

piece. Thus, a strength ratio of 75 percent applies to a grade in which the maximum reduction in strength from that of green, clear wood is 25 percent.

Working stresses for any grade of structural lumber are found by multiplying the strength ratio by the basic stress. Basic stress is a generalized working strength value for the clear wood of a species. It contains all of the factors appropriate to the nature of structural lumber and the conditions under which it is used, except for those characteristics which are accounted for in the strength ratio.

#### General Discussion and Deductions

The sampling and testing of Alaska woods has not been extensive enough to afford as complete an appraisal of the properties and range of properties as might be desired, because appreciable differences in properties may occur even in adjacent localities. In planning the study, however, it was necessary to keep the work within certain definite limitations, similar to those used in the general study of the properties of woods grown in other parts of the United States. It is felt that properly interpreted, the results are a valuable means of appraising the properties and establishing design values.

Tables 2 and 3 show a fairly close agreement in strength values obtained for certain species in Alaska with those for lots of the same species from other regions. Considering the

aggregate of six of the most important strength properties, this similarity is evident in the western hemlock from Cordova, Alaska, compared with that from Washington and that from Oregon; in balsam poplar from Girdwood, Alaska, compared with the shipment from Bennington County, Vt.; and in Sitka spruce from Girdwood and Ketchikan, Alaska, compared with the two shipments from Oregon.

Of the various species tested, only western redcedar shows a difference as great as 10 percent in average properties in favor of any shipment from other parts of the United States. In this case the material from Snohomish County, Wash., was about 10 percent higher in the average of several properties than that from Ketchikan, Alaska. At the same time the Alaska western redcedar averaged higher by about 7 percent than did that from Missoula County, Mont. These differences may be due to change in sampling, or at most, can be regarded as applicable to the particular and immediate sites from which the samples were taken. They should not necessarily be interpreted, however, as representing the relative strengths of this species in these respective general geographic regions.

On the other hand, in six cases the averages of the Alaska material, by localities, are 10 percent or more higher in the principal strength properties than certain individual shipments from other regions of the United States. These cases are found in Alaska-cedar, mountain hemlock, western hemlock, and Sitka spruce.

In considering the causes of variations in properties of wood, it may first be observed that there are many factors affecting tree growth. Immediate site factors, such as soil, soil moisture, and competition for light and food, are subject to large variations within small areas, and are further subject to large variations within the life of the tree. Their effect, within the normal range of a species, is seemingly of greater importance than geographical location, as is shown by significant differences in strength properties of samples of a species from adjacent areas and from the inner and outer portions of the same tree and similarity in strength of samples from widely separated regions.

A specific example is noted in Sitka spruce. Tests show differences between averages of samples from two localities in Oregon of 12 percent in specific gravity and 20 percent or more in modulus of rupture, which is several times the probable difference that would be expected considering all Sitka spruce as belonging to the same population. In contrast, the average for samples of Sitka spruce from near Ketchikan, Alaska, tested in a green condition, was identical in specific gravity with that of one of these groups of samples from near Portland, Oreg., and was within a few percent in modulus of rupture. These and similar observations lead to the general conclusion that, in the absence of specific data concerning any given lot of material, the general average of all material for the species is a more reliable estimate of the strength properties than data on samples from adjacent localities or from sites that appear to be the same. This does not

mean, however, that there may not be differences apparent in the grade and quality of wood from different stands, such as prevalence of defects, seasoning characteristics, and the like, sufficient in importance to justify marketing preferences.

The whole problem of the effect of region, site, and conditions of stand on wood properties is an exceedingly complicated one, and sufficient data are not available nor has sufficient study been made to attempt a final appraisal. The data show quite conclusively that the mechanical properties of woods from the coastal forests of Alaska are fully the equal of those of the same species grown elsewhere. Moreover, the growth conditions appear to be favorable to the production of timber of good strength properties.

The average strength values for the species given in table 4, which are based on all comparable tests made at the Forest Products Laboratory, are accordingly recommended as a basis for species comparison. They may likewise be used in wood design where the properties of clear material are required or as a basis for arriving at safe working stresses for structural timbers. Comparisons with other species not listed in table 4 may be made by reference to Wood Handbook (41).

Taken as a whole, the information presented in tables 2, 3, and 4 shows that the different Alaska species have a large range in properties and are available to fill many diverse demands in addition to the pulp and paper possibilities, which offer the most significant outlet for Alaska woods.

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## APPENDIX

Table 1.--Comparative terms used in describing wood properties

Index figure	Specific gravity or weight	Descriptive terms for--		
Classification limits (specific gravity)	Descriptive terms	Strength in bending and compression	Stiffness	
1.....	Below 0.20.....	Extremely light..	Extremely weak....	Extremely limber
2.....	From 0.20 to 0.25.....	Exceedingly light	Exceedingly weak...	Exceedingly limber
3.....	From 0.25 to 0.30.....	Very light.....	Very weak.....	Very limber
4.....	From 0.30 to 0.36.....	Light.....	Weak.....	Limber
5.....	From 0.36 to 0.42.....	Moderately light..	Moderately weak....	Moderately limber
6.....	From 0.42 to 0.50.....	Moderately heavy..	Moderately strong..	Moderately stiff
7.....	From 0.50 to 0.60.....	Heavy.....	Strong.....	Stiff
8.....	From 0.60 to 0.72.....	Very heavy.....	Very strong.....	Very stiff
9.....	From 0.72 to 0.86.....	Exceedingly heavy	Exceedingly strong..	Exceedingly stiff
10.....	Above 0.86.....	Extremely heavy..	Extremely strong...	Extremely stiff

Index figure	Descriptive terms for--		
Hardness	Shock resistance	Shrinkage	
1.....	Extremely soft.....	Extremely low.....	Extremely small
2.....	Exceedingly soft.....	Exceedingly low.....	Exceedingly small
3.....	Very soft.....	Very low.....	Very small
4.....	Soft.....	Low.....	Small
5.....	Moderately soft.....	Moderately low.....	Moderately small
6.....	Moderately hard.....	Moderately high.....	Moderately large
7.....	Hard.....	High.....	Large
8.....	Very hard.....	Very high.....	Very large
9.....	Exceedingly hard.....	Exceedingly high.....	Exceedingly large
10.....	Extremely hard.....	Extremely high.....	Extremely large

Index figure	Descriptive terms for--					
Ease of kiln drying	Ability to stay in place	Workability	Nail-holding ability	Ease of gluing	Resistance to decay	
2....	Very easy.....	Very good ..	Very easy.....	Very high...	Very easy.....	Very high
4....	Easy.....	Good.....	Easy.....	High.....	Easy.....	High
6....	Moderate.....	Moderate..	Moderate.....	Moderate....	Moderate.....	Moderate
8....	Difficult. . . .	Poor.....	Difficult.....	Low.....	Difficult.....	Low
10....	Very difficult	Very poor ..	Very difficult	Very low....	Very difficult	Very low

Table 2.—Average mechanical properties, by localities, of woods from Alaska (based on tests of small, air-dry specimens in the green and air-dry conditions)

Common and botanical name	Place of growth: in Alaska of	Tree: inch	Moisture: per cent	Specific gravity: per cubic foot	Weight: pounds per cubic foot	Shrinkage from green: to oven-dry condi- tion, based on dimen- sions when green	(8)	(9)	(10)	Static bending		(15)	(16)	(17)	(18)	(19)	(20)	(21)	Hardness: (load required to embed a 0.444-inch ball to one- half its diameter)			
										Modulus of elasticity	Strength									Compression: parallel to grain	Impact: height of drop	Compression: perpendicular to grain
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Birch, Alaska paper ( <i>B. papyrifera</i> ):																						
Green.....		10	29	58	0.49	48	16.7	6.5	9.9	3,800	7,100	1,350	0.60	11.6	37	1,970	3,030	430	920	200	550	560
Seasoned.....				32	.55	38				7,800	15,800	1,900	1.87	13.8	40	4,900	7,510	830	1,420	670	860	840
Cedar, Alaska ( <i>Chamaecyparis nootkatensis</i> ):																						
Green.....		3	23	35	.44	37	11.4	4.2	7.7	4,100	6,900	1,420	.77	8.8	27	2,800	3,330	470	880	430	570	500
Seasoned.....				32	.47	33				8,200	13,200	1,700	2.12	13.0	29	6,100	7,520	910	1,380	370	950	690
Cedar, western red ( <i>Thuja plicata</i> ):																						
Green.....		5	18	34	.31	26	7.0	2.2	4.6	3,000	4,900	850	.62	4.9	17	2,130	2,560	380	690	280	430	290
Seasoned.....				12	.33	23				5,780	8,000	1,040	1.80	5.6	19	4,060	4,990	700	870	300	720	390
Redlock, mountain ( <i>Tsuga mertensiana</i> ):																						
Green.....		5	29	54	.45	43	11.9	4.4	7.6	4,100	7,200	1,220	.80	9.8	28	2,460	3,418	540	940	300	610	540
Seasoned.....				12	.50	35				8,500	12,600	1,570	2.70	8.4	29	5,730	7,790	1,060	1,290	300	1,260	860
Hemlock, western ( <i>Tsuga heterophylla</i> ):																						
Green.....		5	21	79	.36	40	11.3	3.9	7.9	3,000	5,600	1,170	.48	7.0	21	2,220	2,780	390	770	330	450	380
Seasoned.....				12	.40	28				6,000	9,200	1,360	1.52	7.4	23	4,510	5,700	620	1,160	340	920	530
Green.....		6	21	66	.42	42	12.4	4.5	7.8	3,800	6,600	1,320	.42	7.3	26	2,680	3,240	460	840	330	560	480
Seasoned.....				12	.44	31				7,800	11,600	1,620	2.10	8.8	31	5,900	7,070	780	1,320	340	1,040	660
Poplar, balsam ( <i>Populus balsamifera</i> ):																						
Green.....		5		104	.30	38	13.0	4.0	8.7	2,100	3,700	700	.37	4.2	13	1,080	1,660	180	490	150	210	200
Seasoned.....				12	.34	24				4,400	6,800	1,190	1.04	4.4	14	2,750	4,230	330	750	380	360	290
Spruce, Sitka ( <i>Picea sitchensis</i> ):																						
Green.....		5	23	39	.39	34	11.4	4.4	7.6	3,400	5,800	1,140	.56	6.7	23	2,240	2,710	420	760	330	400	330
Seasoned.....				12	.42	29				6,800	11,300	1,620	1.59	10.1	21	4,700	6,340	690	1,110	340	650	520
Green.....		5	17	59	.38	33	11.6	4.0	7.7	3,300	5,900	1,300	.51	6.3	23	2,290	2,810	380	780	300	460	400
Seasoned.....				12	.42	29				7,000	10,700	1,580	1.76	9.6	29	4,800	5,930	720	1,060	420	950	580
Spruce, white ( <i>Picea glauca</i> ):																						
Green.....		5	22	50	.39	36	12.6	5.8	9.1	3,200	5,700	1,150	.51	5.8	24	2,150	2,720	330	710	230	370	350
Seasoned.....				12	.43	30				6,700	10,600	1,400	1.83	8.0	22	4,750	6,230	740	1,310	390	640	500

†Test specimens 2 by 2 inches in section. Bending specimens 30 inches long; others shorter, depending on kind of test.  
 ‡The values in the first line for each species are from tests of green material; those in the second line are from tests of seasoned material adjusted to an average air-dry condition of 12 percent moisture.  
 §Based on volume when green and weight when oven-dry.



Table 4. --Average mechanical properties of 18 species of wood (based on tests of small clear specimens in the green and air-dry conditions).

Common and botanical name	Rings: Summer per inch		Moisture content		Specific gravity		Shrinkage from green		Static bending		Impact		Compression		Shearing		Hardness		
	No.	Per.	Lb.	Per.	Per.	Per.	Per.	Per.	Per.	Per.	In.	Per.	Per.	Per.	Per.	Per.	Per.	Per.	
Alder, red ( <i>Alnus rubra</i> )	11	98	0.37	46	12.6	4.4	7.3	3,800	6,500	1,170	0.70	8.0	22	2,620	2,960	310	770	390	550
Seasoned		12	41	29				6,900	9,800	1,380	1.85	8.4	20	4,530	5,960	540	1,080	420	580
Sirch Alaska paper ( <i>Betula papyrifera</i> )	29	65	48	50	16.7	6.3	8.6	3,000	6,400	1,170	45	16.2	49	1,640	2,340	350	840	380	540
Seasoned		12	55	39				6,900	12,300	1,590	1.80	16.0	34	3,610	5,690	740	1,210	670	890
Birch gray ( <i>Betula populifolia</i> )	63	63	45	46	14.7	5.2		1,800	4,900	400	67	13.9	59	1,000	1,860	300			460
Seasoned		12	51	35				5,400	9,800	1,130	1.44	10.8	35	3,050	4,380	950			690
Birch yellow ( <i>Betula alleghaniensis</i> )	16	26	55	57	16.7	7.2	9.2	4,200	8,300	1,500	70	16.1	48	2,620	3,380	530	1,110	430	810
Seasoned		12	62	43				10,100	16,600	2,010	2.69	20.8	55	6,130	8,170	1,190	1,880	920	1,480
Cedar, Alaska ( <i>Chamaecyparis nootkatensis</i> )	28	38	42	36	9.2	2.8	6.0	3,800	6,400	1,140	77	9.2	27	2,500	3,050	430	840	330	540
Seasoned		12	44	32				7,100	11,100	1,420	2.06	10.4	29	5,210	6,310	770	1,130	360	790
Cedar northern white ( <i>Thuja occidentalis</i> )	23	35	29	28	7.0	2.1	4.7	2,600	4,200	640	60	5.7	15	1,490	1,990	290	260	260	320
Seasoned		12	31	22				4,900	6,500	800	1.72	6.8	12	2,630	3,960	380	858	240	450
Cedar western red ( <i>Thuja plicata</i> )	39	36	31	27	7.7	2.4	5.0	3,200	5,100	920	69	5.0	17	2,470	2,750	340	710	230	270
Seasoned		12	33	23				5,300	7,700	1,200	1.64	6.8	17	4,360	5,020	610	860	220	350
Cottonwood, black ( <i>Populus trichocarpa</i> )	6	132	32	46	12.4	3.6	8.6	2,900	4,800	1,070	64	5.0	20	1,760	2,160	200	600	270	280
Seasoned		12	35	24				5,300	8,300	1,240	1.25	6.7	22	3,270	4,420	370	1,020	330	540
Douglas-fir (coast type) ( <i>Pseudotsuga mucronata</i> )	14	36	45	39	11.8	6.8	7.6	4,500	7,600	1,570	75	7.6	26	3,130	3,860	440	930	300	570
Seasoned		12	68	34				7,800	12,200	1,930	1.77	9.9	31	5,850	7,430	870	1,160	340	900
Douglas-fir (mountain type) ( <i>Pseudotsuga mansuetii</i> var. <i>glauca</i> )	22	27	40	35	10.6	3.6	6.2	3,600	6,400	1,180	65	6.8	20	2,540	3,000	450	880	350	400
Seasoned		12	63	30				6,300	9,600	1,400	1.40	6.4	26	4,660	6,060	820	1,070	330	740
Hemlock, eastern ( <i>Tsuga canadensis</i> )	17	34	36	50	9.7	3.0	6.8	3,800	6,400	1,070	76	6.7	21	2,400	3,080	440	850	230	300
Seasoned		12	40	29				6,100	8,900	1,200	1.79	6.8	21	4,020	5,410	800	1,060	220	310
Hemlock, mountain ( <i>Tsuga mertensiana</i> )	26	65	42	44	11.1	4.4	7.1	3,500	6,300	1,040	70	11.0	32	2,100	2,880	410	930	330	580
Seasoned		12	65	33				6,800	11,500	1,330	2.03	10.4	32	4,040	6,440	940	1,540	320	1,090
Maple, bigleaf ( <i>Acer macrophyllum</i> )	12	72	46	47	11.6	3.7	7.1	4,400	7,400	1,100	1.02	8.7	23	2,510	3,240	550	1,110	600	760
Seasoned		12	48	34				6,600	10,700	1,450	1.66	7.8	28	4,790	5,950	930	1,730	540	1,330
Pine, western white ( <i>Pinus monticola</i> )	20	33	36	35	11.8	4.1	7.4	3,400	5,200	1,170	56	5.0	19	2,430	2,990	290	640	260	310
Seasoned		12	38	28				6,200	9,500	1,510	1.67	8.8	23	4,480	5,620	540	850	280	460
Poplar, balsam ( <i>Populus balsamifera</i> )	7	112	30	40	10.5	3.0	7.1	2,100	3,900	750	35	4.2	16	1,220	1,690	170	500	160	240
Seasoned		12	33	23				4,200	6,800	1,100	98	5.0	14	2,920	4,020	370	790	350	380
Spruce, Sitka ( <i>Picea sitchensis</i> )	15	35	47	33	11.5	4.2	7.5	3,300	5,700	1,230	53	6.3	24	2,240	2,670	340	760	250	350
Seasoned		12	40	28				6,700	10,200	1,570	1.62	9.4	25	4,780	5,610	710	1,150	370	760
Spruce, white ( <i>Picea glauca</i> )	17	26	37	35	13.7	3.8	7.5	3,300	5,600	1,070	60	6.0	22	2,130	2,570	290	690	220	320
Seasoned		12	40	29				6,500	9,800	1,340	1.76	7.7	20	3,780	5,470	570	1,080	360	610

The values given in this table comprise the average of all comparable data on each species regardless of region where grown.

Test specimens 2 by 2 inches in section. Bending specimens 30 inches long; others shorter, depending on kind of test.

The values in the first line for each species are from tests of green material; those in the second line are from tests of seasoned material adjusted to an average air-dry condition of 12 percent moisture.

Based on volume when green and weight when oven-dry.

Table 5.--Basic stresses for clear lumber under long-time service at full design load<sup>1,2</sup>  
 For use in determining working stresses according to grade of lumber and other applicable factors

Commercial names for lumber	Extreme fiber in bending or tension parallel to grain, p.s.i.	Horizontal shear, maximum, p.s.i.	Compression perpendicular to grain, p.s.i.	Compression parallel to grain, p.s.i. (L/d = 11 or less)	Modulus of elasticity in bending, p.s.i.
(1)	(2)	(3)	(4)	(5)	(6)
<b>SOFTWOODS</b>					
Baldcypress (cypress).....	1,900	150	220	1,450	1,200,000
Cedar:					
Alaska.....	1,600	130	185	1,050	1,200,000
Atlantic white (southern white cedar) and northern white.....	1,100	100	130	750	800,000
Port Orford.....	1,600	130	185	1,200	1,500,000
Western red cedar.....	1,300	120	145	950	1,000,000
Douglas-fir:					
Coast type, medium-grained.....	2,200	130	235	1,450	1,600,000
Coast type, close-grained.....	2,350	130	250	1,550	1,600,000
Rocky Mountain type.....	1,600	120	205	1,050	1,200,000
All types, dense.....	2,550	130	275	1,700	1,600,000
Fir:					
Balsam.....	1,300	100	110	950	1,000,000
California red, grand, noble, and white.....	1,600	100	220	950	1,100,000
Hemlock:					
Eastern.....	1,600	100	220	950	1,100,000
Western (West Coast hemlock).....	1,900	110	220	1,200	1,400,000
Larch, western.....	2,200	130	235	1,450	1,600,000
Pine:					
Eastern white (northern white), pon- derosa, sugar, and western white (Idaho white).....	1,300	120	185	1,000	1,000,000
Jack.....	1,600	120	160	1,050	1,100,000
Lodgepole.....	1,300	90	160	950	1,000,000
Red (Norway pine).....	1,600	120	160	1,050	1,200,000
Southern yellow, medium-grained.....	2,200	160	235	1,450	1,600,000
Southern yellow, dense.....	2,550	160	275	1,700	1,600,000
Redwood.....	1,750	100	185	1,350	1,200,000
Close-grained.....	1,900	100	195	1,450	1,200,000
Spruce:					
Engelmann.....	1,100	100	130	800	1,000,000
Red, white, and Sitka.....	1,600	120	185	1,050	1,200,000
Tamarack.....	1,750	140	220	1,350	1,300,000
<b>HARDWOODS</b>					
Ash:					
Black.....	1,450	130	220	850	1,100,000
Commercial white.....	2,050	185	365	1,450	1,500,000
Aspen, bigtooth and quaking.....	1,300	100	110	800	800,000
Beech, American.....	2,200	185	365	1,600	1,600,000
Birch, sweet and yellow.....	2,200	185	365	1,600	1,600,000
Cottonwood, eastern.....	1,100	90	110	800	1,000,000
Elm:					
American and slippery (soft elm).....	1,600	150	185	1,050	1,200,000
Rock.....	2,200	185	365	1,600	1,300,000
Hickory, true and pecan.....	2,800	205	440	2,000	1,800,000
Maple, black and sugar (hard maple).....	2,200	185	365	1,600	1,600,000
Oak, commercial red and white.....	2,050	185	365	1,350	1,500,000
Sweetgum (gum, red gum, sap gum).....	1,600	150	220	1,050	1,200,000
Tupelo, black (black gum) and water.....	1,600	150	220	1,050	1,200,000
Yellow-poplar (poplar).....	1,450	130	160	1,050	1,200,000

<sup>1</sup>Taken from "Methods for Establishing Structural Grades of Lumber," (D 245-61T) American Society for Testing and Materials.

<sup>2</sup>These stresses are based on the strength of green lumber and are applicable, with certain adjustments, to lumber of any degree of seasoning, or lumber used under any conditions of duration of load.

Table 6.--Typical values of average fiber length, density, and yields of chemical pulp for various softwoods and hardwoods<sup>1</sup>

Species	Fiber	Density <sup>2</sup>	Yield of chemical pulp <sup>3</sup>		
	length:		Sulfite <sup>4</sup>	Sulfate	Soda <sup>4</sup>
	Mm.	Lb. per cu. ft.	Percent	Percent	Percent
SOFTWOODS (Conifers)					
Hemlock ( <i>Tsuga</i> sp.)	:	:	:	:	:
Western ( <i>T. heterophylla</i> )	4.0	25	46	547	.....
Mountain ( <i>T. mertensiana</i> )	3.7	26	.....	545	.....
Spruce ( <i>Picea</i> sp.)	:	:	:	:	:
Sitka ( <i>P. sitchensis</i> )	5.5	24	48	547	42
White ( <i>P. glauca</i> )	3.5	23	48	550	43
Cedar	:	:	:	:	:
Western redcedar ( <i>Thuja plicata</i> )	3.8	19	43	540	.....
Alaska-cedar ( <i>Chamaecyparis nootkatensis</i> )	2.7	26	.....	.....	.....
Pine ( <i>Pinus</i> sp.)	:	:	:	:	:
Lodgepole ( <i>P. contorta</i> )	3.5	25	45	548	.....
HARDWOODS (Broad-leaf trees)					
Poplar ( <i>Populus</i> sp.)	:	:	:	:	:
Black cottonwood ( <i>P. trichocarpa</i> )	1.3	20	.....	452	.....
Balsam poplar ( <i>P. balsamifera</i> )	1.0	19	49	452	47
Quaking aspen ( <i>P. tremuloides</i> )	1.2	23	52	452	46
Birch, paper ( <i>Betula papyrifera</i> )	1.2	34	46	450	52
Alaskan paper birch	.....	.....	.....	.....	.....
Western paper birch	.....	.....	.....	.....	.....
Kenai birch	.....	.....	.....	.....	.....

<sup>1</sup> Considerable variation between samples of the same species can be expected.

<sup>2</sup> Based on volume when green and weight when oven-dry.

<sup>3</sup> Yields of moisture-free, screened pulp based on weight of moisture-free wood. Screenings, which may amount to about 0.5 percent, are frequently refined and returned to the pulp system or converted into lower grade products and therefore are not actually lost. (Yields of semichemical, other chemi-mechanical, and groundwood pulps are not included because they are relatively independent of the kind of wood used.)

<sup>4</sup> Bleachable pulp of papermaking grade.

<sup>5</sup> Kraft type, wrapping and board grade; bleachable pulp may be 2 or 3 percent lower than the values given.

Table 7.--Typical values for chemical analysis of several pulp woods<sup>1</sup>

Species	Chemical analysis <sup>2</sup>									
	Lignin	Cellulose	Total	pentosans	Alcohol	Ethyl	One	Hot	Solubility in--	
	Holo	Alpha			benzene	ether	percent	water		
									NaOH	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
SOFTWOODS (Conifers)										
Hemlock ( <i>Tsuga</i> sp.)	29	67	49	6.8	3.1	0.5	11.4	3.8		
Western ( <i>T. heterophylla</i> )	27	60	43	7.0	4.6		11.6	4.8		
Mountain ( <i>T. mertensiana</i> )										
Spruce ( <i>Picea</i> sp.)										
Sitka ( <i>P. sitchensis</i> )	28		45	9.0	4.5	.8	15.0	5.5		
White ( <i>P. glauca</i> )	30		43	12.0	1.8	.8	12.2	3.2		
Cedar										
Alaskan-cedar ( <i>Chamaecyparis</i> <i>nootkatensis</i> )	31			7.9		2.6	13.4	3.1		
Western redcedar ( <i>Thuja plicata</i> )	32			9.0	14.1	2.5	21.0	11.0		
Pine ( <i>Pinus</i> sp.)										
Lodgepole ( <i>P. contorta</i> )	27	70	46	9.3	3.0	1.6	14.0	3.7		
HARDWOODS (Broad-leaf trees)										
Paper birch ( <i>Betula papyrifera</i> )	19	77	45	23.3	2.8	1.3	14.1	1.5		
Alaska paper birch										
Kenai birch										
Western paper birch										
Poplar ( <i>Populus</i> sp.)										
Black cottonwood ( <i>P. trichocarpa</i> )	21	75	49	19.2	2.7	.7	18.0	2.6		
Balsam poplar ( <i>P. balsamifera</i> )										
Quaking aspen ( <i>P. tremuloides</i> )	19	79	49	18.8	2.9	1.0	18.7	2.8		

<sup>1</sup>Values are for species grown in Oregon, Washington, or other Northern States. Tests made on woods received at the Forest Products Laboratory.

<sup>2</sup>Based on moisture-free wood.

Table 8. -- Fact sheet on pulping processes suitable for wood species grown in Alaska

Pulp classification	Name of process	Process description	Woods used	Yield of pulp: by weight Percent	Strength of pulp	How pulp is used	Final product	Minimum mill capacity: In U.S. (1960)	Number of pulp mills in U.S. (1960)
Chemical	Sulfite	Woodchips reduced under steam pressure to pulp with an acid chemical (calcium, magnesium, sodium, or ammonium bisulfites plus sulfuric acid).	Softwoods, including: Spruce, Hemlock, Lodgepole pine Hardwoods, including: Aspen, Birch, Cottonwood, Poplar	49	Medium high	Usually mixed with other pulp. When purified, used for cellulose products.	Book and magazine Wrapping Bond and writing Tissue Newsprint Glassine Rayon and cellulose derivatives	100	62
	Kraft	Woodchips reduced under steam pressure to pulp with alkaline chemicals (sodium hydroxide and sodium sulfide).	Softwoods and hardwoods: woods occasionally pulped together	46-49	Softwoods high to very high; hardwoods medium to medium high	Alone or mixed with other pulps	Higher yield pulps for container board. Lower yields for strong wrapping and bag papers, book, newsprint, high grade magazine and other printing papers, bond and writing paper. Fre-hydrolysis pulp for rayon.	Kraft grade 250	85
	Soda	Woodchips reduced under steam pressure to pulp with an alkaline chemical (caustic soda).	Mostly hardwoods	40-48	Medium to medium low	Usually bleached and mixed with sulfite or other pulps	Book Magazine Lithograph and other printing papers Envelope Blotting paper	100	11
Semichemical	Neutral sulfite, bisulfite, acid sulfite, kraft	Woodchips partially softened under steam pressure with chemicals are reduced to pulp by mechanical action.	Hardwoods: Often pulped in mixtures Softwoods	60-80	Medium to low	Alone for some products, bleached pulps mixed with softwood pulps	Corrugating board Food and other speciality boards Glassine Magazine Newsprint and other papers	250	40
Chemimechanical	Chemical-groundwood	Mild chemical treatment of bolts with neutral sulfite liquor under steam pressure followed by grinding.	Hardwoods	80-95	Medium low	Mixed with softwood groundwood and sulfite pulps	Corrugating board Newsprint	100	1

Table 8.--Fact sheet on pulping processes suitable for wood species grown in Alaska--Con.

Pulp classification	Name of process	Process description	Woods used	Yield of pulp: by weight	Strength of pulp	How pulp is used	Final product	Minimum mill capacity: in U.S., (1960)	Number of pulpmills
				Percent					Tons per 24 hours
Chemimechanical:	Cold soda	Woodchips given mild treatments with sodium hydroxide solutions and then mechanically fiberized to pulp.	Hardwoods: Often pulped in mixtures	80-95	Medium low to low	Alone for some products, but often mixed with other pulps	Corrugating board Boxboard and molded pulp products Book and newsprint paper	50	9
		Hot sulfite: Woodchips given mild treatments with sodium sulfite solutions and then mechanically fiberized to pulp.	Softwoods, including: Hemlock and Spruce Hardwoods	80-95	Medium to medium low	Mixed with ground-wood and sulfite pulps	Book paper	50	2
		Coarse fibers (Exploded, defiberized, and "rapid cycle")	Softwoods and hardwoods Water at high temperatures and pressures to soften the wood followed by mechanical fiberization:	80-95	Low to very low	Coarse pulps composed of a mixture of single fibers and fiber bundles used alone and mixed with waste paper and other pulps	Hardboard Insulating board Roofing and linoleum felts	50	48
Mechanical	Groundwood	Wood bolts reduced to pulp by pressing on a revolving grindstone, or chips mechanically fiberized to pulp.	Softwoods, including: Hemlock, Lodgepole pine, Spruce Hardwoods: Aspen, Birch, Cottonwood, Poplar	93	Low	Usually mixed with chemical pulp	Newsprint Magazine-book Catalog Tissues Toweling Carton board Container board Building board Insulating board	50	93

<sup>1</sup>A very general rating based on the full range of pulp strength. Good strength in a pulp is desirable though not necessarily essential to its usefulness. Between 2 pulps otherwise comparable the 1 with the better strength would be preferred.

<sup>2</sup>Recovery of spent sodium sulfite liquors now under commercial development. Minimum size of these new recovery plants not known; probably not less than 50 tons of pulp per 24 hours. If semichemical pulp plants are integrated with kraft mills their spent liquors can be processed in the kraft chemical recovery plant. Probably no limitation on the size of a kraft semichemical pulp plant if so integrated. A neutral sulfite semichemical pulp plant would be limited to a size equivalent to about one-fourth the liquor recovery capacity of the kraft mill. In either case the integrated recovery system would need to have sufficient capacity to process the combined spent liquors from both plants.

Table 9. --Height, in pounds, of moisture-free pulp produced per cord of rough logs for various kinds and percentage yields of pulp, and densities of wood<sup>1</sup>

Density: Wood of wood <sup>2</sup> per cord <sup>3</sup>	Yield of chemical pulp <sup>4</sup>																			Yield of semichemical pulp <sup>4</sup>																			Chemomechanical pulp <sup>4</sup>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
	33	38	40	41	42	43	44	45	46	47	48	49	50	55	60	65	70	75	80	85	90	95	33	38	40	41	42	43	44	45	46	47	48	49	50	55	60	65	70	75	80	85	90	95	33	38	40	41	42	43	44	45	46	47	48	49	50	55	60	65	70	75	80	85	90	95																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
19	1,575	520	595	610	625	640	655	670	685	700	715	730	745	815	890	965	1,040	1,115	1,190	1,265	1,340	1,415	1,490	1,565	1,640	1,715	1,790	1,865	1,940	2,015	2,090	2,165	2,240	2,315	2,390	2,465	2,540	2,615	2,690	2,765	2,840	2,915	2,990	3,065	3,140	3,215	3,290	3,365	3,440	3,515	3,590	3,665	3,740	3,815	3,890	3,965	4,040	4,115	4,190	4,265	4,340	4,415	4,490	4,565	4,640	4,715	4,790	4,865	4,940	5,015	5,090	5,165	5,240	5,315	5,390	5,465	5,540	5,615	5,690	5,765	5,840	5,915	5,990	6,065	6,140	6,215	6,290	6,365	6,440	6,515	6,590	6,665	6,740	6,815	6,890	6,965	7,040	7,115	7,190	7,265	7,340	7,415	7,490	7,565	7,640	7,715	7,790	7,865	7,940	8,015	8,090	8,165	8,240	8,315	8,390	8,465	8,540	8,615	8,690	8,765	8,840	8,915	8,990	9,065	9,140	9,215	9,290	9,365	9,440	9,515	9,590	9,665	9,740	9,815	9,890	9,965	10,040	10,115	10,190	10,265	10,340	10,415	10,490	10,565	10,640	10,715	10,790	10,865	10,940	11,015	11,090	11,165	11,240	11,315	11,390	11,465	11,540	11,615	11,690	11,765	11,840	11,915	11,990	12,065	12,140	12,215	12,290	12,365	12,440	12,515	12,590	12,665	12,740	12,815	12,890	12,965	13,040	13,115	13,190	13,265	13,340	13,415	13,490	13,565	13,640	13,715	13,790	13,865	13,940	14,015	14,090	14,165	14,240	14,315	14,390	14,465	14,540	14,615	14,690	14,765	14,840	14,915	14,990	15,065	15,140	15,215	15,290	15,365	15,440	15,515	15,590	15,665	15,740	15,815	15,890	15,965	16,040	16,115	16,190	16,265	16,340	16,415	16,490	16,565	16,640	16,715	16,790	16,865	16,940	17,015	17,090	17,165	17,240	17,315	17,390	17,465	17,540	17,615	17,690	17,765	17,840	17,915	17,990	18,065	18,140	18,215	18,290	18,365	18,440	18,515	18,590	18,665	18,740	18,815	18,890	18,965	19,040	19,115	19,190	19,265	19,340	19,415	19,490	19,565	19,640	19,715	19,790	19,865	19,940	20,015	20,090	20,165	20,240	20,315	20,390	20,465	20,540	20,615	20,690	20,765	20,840	20,915	20,990	21,065	21,140	21,215	21,290	21,365	21,440	21,515	21,590	21,665	21,740	21,815	21,890	21,965	22,040	22,115	22,190	22,265	22,340	22,415	22,490	22,565	22,640	22,715	22,790	22,865	22,940	23,015	23,090	23,165	23,240	23,315	23,390	23,465	23,540	23,615	23,690	23,765	23,840	23,915	23,990	24,065	24,140	24,215	24,290	24,365	24,440	24,515	24,590	24,665	24,740	24,815	24,890	24,965	25,040	25,115	25,190	25,265	25,340	25,415	25,490	25,565	25,640	25,715	25,790	25,865	25,940	26,015	26,090	26,165	26,240	26,315	26,390	26,465	26,540	26,615	26,690	26,765	26,840	26,915	26,990	27,065	27,140	27,215	27,290	27,365	27,440	27,515	27,590	27,665	27,740	27,815	27,890	27,965	28,040	28,115	28,190	28,265	28,340	28,415	28,490	28,565	28,640	28,715	28,790	28,865	28,940	29,015	29,090	29,165	29,240	29,315	29,390	29,465	29,540	29,615	29,690	29,765	29,840	29,915	29,990	30,065	30,140	30,215	30,290	30,365	30,440	30,515	30,590	30,665	30,740	30,815	30,890	30,965	31,040	31,115	31,190	31,265	31,340	31,415	31,490	31,565	31,640	31,715	31,790	31,865	31,940	32,015	32,090	32,165	32,240	32,315	32,390	32,465	32,540	32,615	32,690	32,765	32,840	32,915	32,990	33,065	33,140	33,215	33,290	33,365	33,440	33,515	33,590	33,665	33,740	33,815	33,890	33,965	34,040	34,115	34,190	34,265	34,340	34,415	34,490	34,565	34,640	34,715	34,790	34,865	34,940	35,015	35,090	35,165	35,240	35,315	35,390	35,465	35,540	35,615	35,690	35,765	35,840	35,915	35,990	36,065	36,140	36,215	36,290	36,365	36,440	36,515	36,590	36,665	36,740	36,815	36,890	36,965	37,040	37,115	37,190	37,265	37,340	37,415	37,490	37,565	37,640	37,715	37,790	37,865	37,940	38,015	38,090	38,165	38,240	38,315	38,390	38,465	38,540	38,615	38,690	38,765	38,840	38,915	38,990	39,065	39,140	39,215	39,290	39,365	39,440	39,515	39,590	39,665	39,740	39,815	39,890	39,965	40,040	40,115	40,190	40,265	40,340	40,415	40,490	40,565	40,640	40,715	40,790	40,865	40,940	41,015	41,090	41,165	41,240	41,315	41,390	41,465	41,540	41,615	41,690	41,765	41,840	41,915	41,990	42,065	42,140	42,215	42,290	42,365	42,440	42,515	42,590	42,665	42,740	42,815	42,890	42,965	43,040	43,115	43,190	43,265	43,340	43,415	43,490	43,565	43,640	43,715	43,790	43,865	43,940	44,015	44,090	44,165	44,240	44,315	44,390	44,465	44,540	44,615	44,690	44,765	44,840	44,915	44,990	45,065	45,140	45,215	45,290	45,365	45,440	45,515	45,590	45,665	45,740	45,815	45,890	45,965	46,040	46,115	46,190	46,265	46,340	46,415	46,490	46,565	46,640	46,715	46,790	46,865	46,940	47,015	47,090	47,165	47,240	47,315	47,390	47,465	47,540	47,615	47,690	47,765	47,840	47,915	47,990	48,065	48,140	48,215	48,290	48,365	48,440	48,515	48,590	48,665	48,740	48,815	48,890	48,965	49,040	49,115	49,190	49,265	49,340	49,415	49,490	49,565	49,640	49,715	49,790	49,865	49,940	50,015	50,090	50,165	50,240	50,315	50,390	50,465	50,540	50,615	50,690	50,765	50,840	50,915	50,990	51,065	51,140	51,215	51,290	51,365	51,440	51,515	51,590	51,665	51,740	51,815	51,890	51,965	52,040	52,115	52,190	52,265	52,340	52,415	52,490	52,565	52,640	52,715	52,790	52,865	52,940	53,015	53,090	53,165	53,240	53,315	53,390	53,465	53,540	53,615	53,690	53,765	53,840	53,915	53,990	54,065	54,140	54,215	54,290	54,365	54,440	54,515	54,590	54,665	54,740	54,815	54,890	54,965	55,040	55,115	55,190	55,265	55,340	55,415	55,490	55,565	55,640	55,715	55,790	55,865	55,940	56,015	56,090	56,165	56,240	56,315	56,390	56,465	56,540	56,615	56,690	56,765	56,840	56,915	56,990	57,065	57,140	57,215	57,290	57,365	57,440	57,515	57,590	57,665	57,740	57,815	57,890	57,965	58,040	58,115	58,190	58,265	58,340	58,415	58,490	58,565	58,640	58,715	58,790	58,865	58,940	59,015	59,090	59,165	59,240	59,315	59,390	59,465	59,540	59,615	59,690	59,765	59,840	59,915	59,990	60,065	60,140	60,215	60,290	60,365	60,440	60,515	60,590	60,665	60,740	60,815	60,890	60,965	61,040	61,115	61,190	61,265	61,340	61,415	61,490	61,565	61,640	61,715	61,790	61,865	61,940	62,015	62,090	62,165	62,240	62,315	62,390	62,465	62,540	62,615	62,690	62,765	62,840	62,915	62,990	63,065	63,140	63,215	63,290	63,365	63,440	63,515	63,590	63,665	63,740	63,815	63,890	63,965	64,040	64,115	64,190	64,265	64,340	64,415	64,490	64,565	64,640	64,715	64,790	64,865	64,940	65,015	65,090	65,165	65,240	65,315	65,390	65,465	65,540	65,615	65,690	65,765	65,840	65,915	65,990	66,065	66,140	66,215	66,290	66,365	66,440	66,515	66,590	66,665	66,740	66,815	66,890	66,965	67,040	67,115	67,190	67,265	67,340	67,415	67,490	67,565	67,640	67,715	67,790	67,865	67,940	68,015	68,090	68,165	68,240	68,315	68,390	68,465	68,540	68,615	68,690	68,765	68,840	68,915	68,990	69,065	69,140	69,215	69,290	69,365	69,440	69,515	69,590	69,665	69,740	69,815	69,890	69,965	70,040	70,115	70,190	70,265	70,340	70,415	70,490	70,565	70,640	70,715	70,790	70,865	70,940	71,015	71,090	71,165	71,240	71,315	71,390	71,465	71,540	71,615	71,690	71,765	71,840	71,915	71,990	72,065	72,140	72,215	72,290	72,365	72,440	72,515	72,590	72,665	72,740	72,815	72,890	72,965	73,040	73,115	73,190	73,265	73,340	73,415	73,490	73,565	73,640	73,715	73,790	73,865	73,940	74,015	74,090	74,165	74,240	74,315	74,390	74,465	74,540	74,615	74,690	74,765	74,840	74,915	74,990	75,065	75,140	75,215	75,290	75,365	75,440	75,515	75,590	75,665	75,740	75,815	75,890	75,965	76,040	76,115	76,190	76,265	76,340	76,415	76,490	76,565	76,640	76,715	76,790	76,865	76,940	77,015	77,090	77,165	77,240	77,315	77,390	77,465	77,540	77,615	77,690	77,765	77,840	77,915	77,990	78,065	78,140	78,215	78,290	78,365	78,440	78,515	78,590	78,665	78,740	78,815	78,890	78,965	79,040	79,115	79,190	79,265	79,340	79,415	79,490	79,565	79,640	79,715	79,790	79,865	79,940	80,015	80,090	80,165	80,240	80,315	80,390	80,465



Table 11.--Index of kiln schedules<sup>1</sup> for 1- to 2-inch Alaska woods

Species	Material	Lower grades		Upper grades		
		4/4 stock	8/4 stock	4/4 stock	8/4 stock	
HARDWOODS						
Aspen	lumber			T12-E7	T12-E7	T10-E6
Birch, paper	do			T10-C4	T10-C4	T8-C3
Do	squares			T10-C6		T8-C4
Cottonwood	lumber			T10-F5	T10-F5	T8-F4
SOFTWOODS						
Cedar:						
Alaska-				T12-A3		T11-A2
Western redcedar	light	T9-A6		T10-B5		T10-B3
Do	heavy			T5-F4		T5-F3
Hemlock, western		T11-E5 <sup>2</sup>	T11-E5	T12-C5	T11-C5	T11-C4
Pine, lodgepole		T5-C5		T10-C4		T9-C3
Spruce:						
Sitka		T7-A5		T12-B5	T12-B4	T11-B3
White				T11-B4		T10-B3

<sup>1</sup>Kiln schedules are in tables 13, 14; method of assembling schedule in table 15.

<sup>2</sup>Maximum wet-bulb depression for this material is 25° F.

Table 12.--Schedules of temperatures for kiln drying Alaska woods

Temper- ature step No.	Moisture content at start of step	Dry-bulb temperatures for temperature schedule No.--							
		T5	T6	T7	T8	T9	T10	T11	T12
		Percent	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	Above 30	120	120	130	130	140	140	150	160
2	30	130	130	140	140	150	150	160	170
3	25	140	140	150	150	160	160	160	170
4	20	150	150	160	160	160	170	170	180
5	15	160	180	160	180	160	180	180	180

Table 13.--Schedules of wet-bulb depressions for kiln drying Alaska woods

Wet-bulb depression step No.	Moisture content at start of step for moisture-content class--						Wet-bulb depressions for wet-bulb depression schedule No.--				
	A	B	C	D	E	F	3	4	5	6	7
		Percent	Percent	Percent	Percent	Percent	°F.	°F.	°F.	°F.	°F.
1	Above 30	Above 35	Above 40	Above 50	Above 60	Above 70	5	7	10	15	20
2	30	35	40	50	60	70	7	10	14	20	25
3	25	30	35	40	50	60	11	15	20	25	30
4	20	25	30	35	40	50	15	20	25	30	35
5	(1)	20	25	30	35	40	20	25	30	35	35
6		(1)	20	25	30	35	25	30	35	35	35
7			(1)	20	25	30	30	35	35	35	35
8				(1)	20	25	35	35	35	35	35
9					(1)	20	35	35	35	35	35
10	15	15	15	15	15	15	50	50	50	50	50

<sup>1</sup>Go directly to step 10.

Table 14.--Examples of assembled temperature and wet-bulb depression schedules for upper grade stock of certain Alaska woods

Birch, paper

Schedule T10-C4

Schedule T8-C3

Moisture content at start of step	4/4 stock			8/4 stock		
	Dry-bulb temperature	Wet-bulb depression	Wet-bulb temperature	Dry-bulb temperature	Wet-bulb depression	Wet-bulb temperature
Percent	°F.	°F.	°F.	°F.	°F.	°F.
Above 40	140	7	133	130	5	125
40	140	10	130	130	7	123
35	140	15	125	130	11	119
30	150	20	130	140	15	125
25	160	25	135	150	20	130
20	170	30	140	160	25	135
15	180	50	130	180	50	130

Cottonwood

Schedule T10-F5

Schedule T8-F4

Above 70	140	10	130	130	7	123
70	140	14	126	130	10	120
60	140	20	120	130	15	115
50	140	25	115	130	20	110
40	140	30	110	130	25	105
35	140	35	105	130	30	100
30	150	35	115	140	35	105
25	160	35	125	150	35	115
20	170	35	135	160	35	125
15	180	50	130	180	50	130

Hemlock, western

Schedule T12-C5

Schedule T11-C4

Above 40	160	10	150	150	7	143
40	160	14	146	150	10	140
35	160	20	140	150	15	135
30	170	25	145	160	20	140
25	170	30	140	160	25	135
20	180	35	145	170	30	140
15	180	50	130	180	50	130

Spruce, white

Schedule T11-B4

Schedule T10-B3

Above 35	150	7	143	140	5	135
35	150	10	140	140	7	133
30	160	15	145	150	11	139
25	160	20	140	160	15	145
20	170	25	145	170	20	150
15	180	50	130	180	50	130