WESTERN HEMLOCK

A FUTURE COAST LEADING SPECIES

Thesis 1929

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INTRODUCTION

When lumbering first started on the Pacific Coast, Douglas fir was the only species recognized by the lumbermen. Douglas fir is, no doubt, the main species of this region, but many valuable species grow mixed with Douglas fir and in some cases grow in pure stands on part of the area. Western hemlock, the subject of this paper, grows on the Pacific Coast region, and is nearly always found as an understory in Douglas fir stands. It is occasionally found in pure stands.

The lumbermen who first began operations on the Pacific Coast were mostly men who had been in the lumber business in the east, and came to the Pacific Coast when the eastern supply of timber became exhausted. The first impulse of these men was to look with disfavor on the hemlock of this coast because of the poor properties of the eastern hemlock, among which they had been operating. The western tree was condemned without a thorough trial, as a result of which little of it was logged, little or none of it was marketed under its own name, and a great deal was left to be destroyed by fire or decay.

Western hemlock, after a thorough trial, has been found to be a good wood. This has been realized by the operators for a long

time, and much has been done by them to acquaint the consumer with its merits, but even today western hemlock is looked upon with disfavor. This has caused the pioneers in the utilization of hemlock to coin fictitious names for it--Alaska fir, Grey fir, or Hemlock spruce--or to substitute its products in shipments of other species, especially Douglas fir. In this way much hemlock has been disposed of, the mill man securing the same price for it as for the other species, and the consumer getting good material which he would not accept under its proper name.

Due to its intrinsic good qualities and the energy of a few good progressive mill men who have realized its worth, western hemlock has now attained a standing in the market under its own name. Seven years ago western hemlock was little known in the United States outside its own region of production, and even then seldom was segregated, sold, or used under its own identity, but was usually mixed with associated species, but today it is winning, and in part has won, a conspicuous position under its own name as one of America's most important softwoods.

Western hemlock is one of the important trees of the Pacific Coast, particularly the Northwest. It is an important part of America's lumber supply, being included in the reforestation plans of the timber holders of this great forest region.

The future of this tree can be assured by the ease which it can be reproduced. It is a very prolific seeder and after logging, if fires are kept out, a second crop begins almost immediately.

THE TREE

Distinguishing Characteristics

Western hemlock is a large forest tree with a slight taper to its trunk. Its tall, clear, smooth looking trunk, fine foliage, and drooping branchlets, distinguishes it readily from its associates. Forest grown trees have small narrowly pyramidal crowns of slender branches, and are from one hundred twenty-five to one hundred sixty feet high, and from two to five feet in diameter. The bark of large branches and young trees is thin, finely scaly, and russet brown, while that of old trunks is about one and one-fourth to one and one-half inches thick, hard, and deeply furrowed; the ridges are wide, flat, and irregularly connected with one another by narrow cross-ridges, it is dark russet brown, tinged with red. The foliage is deep, glossy, and yellow green, and clothes the branchlets thickly, but the small size of the leaves gives it a thin appearance. The leaves appear to grow mainly from two opposite sides of the branchlets, a sort of comb-like arrangement. They are flat, grooved above, have a rounded end, and a distinct thread-like stem, and are about one-fourth to seven-eighths of an inch long. The small few scaled cones nod from the tips of the branches, maturing from the middle to the end of August. They open rapidly and usually shed their thin, small, winged seeds during September. By spring most of the cones have fallen from the tree.

The cones are from about three-fourths of an inch to sometimes nearly one and one-fourth inches long, and when open are reddish clay brown.

Range and Distribution

Western hemlock is common throughout the Pacific Coast forests from Alaska to Northern California. Its range is from Cape Puget on the western side of Prince William Sound, southward along the Coast Ranges through British Columbia, Washington, and Oregon, to Marin County, California; in the southern part of its range it extends only to the crest of the Cascades. In the Northern part of Washington and Southern part of British Columbia it extends from the sea eastward to the western spur of the Rocky Mountains in Northern Idaho and Montana.

The chief distribution of western hemlock indicates clearly that its chief requirements is a cool and moist climate. This is shown by its local distribution in Washington and Oregon where the rainfall is seventy to one hundred inches a year. Its general distribution in Oregon and Washington is within the strip most generally spoken of as the "fog belt".

Western hemlock is found abundantly along the southern part of Alaska. Here, due to the favorable weather, which is humid, it forms almost pure stands, for it seeds up all areas so rapidly and effectively that other species have great difficulty in establishing themselves. This tree is not fastidious in its choice of sites, but on account of the severe competition of Sitka spruce,

it does not come up so well on the drier, well-drained slopes.

Western hemlock is found at all elevations from sea level in Alaska, British Columbia, Washington, and Oregon, to an elevation of over six thousand feet in the Cascades in Oregon. In Idaho it is found at a maximum elevation of about forty-five hundred feet.

Associated Species

Western hemlock occurs but rarely in pure stands of any extent, except in southwestern Alaska and along the west slopes of the Olympic and Coast Range Mountains of Washington. In Alaska its principal associate is Sitka spruce.

On the western slope of the Olympics and the Coast Range in Washington and Oregon, it is found with Sitka Spruce (Picea sitchensis), western red cedar (Thuja plicata), Douglas fir (Pseudotsuga taxifolia), amabilis fir (Abies amabilis), and grand fir (Abies grandis). In the southwestern part of Oregon and northern California, it is found rather sparingly in mixture with Lawson cypress (Chamaecyparis lawsoniana), and redwood (Sequoia sempervirens).

On the west slope of the Cascade, western hemlock occurs in stands in which Douglas fir predominates. With Douglas fir, Sitka spruce, western red cedar, and amabilis fir, it constitutes the forest now being cut in the foothills; higher in the mountains its associates are western white pine, noble fir, grand fir, and amabilis fir.

Eastward in Idaho and Montana, western hemlock is of little importance either silviculturally or commercially, and is here greatly inferior in both size and quality to the hemlock in the Coastal Region.

Soil and Moisture Requirements

An abundance of both soil and atmospheric moisture is essential for the best development of western hemlock. It grows upon various soils, from a mucky lowland soil to almost bare rock; it can thrive on a poor soil on any exposure provided there is an abundance of moisture. Its best growth is attained in moist draws, at the heads of streams, on bottom lands, on well-drained slopes, on poorly drained plateaus which have a high precipitation, and on good, deep, porous soils, usually where the annual precipitation is seventy inches or more. The finest hemlock in Washington grows at elevation of from fifteen hundred to three thousand feet where the annual precipitation averages eighty inches or more.

Tolerance

Western hemlock is one of the most tolerant trees on the Pacific slope; only western red cedar and western yew being more tolerant. Throughout its life it can survive in the understory of a mature stand of intolerant species such as Douglas fir and western white pine, or as the dominant species in a dense stand of tolerant

conifers such as amabilis fir and red cedar. Its seedlings start readily either under the cover of a dense forest or in the open. Thus this species has the advantage over its associates in not being particular as to its light requirements. Shade, however, is not essential to its growth; in fact, it is detrimental to its best development. With the admission of light it recovers from suppression remarkably well.

Owing to its tolerance, western hemlock gains an entrance into all Douglas fir stands where they become decadent and open, resulting in an ultimate stand in which it becomes the predominating species.

Reproduction

Western hemlock is a prolific seeder and is not fastidious as to its seed bed, and it reproduces freely under a wide range of conditions. Open grown trees begin to bear seed when from twenty-five to thirty years old, but trees grown under cover do not bear until considerably later. Some trees bear a few seeds every year, and heavy crops at rather frequent intervals. The seeds are winged, small, and of very light weight, and are widely disseminated by the wind. They germinate readily on moist duff, decaying logs, and stumps; the seedlings that start on the stumps and rotten logs seem to attain a better growth than those that start on the ground, this being due perhaps to the better light

conditions for those germinating above the surface vegetation. The young growth is tolerant of shade, but there is practically no reproduction in the densest woods, except in places where the crown canopy has been opened. On dry, bare, recently burned over land, western hemlock does not seed up to any extent, but as soon as such areas are covered with a slight growth of brush, seedlings come in gradually.

Susceptibility to Injury

Western hemlock is very susceptible to injury. Its shallow root system is exposed to the ground and surface fires, and renders the tree liable to wind throw. The bark is thin and affords little protection against fire and other injury. In old age the tree is subject to attack by several fungi, notably conk, pipe rot, or white pitted rot (Trametes pini), Indian paint fungus or stringy brown rot (Echinodontium tinctorum), and ground rot (Polyporous schwenitzii). These fungi flourish where an abundance of moisture exists, and as it is just such a condition that is favorable to the growth of hemlock, naturally these diseases find excellent hosts upon which to spread and develop.

Western hemlock is generally considered to be less fire resistant than Douglas fir, though for trees of small diameters, the resistance of both species is similar.

The fire resisting qualities of the smaller hemlocks are due to the fact that the bark is harder, firmer, and less resinous than the bark of Douglas fir of the same size. On larger trees, however, the bark of fir is two to six or eight inches thick, while that of hemlock is seldom over one and one-half inches thick. Hence, large Douglas fir is much more resistant to fire. A factor which exposes hemlock to fire injury, particularly, is its habit of germinating upon windfalls, which leaves a portion of the hemlock roots out of the ground when the fallen tree is burned.

Western hemlock does not suffer much from attacks by insects. One species of bark beetle (Hylesinus tsuga Hopk) attacks the living tree, while there are a number of various other beetles that work in the wood and inner bark of injured, declining, or dead trees.

Longevity

Western hemlock is one of the long-lived trees of the Pacific Coast region, though it does not attain the extreme age of either western red cedar or Douglas fir. Many stumps showing between four hundred and five hundred rings have been recorded, but only one tree has been found with over five hundred rings, and that had five hundred forty-three rings at a height of four and one-half feet above the ground, and was sixty inches in diameter.

Rate of Growth

Western hemlock is one of the rapid growing species of the coastal region. It compares favorably with the trees with which it is associated, probably all except Douglas fir. Since it grows under a wide variety of conditions, it has a wide range in height, diameter, and volume growth. When in the dense shade as an understory, its growth is extremely slow. As a dominant and co-dominant tree in a mixed stand, it attains a growth about equal to that of its associates.

The average rate of diameter, height, and volume growth of western hemlock grown under average conditions in western Washington, exclusive of suppressed trees grown in an understory, is shown in Table 1.

Table 2 shows the average rate of diameter growth of western hemlock in mixed and pure stands; and the rate of height growth in a pure stand.

Properties of the Wood

The wood of western hemlock has an unattractive, even grain, and the wood cells are comparatively uniform in size and quality. There is but little variation in the hardness of its springwood and summerwood. It surpasses almost all other softwoods in uniformity of grain and texture throughout the tree. The wood fibres are long and tough, which makes it a valuable pulp wood. Its natural color is a pale yellowish or gray, with the slightest tinge of red.

TABLE 1

Average rate of diameter, height, and volume growth of western hemlock grown under average conditions in western Washington, exclusive of suppressed trees grown in an understory. Diameter based on 552 trees, height on 530 trees, and volume on 550 trees.

Age in Yrs.	Average diameter D. B. H. Inches	Ave. annual growth in each decade Inches	Average total height Feet	Average annual height growth in each decade Feet	Average Volume Board Feet	Average annual vol. growth in each decade Board Feet
10	0.8		7.5			
20	3.3	.25	24.3	1.68		
30	5.6	.23	46.0	2.17		
40	7.6	.20	65.1	1.91	110	
50	9.5	.19	80.3	1.52	150	4.0
60	11.2	.17	93.2	1.29	204	5.4
70	12.8	.16	104.4	1.12	268	6.4
80	14.3	.15	114.3	.99	344	7.6
90	15.8	.15	123.0	.87	433	8.8
100	17.2	.14	130.7	.77	534	10.2
110	18.5	.13	137.5	.68	650	11.6
120	19.8	.13	143.5	.60	779	12.9
130	21.1	.13	148.7	.52	923	14.4
140	22.4	.13	153.3	.46	1081	15.8
150	23.7	.13	157.3	.40	1253	17.2
160	25.0	.13	160.8	.35	1436	18.3
170	26.2	.12	163.9	.31	1628	19.2
180	27.4	.12	166.6	.27	1826	19.8
190	28.6	.12	169.1	.25	2027	20.1
200	29.8	.12	171.3	.22	2230	20.3
210	31.0	.12	173.3	.20	2434	20.4
220	32.2	.12	175.1	.19	2637	20.3
230	33.4	.12	176.9	.18	2839	20.2
240	34.6	.12	178.6	.17	3039	20.0
250	35.8	.12	180.3	.17	3237	19.8
260	36.9	.11	181.9	.16	3434	19.7
270	38.0	.11	183.5	.16	3630	19.6
280	39.1	.11	185.0	.15	3825	19.5
290	40.2	.11	186.4	.14	4020	19.5
300	41.3	.11	187.8	.14	4214	19.4

Table compiled by the United States Forest Service.

TABLE 2

Average rate of diameter growth of western hemlock in mixed and in pure stands; and the rate of height growth in a pure stand.

Age in Yrs.	Mixed hemlock, Douglas fir, and noble fir, Palmer, Oregon: Average D. B. H. Inches	Mixed hemlock, Douglas fir, and noble fir, Palmer, Oregon: Average annual diameter growth each decade. Inches	Pure stand of western hemlock, Pilchuch Block, Snoqualmie National Forest: Average D. B. H. Inches	Pure stand of western hemlock, Pilchuch Block, Snoqualmie National Forest: Average annual diameter growth each decade. Inches	Pure stand of western hemlock, Pilchuch Block, Snoqualmie National Forest: Average total height. Feet	Pure stand of western hemlock, Pilchuch Block, Snoqualmie National Forest: Average annual height growth each decade. Feet
10	1.1		1.4		28.0	
15	3.0	.37	3.6	.40	44.0	2.70
20	4.8		5.4		55.0	
25	6.6	.34	7.0	.29	65.0	1.95
30	8.2		8.3		74.5	
35	9.7	.30	9.4	.21	83.0	1.65
40	11.2		10.4		91.0	
45	12.4	.23	11.4	.18	98.0	1.30
50	13.5		12.2		104.0	
55	14.5	.20	13.0	.15	110.0	1.15
60	15.5		13.7		115.5	
65	16.4	.17	14.4	.13	120.5	.95
70	17.2		15.0		125.5	
75	18.0	.16	15.5	.11	129.0	.90
80	18.8		16.1		134.0	
85	19.5	.15	16.5	.08	138.0	.80
90	20.3		16.9		142.0	
95	21.0	.14	17.2	.06	146.0	.75
100	21.7		17.5		149.0	
105	22.3	.13	17.8	.05	153.0	.65
110	23.0		18.0		156.0	

Table compiled by the United States Forest Service.

TABLE 3

HEMLOCK COMPARED WITH OTHER WELL KNOWN WOODS

ecies	Shearing strength per square inch	Bending: Fiber strength at elastic limit per square inch	Bending: Modulus of rupture per square inch	Bending: Modulus of elasticity per square inch	Horizontal shear per square inch	Compression With Grain: Strength at elastic limit per sq. in.	Compression With Grain: Parallel: Crushing strength per sq. in. Max. Load.	Compression With Grain: Parallel: Modulus of elasticity per sq. in.	Compression With Grain: Strength at elastic limit per square inch	Shear: Strength
	lbs.	lbs.	lbs.	1000lbs.	lbs.	lbs.	lbs.	1000lbs.	lbs.	lbs.
gleaf P.										
uctural	35	3734	6140	1463	353	3480	4800		568	973
mall		4950	9070	1540			4400			
atio		.75	.68	.95			1.09			
rtleaf P.										
uctural	30	3237	5548	1473	332	2460	3435	1548	351	
mall		4360	7710	1395			3570		400	704
atio		.74	.72	1.06			.96		.88	
glas Fir										
uctural	28	3968	5983	1517	166	2770	3495	1414	570	
mall		5272	8280	1597		3500	4030	1925		765
atio		.76	.72	.95		.79	.87	.74		
Larch										
uctural	28	3325	4918	1300	288	2674	3509	1575	456	700
mall		4274	7251	1310			3696	1545		
atio		.78	.68	.91			.95	1.02		
lolly P.										
uctural	31	3040	5084	1387	335	2050	2940	548	500	
mall		4100	7870	1440			3240			680
atio		.74	.65	.96			.91			
arack										
uctural	30	3813	4556	1220	261	2400	3230	1373		
mall		3875	6820	1141			3190			668
atio		.73	.67	1.07			1.01			
Hemlock										
uctural	27	3516	5295	1445	288	2910	3400	1619	465	
mall		4406	7294	1428		2938	3392	1737		630
atio		.80	.73	1.01		.99	1.00	.93		
wood										
uctural	22	3760	4472	1042	302	3194	3882	1240	437	
mall		4750	6980	1061		3490	3980	1222	569	742
atio		.79	.64	.98		.92	.98	1.01	.76	
way P.										
uctural	25	2492	3864	1133	232	2065	2555	1002		
mall		2808	5173	960			2504			589
atio		.89	.75	1.08			1.02			

The wood is of light weight when seasoned, strong, stiff, quite durable--moderately soft and easily worked. In proportion to its weight western hemlock is one of the stiffest and strongest woods among the conifers. It has little tendency for warping or raised grain, does not split easily and holds nails firmly. It is free from pitch and resin, takes and holds stains, paint, and varnish excellently and is a superior wood for enamels. It is odorless and tasteless when dry.

Strength

In strength, ease of working, and freedom from warp and shake, western hemlock differs greatly from the eastern species, whose deficiencies in these respects are its chief drawbacks. Western hemlock cannot be classed in strength with the oaks, red fir, or longleaf pine, nor is it suitable for heavy construction, especially where exposed to the weather, but is possesses all the strength for ordinary building material.

Table 3 shows the strength values of western hemlock compared with other well known species.

Texture and Grain

The grain of western hemlock is rather wide, uniform, straight and somewhat contrastive, and it has a fine texture. The wood is sufficiently soft to be worked well, yet hard and firm enough to be readily dressed to a smooth finish which is capable of taking on an

excellent polish. The gradual change in the character of the cells composing the spring and the summerwood and the compactness and strength of the tissues gives it excellent wearing qualities. The wood fibres are long and tough.

The knots in most cases are so diffused with the clear fibres that they are unlikely to affect the strength or fall out when the wood is dried.

The absence of large and numerous resin ducts disposes of the annoyance from pitch.

Tangentially cut western hemlock presents a very pleasing grain, and when properly stained and polished gives a high class interior finish. There is not much contrast between the springwood and the summerwood, the color being nearly the same throughout, a characteristic that is preferred by many people.

Pitch

Western hemlock is usually considered free from pitch or resin since the resin cells are few and scattered. A microscopical examination will show groups or pockets of these resin cells, but for all practical purposes hemlock can be considered free from pitch.

Weight

The weight of western hemlock varies like most other woods, according to rate of growth, percentage of springwood and summer-

wood, and other factors affecting its structure. Table 4 shows the weight of western hemlock under different ranges of moisture content.

TABLE 4
Weight of Western Hemlock

	Pounds per Cubic Foot		
	High	Low	Average
Green	59	29	39
Air Dry	42	23	32
Oven Dry	35	19	27

Western hemlock, it can be seen from Table 4, is considerably heavy, heavier than most conifers, but is rather light when oven dry. Though fairly light when oven dry it cannot compete with white pine, spruces, or white firs. Weight is a very important factor when considering marketing of woods like hemlock, which is frequently shipped hundreds of miles.

Color and Odor

The green, freshly cut wood is a gray white, often tinged with red which changes to a yellowish brown as seen in piles of air seasoned lumber. The dry dressed stock is a gray white, except for the summer wood which is distinctly brown with a slight tinge of red. The springwood which composes the bulk of the structure, has very little color.

Green hemlock has a noticeable sourness which disappears when the wood is thoroughly dry. The odor is said, however, to return to a certain extent when the wood reabsorbs moisture.

Moisture Content and Seasoning

Green western hemlock contains a relatively large proportion of moisture, amounting to from forty to sixty percent of its oven dry weight. Seasoning is of great importance in reducing the weight of lumber for shipment.

Natural Seasoning: Hemlock dimension stock and boards are very frequently partially air seasoned before shipment. Although there is considerable moisture in the green wood, it loses its moisture fairly readily under favorable drying conditions. Dimension lumber is said to air dry in fifty to seventy days during dry weather. Box boards and other one-inch lumber air seasons in twenty-five to forty days, except during rainy weather.

Air seasoned hemlock contains sixteen to twenty percent moisture.

Artificial Drying: Many inexperienced kiln operators have had a difficulty in drying western hemlock. This wood, however, can be successfully kiln dried under the proper conditions, but, as in air seasoning, this wood drys slowly because of its large moisture content. Because of this excess of moisture there is danger of caseharding, warping, and checking, if the kilns are not properly handled. The checking and warping are frequently caused by excessive surface drying when the lumber has been exposed to the sun before reaching the kiln. Hemlock is a wood that can withstand a high temperature in drying so that a large part

of the moisture can be vaporized by subjecting it to a temperature above the boiling point. Drying can therefore be accomplished without the ventilation and by heating the wood from 212 to 230 degrees Fahrenheit. Under these conditions the wood is kept surrounded by saturated vapor, and the water only evaporated from the wood as fast as it comes from the interior to the surface, without caseharding or surface checking.

The time required for kiln drying depends upon the moisture content of the boards at the time they reach the kiln, the method of stacking, the temperature and the degree of dryness desired by the operator. Under ordinary conditions one inch hemlock can be dried from about forty to sixty percent moisture content in the green material to about three to eight percent moisture content in the dry material, in from fifty to seventy-five hours.

Shrinkage

From observations made by the Forest Service, hemlock does not shrink to a greater extent than most of the wood with which it is in competition, with the possible exception of western red cedar. Measurements on small clear shrinkage specimens show that in passing from the green to the thoroughly dry condition western hemlock shrinks five percent radially, 8.4 percent tangentially, and .08 percent longitudinally, which gives a total volumetric shrinkage of 13.8 percent based on oven dry volume.

The impression that hemlock shrinks more than other woods in drying can be traced to the erroneous belief that shrinkage is in direct proportion to the average green moisture content of the wood, and because hemlock has a relatively high moisture content it has been credited with an excessive amount of shrinkage. Woods do not begin to shrink until they have reached the saturation point, which is about thirty percent for hemlock and is fairly constant for other conifers. The moisture that has evaporated up to this point is the free moisture in the cell cavities and intercellular spaces. All the moisture in hemlock above thirty percent moisture content does not affect the shrinkage of the wood. Compared with other coniferous woods, they all have a fibre saturation point of about thirty percent, so it can be seen that hemlock does not shrink to a greater extent than other of its competing woods.

Hygroscopicity

In protected situation hemlock does not absorb moisture to any great extent from the air, causing it to warp and swell materially, but when it comes in contact with water and extreme dampness it is said to cause considerable annoyance through its character of deformation.

When exposed to moisture it is also said to resume the sour odor characteristic of the green material, which frequently precludes its use for the manufacture of certain materials for containers such as barrels, buckets, and so forth.

The present use of hemlock indicates that it does not give trouble through unusual hygroscopic properties when used for interior purposes.

Durability

Decay: Hemlock is less durable in contact with the soil than many of the woods with which it is called upon to compete and is, therefore, not recommended for use in its natural state where the structure is of a permanent character, if decay is likely to cause deterioration. Its pathological durability, however, may be increased by proper impregnation with wood preservatives and, when so treated, should give satisfaction even in permanent structures.

Marine Borers: Salt water piling of western hemlock is said to be particularly resistant to marine borers, provided the piles are unpeeled, but it is not immune from the attack of borers.

Abrasion: The close, compact structure of the wood of hemlock affords excellent wearing qualities in protected situations, as for flooring, but when exposed to the elements, as in use for ties, is rather rapidly disintegrated through incipient decay, and, for this reason, is frequently thought to have a very poor mechanical life.

Weathering: When unprotected with paints or other preservatives, hemlock is not durable if exposed to the weather in fences

and sheds, since it warps and checks and will decay where water collects and remains. It is satisfactory for exterior use if painted or used in protected situations.

Penetrability With Preservatives

Western hemlock can be easily penetrated "along the grain" with coal tar creosote and other preservatives. In this longitudinal direction four-inch wood paving blocks have been given a complete penetration in from five to ten hours without pressure except the atmospheric pressure produced in the open tank process of impregnation. Radial and tangential penetration is difficult.

Affinity for Paints and Glue: Western hemlock takes paint, stains, and enamels, exceptionally well. It is also very receptive of glue, a quality particularly desirable for use in certain industries.

Tendency to Split in Nailing

Hemlock lumber can be nailed without splitting except when used in very thin pieces. In the form of planing mill products and common boards no difficulty is experienced through a tendency to split. Very thin box boards of this species, however, split more easily than Sitka spruce, its chief competitor in the box industry. Square cut nails greatly reduce splitting, since they tend to cut the fibres instead of pushing them aside, as is done in nailing with the sharp-pointed round nails.

Utilization

The utilization of western hemlock has been on the increase since lumbering began on the West Coast. Even at that, the utilization of hemlock can be increased greatly without using it for purposes to which it is not suited. The using of hemlock for purposes to which it was not suited put a "damper" on the sale of hemlock. The poor quality of the eastern hemlock, which was fixed so well in the minds of lumberman and consumer, put further prejudice on the western species.

The first logging operations on the Pacific Coast left the hemlock standing; these trees left standing formed the principal part of a new forest, and now a good many thousand board feet per acre can cut from the areas. Later, logging methods changed, all trees that interfered with the logging of the more valuable species, Douglas fir, were fallen to lay on the ground where they were destroyed by fire or decay. The few hemlock that were left standing were killed by fire, and on many areas they are still standing only to mark the place where once a virgin forest stood.

Of late, the qualities of western hemlock for certain purposes is becoming realized by the lumberman and consumer; along with a comparatively new industry, pulp, hemlock is now receiving closer attention and as a result the hemlock stands are being more closely utilized. A few years ago the Crown-Willamette Pulp and Paper Company relogged some of their land in which many hem-

lock had been left standing or laying on the ground. On this relogging they realized between eight to twelve thousand board feet to the acre, which is as much as some virgin stands of pine produce. The realizing of its merits and the coming of new uses will see closer utilization of western hemlock.

USES

Rough Lumber

Common Boards: Large quantities of western hemlock boards are sold readily in the local, middle west, and eastern markets.

Hemlock boards are used for concrete work, house sheathing, box and casket manufacture, shelving, and many other uses where a good quality of common lumber is desired. Boards of this species are frequently given preference over other woods.

Dimensions: Some difficulty has been experienced in marketing hemlock floor joists, two by four and other dimension lumber, owing to the fact that it is slightly weaker than Douglas fir, its chief competitor. Discrimination against hemlock on this ground is not justified, however, since it is sufficiently strong to meet the demands of dimension lumber in most building work.

Western hemlock dimension comes straight and when properly seasoned is not inclined to crook or warp. For studding and framing its uniformity of growth and small knots make it interchangeable in strength with Douglas fir. It gives satisfactory

service in some forms of heavy construction, particularly for temporary work in trestles or mine shafts.

Timbers: Western hemlock has been little used for timbers and bridge stringers. This has been mostly due to the belief that hemlock is a weak wood and its tendency to decay. For temporary construction western hemlock should find a place except where the competition of Douglas fir precludes its use. For permanent use western hemlock timbers can be treated, which gives them much more life.

Sawed Ties: Western hemlock has been put to little general use as a tie where it will come in direct contact with the ground, because of its lack of resistance to decay. It has been used in temporary construction of logging roads, side tracks, and spurs on mainlines. Tests have been made which showed that western hemlock ties used in the green state will last from five to seven years. Impregnation with creosote or other preservatives will greatly increase the life of the ties.

Planing Mill Products

Western hemlock is manufactured into all of the planing mill patterns and is readily marketed in competition with other species. The patterns mostly manufactured are flooring, finish, bevel siding, crating, drop siding, rustic, and shiplap. The wood is exceptionally suited to this class of manufacture, since it is soft enough to work easily and yet hard enough to give a smooth surface

when dressed. It is also lighter than Douglas fir when dry, and since it is sold on the same shipping weight, it offers larger profits through under weights.

Flooring: Western hemlock flooring comes in convenient lengths. It is straight, easy to saw, and easy to handle in laying and finishing, making for saving of labor, time, and expense. In fact, it is the equal in manufacture, appearance, and service, of several of the more expensive hardwoods, and it gives the home owner a floor of beauty and durability at a reasonable, moderate cost.

Vertical grain western hemlock makes the ideal floor for gymnasiums, ballrooms, and drill halls, which are subject to heavy wear and frequent sharp blows and shocks, because it is strong and durable, wears smoothly, does not splinter or mar easily, is compact and firm, yet is elastic and resilient, and does not make the players' or the dancers' feet sore. It is much used for these purposes as well as in schools, hospitals, clubs, and apartments. These same qualities in western hemlock vertical grain flooring make it highly favored for floors in factories and industrial plants which must withstand heavy foot traffic and wear from hard truck wheels.

Slash grain western hemlock flooring is recommended for use in closets and pantries, in rooms not subject to heavy wear or which are covered or carpeted and for sub-flooring. This flooring possesses many of the qualities of the vertical grain flooring,

the fibers are well bound and the grain does not raise or separate. It receives the same care in manufacture and seasoning as vertical grain flooring, and its material figures give it a pleasing appearance.

Hemlock is not recommended for flooring that is likely to become wet, because the wood is inclined to warp when exposed to water or extreme dampness.

Interior Finish: For the finish and trim of all kinds of interiors, no wood is better adapted than western hemlock. Probably no other softwood so closely resembles the hardwoods in color, texture, grain effect, finish possibilities, and wear resistance. It offers all the beauty, service, and rich appearance of the more expensive woods at a moderate cost. It is readily adaptable to any artistic design or treatment, and is surpassed by few woods for taking and holding stains, paint, varnish, and enamels. A great variety of effects can be obtained with western hemlock by using stains, reproducing any desired shade, tone, or color. When cut slash grain, the attractive subdued natural fibers of the wood are brought out in charming designs.

Bevel and Drop Siding and Rustic: These products are of less importance than the forms previously mentioned, but they are in constant demand, and their use will increase when the merits of western hemlock become more widely known. The bevel siding of hemlock competes easily with that of western red cedar and Sitka spruce, although they are sold at the same price at the mill.

Car Material: Most of the hemlock manufactured into car material in the past has been shipped in with Douglas fir, but it has many qualities which recommend it for this use, and it is anticipated that in the near future hemlock will be specified in orders for lumber to be used in car construction.

Shiplap and Sheathing: Large quantities of western hemlock lumber are manufactured into shiplap and sheathing, for in these two forms the common lumber is greatly in demand.

Western hemlock is especially favored for sheathing, under flooring and roofing boards. Due to its small, compact wood cells and low specific gravity, and hence high proportion of air voids, western hemlock sheathing is distinctly effective insulator. Western hemlock shiplap, dressed and matched and common boards, are in great demand for sheathing, sub-flooring, and roof-boarding.

Manufactured Products

Boxes and Crates: Western hemlock has been used to a large extent for certain classes of boxes, and has given excellent satisfaction. It has been used in all the common forms of box making, but due to its tendency to split in nailing where small boards are used, it is preferable for the thick ends of boxes and for packing cases and other containers where fairly thick pieces are employed.

Western hemlock is not recommended for use in the manufacture of containers for foodstuffs which are inclined to become tainted should the wood be subjected to dampness and resume its sour odor. It is, nevertheless, well suited to the manufacture of boxes and crates for dry foodstuffs, fruit, canned goods, and a large variety of other commodities shipped in wooden containers.

Sitka spruce is the principal box wood of the Pacific Coast, but owing to the limited and rapidly diminishing supply of this much desired species the relatively high price has produced a general substitution of western hemlock.

Sash and Doors: Although western hemlock does not form a large percentage of the material used for sash and door manufacture, it is well fitted to such use and its limited employment at the present time is attributed to the relatively small amount of this species cut and the lack of knowledge on the part of the manufacturer of the properties of the wood.

Furniture: Western hemlock is a secondary species in the manufacture of furniture, but it has qualities which will meet the requirements for certain purposes in the industry. It is particularly desirable for hidden work such as drawer bottoms, shelves, backs, frames, and the sub-structure of all classes of veneered furniture. It is also employed for kitchen tables, cots, bed springs, kitchen cabinets, and cupboards. It is used in the general construction of enamel bedroom furniture, such as washstands, bureaus, chiffoniers, wardrobes, and beds.

Fixtures: Western hemlock is used to a small extent in the construction of bar, church, office, and store fixtures. It is used principally for shelving, drawer bottoms, cupboards, turned and carved work, and the core for veneered structures. Hemlock has properties which make it preferable to other species of softwoods commonly used for fixtures.

Wooden Ware: Manufacturers of woodenware, such as drain boards, step ladders, clothes racks, and various other wooden household commodities, find in western hemlock properties well suited to their needs.

Caskets: Western hemlock is employed in the manufacture of caskets, coffins, and outer boxes, and in this use readily meets competition with other Northwest softwoods. Theability of this wood to take glue is an important factor in the casket industry, since various parts of the caskets are held together by glue and the cloth covers are fastened to the wood by this means. Furthermore, common lumber is usually employed in casket manufacture, and hemlock is preferred to many other species because the knots are firm and do not drop out when the wood is dried.

Veneer and Baskets: Most of the western hemlock veneer is used in the manufacture of fruit, bread, clothes, fish, and fuel buckets and berry boxes, although a considerable portion is manufactured into both the cores and surfaces of built up stock. It is reported by certain basket makers to be as desirable as Sitka spruce, one of the principal basket woods of the Pacific Northwest.

Western hemlock is readily cut into veneer and the rotary cut surfaces present a very attractive grain which, along with its gluing properties, gives the wood preference over many other softwoods in the manufacture of panels for interior finish.

Slack Cooperage: Western hemlock is employed in the manufacture of slack cooperage in competition with many other species. Its lack of odor when dry and its light color makes it preferable for sugar, flour, and cracker barrels and candy pails, but it is suitable for all classes of slack cooperage. Hemlock used by the cooperage industry is purchased in the form of logs, bolt, or rough lumber.

Pulp

By the sulphite process western hemlock produces a very superior grade of pulp, the fibers being long, white, tough, clean, with very little waste in the form of "shivers" and screening. The sulphite process is used exclusively in mills where a superior strength of paper is desired, such as is employed for wrapping and bag stock. Hemlock is said to require a slightly stronger acid solution and somewhat longer cook than other species manufactured by this process and when used alone produces an average of about one thousand fifty pounds of air dry pulp per cord.

On the basis of amount of wood used, western hemlock is the leading pulp wood in Washington and elsewhere on the Pacific Coast, Sitka spruce ranking second. Both of these woods are in

great demand for newsprint manufacture. About 0.30 cords of Sitka spruce and 0.95 cords of hemlock are required to make one ton of air dry pulp for newsprint.

The amount of different woods used for pulp in Washington is shown in Table 5.

Table 5

Wood Used for Pulp Manufacture in Washington in 1925

Kind of Wood	Cords
Western hemlock	114,890
Sitka spruce	40,184
White fir	38,300
All others	25,774
Mill waste	22,002
Total	241,100

The decrease in the supply of Sitka spruce will see a larger drain on the hemlock stands throughout the Pacific Coast. New and better methods of manufacture are continually finding a way to use the less favored species.

Piles

Western hemlock, except in Alaska, has been used only to a slight extent for piling, but it is as well suited for this class of work as other coniferous species of the Northwest, with which it competes. There are many contradictory statements regarding the value of various Northwest species for piling, but it has been proved that unpeeled western hemlock resists the

attacks of Teredoes (ship worms) and Limnoria (wood lice) provided the bark remains intact. However, where small portions of the bark are scraped off, a condition particularly hard to avoid, these wood destroyers will attack the piles and work up and down inside of the bark, greatly increasing the inefficiency of the piles. Winter cut piles are therefore preferable since the bark is more tenacious.

Where grown in pure stands hemlock produces long, clean boles free from branches which yield excellent forms of piling.

Hemlock is not recommended for piling and trestle work in contact with the soil unless a preservative is used, since the wood is readily attacked by decay. Peeling and seasoning will greatly increase the life of hemlock used under these conditions.

Poles

Western hemlock has never been used extensively for telephone or telegraph poles, owing to the abundance of more desirable species; but it has properties which recommends its use for this purpose, except its tendency to decay which necessitates a preservative treatment. Hemlock has sufficient strength for pole use, and grows in such dimensions as to make it desirable for this work. It can, therefore, be reasonably employed for poles where lines are being constructed adjacent to this species.

Hewed Ties

Western hemlock has only recently been employed for tie timber in the manufacture of hewed ties, because of the large quantities of better species accessible to the various railroads constructed in the regions of its growth. Recently, however, sales of hemlock have been made in the National Forests of Washington, and hewed ties of this species are said to have been used in the construction of permanent tracks.

Hemlock is not recommended for hewed ties where more desirable species can be obtained, unless the ties are treated properly with a preservative, as the hemlock decays quickly in contact with the ground. Hewed ties contain a large amount of sap wood, and tend to decay much faster. Hemlock is recommended for hewed ties in the construction of temporary roads and spurs, where life of from three to five years is sufficient.

Utilization of the Bark

The bark of western hemlock is rich in tannin. Although the bark is thinner than that of eastern hemlock, it contains more tannin. Western hemlock contains ten to fifteen percent tannin, and eastern hemlock contains ten to thirteen percent tannin.

Despite the large supply of western hemlock bark, the cost of harvesting it is high. So far, eastern methods have been used under conditions which differ markedly from those encountered in

eastern hemlock forests. Eastern hemlock trees are relatively small and the bark can be transported easily from the forests. Western hemlock grows to large dimensions in dense stands where the ground is rough and covered with brush. Moreover, the harvesting of western hemlock bark interferes with saw log operations.

The future of western hemlock bark as a source of tannin will be important when the eastern hemlock becomes more scarce and methods are devised whereby the bark can be harvested in connection with the saw log operation. At the present time the tannin industry in the Northwest is just being exploited, and with large virgin stands of western hemlock still standing, the future for tanning looks promising.

Tables 6 and 7 show the amount of bark that can be produced from trees of different diameters and heights in second growth stands and old growth stands, respectively.

MANAGEMENT

The virgin supply of timber in the United States is decreasing annually by forty billions of board feet. At the present rate of cut, one writer predicts "that in thirty-seven years the virgin timber will be completely exhausted." This may be somewhat modified, for a second crop is growing on part of the cut over land which will find its way to the market and lessen the drain on the virgin timber.

The rapidity at which the standing timber is being removed has caused far-sighted timbermen to consider the future. Besides

TABLE 6

Volume of bark per tree and number of trees per cord for second growth western hemlock, lower slope, Cascade Mountain Region. Bark utilized to a point eight inches in diameter inside the bark. One cord equals 2300 pounds of dry bark.

Diameter breast high. Inches	Total height of tree. Feet	Volume of bark per tree. Cubic Feet	Cords of 2000 lbs.: Cords per tree	Number of trees per cord	Cords of 2240 lbs.: Cords per tree	Number of trees per cord
12	120.0	4.80	.07	14.3	.06	16.6
13	127.0	6.05	.09	11.1	.08	12.5
14	133.5	7.25	.11	9.1	.09	11.1
15	139.5	8.50	.13	7.7	.11	9.1
16	145.0	9.80	.15	6.7	.13	7.7
17	150.0	11.10	.17	5.9	.14	7.2
18	154.0	12.40	.19	5.3	.16	6.2
19	157.5	13.80	.21	4.8	.18	5.5
20	160.5	15.35	.23	4.3	.20	5.0
21	163.0	16.90	.25	4.0	.22	4.6
22	164.0	18.55	.28	3.6	.24	4.2
23	165.0	20.25	.30	3.3	.26	3.8
24	166.0	22.05	.33	3.0	.29	3.4
25	166.0	24.00	.36	2.8	.31	3.2
26	167.0	26.00	.39	2.6	.34	3.0
27	167.0	28.00	.42	2.4	.36	2.8
28	168.0	30.00	.45	2.2	.39	2.6
29	168.0	32.00	.48	2.1	.42	2.4
30	168.0	34.00	.51	2.0	.45	2.2

TABLE 7

Volume of bark per tree and number of trees per cord for old growth western hemlock, Coastal Region. Bark utilized to a point eight inches inside the bark.

Diameter breast high. Inches	Total height of tree. Feet	Volume per tree. Cubic Feet	Cords of 2000 lbs. Cords per tree	Cords of 2000 lbs. Number of trees per cord	Cords of 2240 lbs. Cords per tree	Cords of 2240 lbs. Number of trees per cord
12	87	3.7	.06	17.8	.05	20.8
14	106	5.6	.08	11.9	.07	13.7
16	117	8.2	.12	8.1	.11	9.4
18	130	11.8	.18	5.7	.15	6.5
20	138	15.8	.24	4.2	.20	4.9
22	145	20.4	.31	3.3	.26	3.8
24	150	25.3	.38	2.6	.33	3.0
26	154	30.3	.45	2.2	.39	2.5
28	158	35.2	.53	1.9	.46	2.2
30	161	40.3	.60	1.7	.52	1.9
32	165	45.2	.68	1.5	.59	1.7
34	169	50.2	.76	1.3	.65	1.5
36	174	55.3	.83	1.2	.72	1.4
38	178	60.7	.91	1.1	.79	1.3
40	183	66.5	1.00	1.0	.86	1.2
42	188	73.0	1.10	.9	.95	1.1
44	193	80.2	1.20	.8	1.04	1.0
46	198	88.0	1.32	.8	1.14	.9

TABLE 8

NORMAL YIELD TABLE, EVEN AGED HEMLOCK

(Site index based on average maximum height at 100 years.)

Age	Average D.B.H.	Total Height	Total No. Trees per Acre	Total Vol. per Acre. Cubic Feet	Vol. of Trees Over 7 Inches in D.B.H. to 5 Inches Top. Cubic Feet	Present Util. Vol. of Trees 14 Inches and Over Board Feet
			Site Index 60			
40	1.7	23				
60	2.8	38	5420	4440		
80	3.5	50	3550	5850		
100	5.8	60	1406	7170		
120	7.0	69	955	8350	2730	
140	8.0	76	748	9320	4960	
160	8.7	80	640	9890	6340	7350
			Site Index 80			
40	2.9	34	5090	3948		
60	4.7	51	2025	6020		
80	6.9	68	981	8240	2525	
100	8.7	80	638	9860	6760	7290
120	9.7	89	526	11090	8350	18200
140	10.5	96	456	12070	8970	25300
160	11.0	100	419	12610	10500	28300
			Site Index 100			
40	4.2	47	2500	5510		
60	7.1	70	930	8490	2573	
80	9.6	88	535	10930	8120	16890
100	11.1	100	413	12680	10680	29730
120	12.5	109	333	13880	12450	38360
140	13.5	115	292	14800	13680	43800
160	14.3	120	264	15520	14520	60700
			Site Index 120			
40	6.3	64	981	7580		
60	9.7	89	526	11100	8360	18230
80	12.1	107	353	13710	12120	36700
100	14.3	120	264	15520	14480	48400
120	15.7	129	224	16780	15880	58600
140	16.7	136	201	17830	16940	65500
160	17.4	140	188	18450	17450	70600
			Site Index 140			
40	8.6	79	652	9700	6040	6660
60	12.4	108	338	13700	12270	38240
80	15.2	126	237	16390	15400	57300
100	17.4	140	188	18460	17470	70100
120	18.6	148	168	19600	18640	78900
140	19.7	155	152	20620	19700	84200
160	20.5	160	142	21400	20480	88900

looking forward to just another crop, they are considering placing their land under management so that they can cut timber perpetually.

To be an important timber tree of the future, the ease by which it can be worked into a management plan will take an important part. The following plan demonstrates how western hemlock can be managed with the production of pulpwood the main objective.

Rotation

Western hemlock is a very rapid growing tree, comparing well with trees with which it is in competition. On Site Index 120 it grows at the rate of about one and one-half to two cords per acre per year for the first forty or fifty years.

The length of rotation can be determined by considering "the maximum volume production gauged by the culmination of mean annual growth of the stand." From the yield table on Site Index 120 the total cubic foot volume at forty years is 7580 cubic feet. Dividing this volume by forty years gives 189.5 cubic feet as the mean annual increment. In a similar manner the mean annual growth may be computed for sixty, eighty, one hundred, and so on, years. The following table gives the mean annual growth on Site Index 120 land from forty to one hundred sixty years.

TABLE 9

Age	Volume Cubic Feet	Annual Increment Cubic Feet
40	7580	189.5
60	11100	185.0
80	13710	171.4
100	15520	155.2
120	16780	139.8
140	17830	127.8
160	18450	115.3

The table shows that there is a gradual decrease in the mean annual increment after the fortieth year. Data are not available as to the volume of stands under forty years of age, but it can be easily seen that the fortieth year is approximately the year in which the mean annual growth begins to culminate.

A shorter rotation than forty years would more than likely be made at the sacrifice of reproduction, for hemlock does not begin to bear seed until twenty-five to thirty years of age, but by the fortieth year a seed crop can be looked forward to with certainty. The infection age of hemlock occurs when the stand is about sixty years of age, so, on a forty year rotation basis, there is not much danger of the stand becoming diseased.

Cutting

To obtain the best results cuttings should be made in strips or blocks. The strip or block should be clear cut and by having the strips narrow enough and the blocks small enough the area cut will be seeded in from the side. The strips should not be over

twice as wide as the heights of the trees on the uncut strips. Cutting the area in this manner is best, for hemlock, upon becoming exposed, is very easily thrown by the wind if the seed tree or selection methods were used.

Slash

The slash remaining on the area after logging, which will not be great because of the close utilization by the pulp industry, should be left on the area and not burnt. Hemlock seed germinates best on moist duff or soil, and a larger survival of seedlings is noted where they start under partial shade. Burning over the area after logging not only leaves the soil exposed, but also kills all advanced reproduction.

Thorough fire protection may be necessary for the first five or six years after logging to give the slash a chance to decay and the young growth a chance to shade the ground and prevent it from drying. The humidity of the region in which hemlock attains its best growth is fairly high, so the danger of fire is at a minimum. Other enemies such as disease and insects need not be considered in a management plan for a rotation as short as forty years, for within this period hemlock is fairly immune from their attacks.

CONCLUSION

Western hemlock is assured of a place in the future as a Pacific Coast leading species. It covers a comparatively large

range, and furthermore, there is a large volume of the virgin timber still standing. The tree is an abundant seeder, and the seed finds good conditions under which to germinate. The seedlings are tolerant of shade, making the possibility of a second crop a certainty.

The properties of the wood fit it for a wide variety of uses. It may be used in all places in which it is possible to use Douglas fir. Furthermore, western hemlock will be a valuable source of pulpwood and tannin, products which cannot be obtained from Douglas fir. These special uses will, no doubt, have more influence upon the future importance of this tree than any other.

The management of western hemlock is comparatively simple, for it reproduces well under the block and strip systems of cutting. The fire hazard is low, for throughout the range of the tree the climate is humid. Furthermore, during the first thirty or forty years western hemlock grows rapidly and can, therefore, be managed on a fairly short rotation.

With the above points in view, and considering the approaching scarcity of present day important trees, western hemlock will take its place as a future leading tree of the Pacific Coast.

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