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WESTERN LARCH: WEED OR TIMBER SPECIES?

A Professional Paper

by

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B.S., Montana State University, 1949

Presented in partial fulfillment of the
requirement for the degree of Mas-
ter of Forestry.

Montana State University

1950

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William R. Walker

Missoula, Montana
May, 1950.

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INTRODUCTION

Western larch (Larix occidentalis, Nutt.) was first discovered by Lewis and Clark in 1806. Their narrative tells of finding a "larch tree", now believed to be western larch on the upper Clearwater River in western Montana. David Douglas observed this tree on the Columbia River near Ft. Colville in northeastern Washington in 1827; he believed it to be the European larch (Larix europaea, D. C.). In 1834 Thomas Nuttall recognized western larch as a new and undescribed species. He described and named it Larix occidentalis in 1849 (Sudworth, 1918). To avoid confusion only Larix occidentalis will be referred to as western larch or larch in this paper.

There is evidence that the genus *Larix* has existed for millions of years in the north temperate and sub-arctic regions of Europe and North America (Collingwood, 1936). According to Kirkwood (1922) western larch migrated into the Northern Rocky Mountain Region from the north or northwest. The migration has continued, and in places the tree is found east of the Continental Divide in Montana.

There are several reasons for the current unpopularity of western larch. Western larch inherited the name tamarack from (Larix laricina, (DuRoi) Koch) a species indigenous to northeastern United States. The wood of tamarack is inferior in most respects to that of western larch. This inherited misnomer was enough to cause some lumbermen to condemn the

species. According to Anderson (1927) the lumber industry attempted an uncoordinated promotion of larch which placed on the market a very unsatisfactory, poorly seasoned product. After this occurred, larch began to lose popularity with the producer, and it was cut only when absolutely necessary. Finally, the lumbermen accepted the fallacy that larch was poor wood, and dumped the lumber on the market at any price. Since western larch was considered to be an unimportant species, it was seldom studied; when it was, much of the written material was never published.

The use of western larch has increased during the past decade; still the allowable annual cut exceeds the actual annual cut. Improved utilization may be expected when the lumber producers join in marketing a uniform well seasoned product, and the architects and the contractors recognize the proper uses for the wood.

The demand for wood products is increasing annually. Behre and Hutchison (1946) estimated the future goal for wood production of the United States to be twenty billion cubic feet per year; this is about six and one half billion cubic feet more than our lands are now producing. With better logging and milling practices western larch will be in a position to contribute to this increased demand.

The forestry economy of the Inland Empire¹ has been based primarily upon ponderosa pine (Pinus ponderosa, Douglas) and

¹Northwestern Montana, northern Idaho, and eastern Washington.

western white pine (Pinus monticola, Douglas). Much of this timber has been exploited with little thought for future production. In many areas the white pine forests of northern Idaho have been exploited so long there remains no chance to practice sustained yield forestry.

The continued existence of the western white pine industry is also being threatened by disease. White pine blister rust (Cronartium ribicola, Fisher) is difficult and expensive to control. In more recent years an unknown disease called pole blight has been killing the important pole stands. These diseases must be effectively controlled in the near future to save the industry. On areas where it is not considered economical to control blister rust, ponderosa pine is often planted. Many of these plantations are at least partially off site, and are not producing timber at the site potential. Western larch is a species that is ecologically adapted to most western white pine sites.

The primary intent of this paper is to place all the material that can be found on western larch between these covers. An attempt will be made to acquaint the reader with the qualities and uses of the wood, the possible methods of future utilization, and a meager knowledge of the silviculture and management of the species. Throughout this paper western larch will be compared to other species, because the writer believes that only by comparison can the reader be given a thorough understanding of the species.

Western Montana produces approximately sixty-three per

cent of the present annual cut of western larch; forty-five per cent of the remaining volume in the United States is found here.² It seems reasonable that we should be interested in promoting western larch utilization.

² Unpublished United States Forest Service figures, 1945.

RESOURCES

Western larch is one of the comparatively few species in the United States which is not being over cut at present. The most recent inventory of larch was taken by the United States Forest Service in 1945 (Unpublished). The volumes obtained by this survey are presented in Table 1.

TABLE 1. THE STATUS OF WESTERN LARCH STANDS IN 1945 AND 1946, VOLUME IN MILLIONS OF BOARD FEET LOG SCALE (Scribner rule)

State	Remaining Volume	Allowable Annual Cut	Actual Annual Cut
Montana	11,606	130	100
Idaho	5,969	85	40
Washington	5,083	35	10
Oregon	3,494	--	--
Totals	26,152	250	150

Current annual production averages about two hundred million board feet. (Anonymous 1948).

Probably more important are the pole stands which will furnish the lumber in the future. The only available information is based on the stands of western Montana and northern Idaho. (Bradner 1941 and 1943). The data from these two publications were combined and are presented in Table 2.

Larch makes up about one per cent of the total volume of saw timber in the United States, it is exceeded in volume by three hardwoods and ten softwoods. In the Inland Empire it is exceeded in volume only by ponderosa pine and Douglas fir. (Johnson and Bradner 1932).

TABLE 2. THE CUBIC FOOT VOLUME OF WESTERN LARCH AND ASSOCIATED SPECIES (Bradner 1941 and 1943)

Species	Western Montana		Northern Idaho	
	Saw Timber Trees ¹	Cordwood Trees ²	Saw Timber Trees ¹	Cordwood Trees ²
	Volume In Millions Of Cubic Feet			
Western Larch	1,808.8	603.8	869.5	674.6
Western White Pine	172.7	67.5	1,892.2	465.3
Ponderosa Pine	1,421.3	235.6	939.7	311.0
Douglas Fir	1,403.9	1,163.5	1,373.7	930.2
Engelmann Spruce	676.1	151.0	460.0	124.2
Lodgepole Pine	395.7	554.2	188.9	230.0
Western Hemlock	26.8	26.9	188.6	177.1
Grand Fir	56.1	94.9	1,190.9	458.1

¹ Pines over 11 inches d.b.h., other species over 13 inches d.b.h.

² Trees 5 inches d.b.h. to saw timber size.

SILVICAL CHARACTERS OF WESTERN LARCH

Description--Western larch is the largest and most massive of all the larches or tamaracks. Short horizontal branches on a tall straight trunk form a narrow pyramidal crown, which runs to a slender point. The thin open crown usually occupies one half to one third of the total height; trees one hundred and sixty to two hundred feet tall may have as much as one hundred feet of clear bole. The comparatively few horizontal branches have the appearance of being thinly clad with leaves. (Sudworth 1918).

Western larch is characterized by a clear, slightly tapering bole and a swollen butt. Average mature trees are from two to four feet in diameter, and from one hundred forty to one hundred eighty feet in height. Koch (1945) described a tree near Seeley lake, Montana measuring seven feet four inches d.b.h.

The bark of young trees is grayish black and relatively thin. Mature trees have dull cinnamon brown bark, which is three to six inches thick, and deeply furrowed at the base of the tree. This thick protective coat tapers to a thickness of about one inch at the top of the first log. The bark is composed of numerous small, flat, irregularly rounded, overlapping plates. The thin upper bark has a scaly appearance, and often on vigorous trees has a silvery sheen.

The flat, pointed needles, yellowish green in color, are rounded on the back, ridged on the inner surface, and are

from one to one and three quarters inches in length. (Sudworth 1918). Bundles of ten to forty needles are borne on stout scaly spur-like twigs. These twigs are at first pale pubescent, but soon become orange-brown and glabrous. (Morton 1921). The larches are unique members of the Pinaceae family; they are deciduous. Shortly after the first frosts the leaves turn a bright lemon yellow. This distinctive coloring makes the western larch on the mountainside easily identified from great distances. The leaves slowly drop from the trees, and by the first of November the trees are bare. Benson (1916) stated that the new pale green foliage emerges from the chestnut-brown buds in the middle of April.

Western larch flowers during the first part of May. (Benson 1916). Staminate and pistillate flowers are borne on the same tree. The yellow-green staminate strobili are about the size of peas; on the same twig are small, scaly, bright purple or red pistillate strobili. These, when fertilized, develop into the broadly egg shaped cones. (Collingwood 1936).

The cones mature in one season, and are from one to one and one half inches long, short stalked, and purplish red to reddish brown in color. The broad cone scales are occasionally finely toothed at the tip of the reflexed apex. The slender exserted bracts are terminated in a long spike. (Harlow and Harrar 1941).

Seed Habit--Western larch is a prolific seeder. It is locally variable in seed production, and sterile periods of

one or more years are common. (Sudworth 1918). Koch (1927) stated that larch bears some seed nearly every year, and a good crop every five or six years. Benson (1916) agrees with these authors in part, but says, "The occurrence of seed years with any suggestion of uniformity is a myth." This is substantiated by Haig (1941) who kept record of the cone crop in northern Idaho for eight consecutive years. His record showed three consecutive poor years, three consecutive good years, and two consecutive fair years.

Larch begins to bear seed at the age of twenty-five to thirty years. (Benson 1916 and Sudworth 1918). Heavy crops are borne after eighty years, and full seed capacity continues to a least four hundred fifty years. The optimum age for seed production is one hundred to two hundred years. (Benson 1916). According to Miller and Cunningham (1927) the best seed producers are vigorous trees with a good portion of the crown exposed to full sunlight.

The seed ripens during the latter part of August and the fore part of September. (Benson 1916). The thin cone scales open and close readily with alternate periods of dry and wet weather, so that the period and rapidity of seed dispersion varies with local climatic conditions. (Pinchot 1907). The writer has observed that some of the cones are persistent, and remain on the trees for one or more seasons.

The seed is small, winged, and chestnut brown in color. (Collingwood 1936). Olson (1930) said the number of seed per pound varies from 98,000 to 152,000. Tillotson (1917) found

that there is one half pound of seed in a bushel of cones. According to Benson (1916) ninety per cent of the seed is disseminated within three chains of the parent tree, ninety-five per cent within five chains, and the remaining five per cent at a distance of five to ten chains.

Root System--Western larch develops a root system ten to twelve inches long the first year. (Benson 1916). Larsen (1916) found that in deep soils the root at ten to fifteen years is a long slender tap with beginnings of laterals five to six inches below the soil surface. These laterals are confined to a vertical distance of not over six inches on the tap root. At fifty years the tap root is thicker, but has not grown proportionately in length. The laterals have enlarged and produced vertical roots which do not branch immediately, but are lost in ramification about two feet below, well within the hard substratum. In gravelly soils and on slopes the main laterals are fewer, larger, strike deeper, and have fewer small vertical roots. This, according to Whitford (1905) is one of the reasons larch is able to exist on drier sites.

Wind Firmness--The deep extensive root system makes western larch the most windfirm tree in this region. Benson (1916) attributes windfirmness to the small, thin, open crown, and the comparatively slender bole. Whitford (1905) found many western larch standing in windfalls where western white pine, Engelmann spruce (Picea engelmannii (Parry) Engelm.), and grand fir (Abies grandis Lindl.) had been blown down. Marshall (1928) compiled a windfirmness scale; the species

range from the most windfirm to the least: Western larch, ponderosa pine, Douglas fir (Pseudotsuga taxifolia (Lamb.) Brit.), western redcedar (Thuja plicata D. Don.), western white pine, lodgepole pine (Pinus contorta Douglas), western hemlock (Tsuga heterophylla (Raf.) Sarg.), grand fir, alpine fir (Abies lasiocarpa (Hook.) Nutt.) and Engelmann spruce.

Fire resistance--All sources concur that mature western larch is the most fire resistant species in this region. Benson (1916) believed that the physical factors which make larch so fire resistant are: (1.) The deep root system. (2.) The lack of resin in the thick bark. (3.) The loose texture of the bark which makes it a poor heat conductor. (4.) The small amount of resin present in the wood. (5.) The clean bole. (6.) The small amount of resin in the needles. (7.) the thin crown. (8.) The open nature of mature stands. Young larch are not so fire resistant, and are quite easily destroyed.

Longevity--Western larch is ordinarily a long lived tree. Benson (1916) wrote that it was not unusual to find entire stands which belong to the advanced age class of four hundred to five hundred years. He attributed great age to fire resistance, windfirmness and comparative freedom from insects and disease. Larson (1916) found that isolated trees representing different age classes, and bridging several fires were a common occurrence. These trees tend to become more secure after each fire because they become more isolated. Benson (1916) reported a sound stump near Fortine, Montana, that showed an age of 835 years. Koch (1945) made a ring count

on a six foot six inch d.i.b. stump near Seeley lake, Montana, and found 915 rings.

Growth--According to Benson (1916) western larch can attain a better development when subjected to a variety of conditions than would any other species; however, its best development occurs in the western white pine type.

Brewster (1918a) found that height growth began at Priest River, Idaho, in the latter part of April or the first part of May, and was completed for the season by the middle or end of July.

Larsen (1916) made a study in Idaho of a larch-spruce mixture located on nearly level land along a small creek. His results indicate that the average larch at one hundred ten years of age has a d.b.h. of 15.8 inches and contains 288 board feet. The following table constructed from data obtained from larch Douglas fir slopes represents an approximate average of all sites, and shows the relationship between height, volume, and age.

TABLE 3. HEIGHT VOLUME AND AGE OF WESTERN LARCH: AN APPROXIMATE AVERAGE OF ALL LARCH-DOUGLAS FIR SITES. (Larsen 1916).

Age	50	60	70	80	100	120	140
Height	50	58	65	70	82	90	94
Volume b.f.	5	10	20	30	55	85	120
Volume cu.ft.	3.8	4.8	6.7	8.9	13.2	19.0	26.0

Cunningham and Fullaway (1926) made some comparisons of the height and diameter growth in mixed stands on the Kaniksu Forest, Idaho; the results indicate that western larch at one

hundred years of age was one hundred twenty-five feet high and 14 inches in diameter, while western white pine was one hundred fourteen feet high and 11.8 inches in diameter. In Douglas fir mixtures larch is invariably taller, although the fir maintains about the same diameter relationship. Other measurements taken on the Kootenai Forest, Montana, indicate that on Site I the average diameter of larch is 14 inches at ninety years. A yield table compiled from a comparatively small number of plots in fully stocked stands on the Lolo Forest, Montana, indicated an average volume of 15,077 board feet per acre at one hundred years. (Cunningham and Fullaway 1926).

Brewster (1919) made an extensive study of the growth rates of larch in western Montana. These results are presented in Table 4.

TABLE 4. GROWTH RATE OF WESTERN LARCH IN WESTERN MONTANA, AVERAGE OF ALL SITES. (Brewster 1919).

Age Class	Number of Trees Measured	Average D.B.H.	Average Rings Last Inch
20	33	3.6	16
40	73	5.1	25
60	147	6.1	31
80	238	8.7	31
100	339	10.1	35
120	322	11.4	39
140	253	12.5	42
160	347	12.5	46

All of the preceding growth data were obtained from stands where no management or silviculture was practiced.

In Table 4 the reader can see that the diameter growth of larch slows appreciably as the stand increases in age. The writer believes that this is a result of the inability of larch to maintain a crown of sufficient size to sustain rapid growth when it has been subjected to side shading after height growth abates.

Distribution--The range of western larch extends from southeastern British Columbia south along the west slopes of the Continental Divide in northwestern Montana; west through the panhandle of Idaho, including the territory for some distance south of the Salmon River; west to the eastern slopes of the Cascades in central Oregon; northward through eastern Washington, into British Columbia and terminating about one hundred miles north of the United States-Canadian border. Larch is found in its greatest abundance on the watersheds uniting to form Flathead Lake in Montana. (Benson 1916). A range map is presented in Figure 1.

Tolerance--Larch is one of the most intolerant of the western coniferous species. Pinchot (1907) stated that larch is intolerant throughout life, probably demanding more light than ponderosa pine. Subsequent investigation and observations by Brewster and Hansen (1915) and Kirkwood (1922) indicate that larch is not as intolerant in the initial stages of life as Pinchot believed. Sudworth (1918) claimed that the disadvantage of intolerance is partially overcome by early rapid height growth which carries the crown above its suppressing, heavier foliated associates.

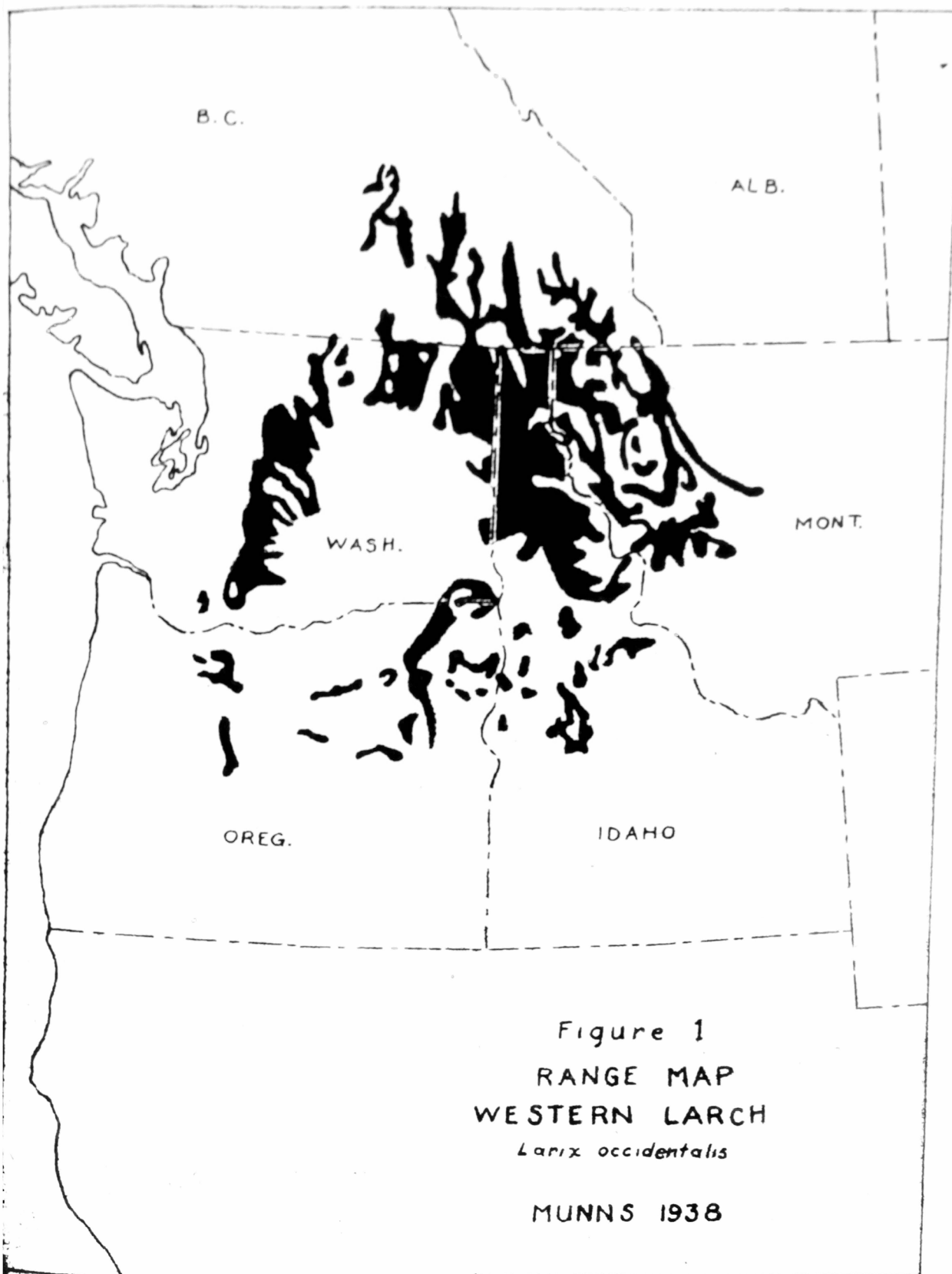


Figure 1
RANGE MAP
WESTERN LARCH
Larix occidentalis
MUNNS 1938

The intolerant character of larch probably accounts for its clear bole, since the lower branches of the crown die when they are shaded to any great extent. According to Larsen (1916) mixed larch stands prune themselves remarkably well up to the base of the live crown. Benson (1916) found that moderately dense stands of larch begin to self prune in twenty years.

Larch is a secondary species in forest succession because of its intolerance. It will not reproduce under the relatively thin crowns of the parent tree; hence, the ground is claimed by the more tolerant species. (Miller and Cunningham 1927). Whitford (1905) states that in no instance was a seedling observed growing in the shade of the forest. Under natural conditions larch is retained in the forest by fire. After severe burns stands of pure larch occur. This is due to the seed furnished by the fire resistant mature trees.

Larsen (1940) claims that the general order of secondary succession in northern Idaho is from ponderosa pine or larch through western white pine to the western redcedar-hemlock climax.

Description of Stand---Western larch normally exists in mixed stands; on drier sites it occurs in open stands with ponderosa pine and Douglas fir; where moisture is more plentiful it is found in more dense stands with western white pine, Engelmann spruce, western hemlock, alpine fir, and lodgepole pine; in the moist bottoms its associates are western redcedar and grand fir and western hemlock. According to Benson

(1916) larch never exists in pure stands after eighty years. Normality decreases from one hundred per cent at eighty years to sixty per cent at two hundred fifty years to twenty per cent at four hundred fifty years.

Altitudinal Distribution--The altitudinal distribution of western larch is from 1,800 to 5,800 feet. The optimum elevation is slightly less than 3,000 feet. (Benson 1916). Pinchot (1907) stated that the altitudinal distribution of this species is from 2,000 to 7,000 feet. The writer believes that 7,000 feet is rather high; near Missoula, Montana, which lies in the southeastern corner of the larch range, larch is rarely found above 6,000 feet.

Associated Species--The large difference in altitudinal extremes, and ability of larch to grow on both moderately dry and moist sites implies that it will have a great number of associated species. At the higher elevations it is commonly associated with Engelmann spruce, alpine fir, and lodgepole pine. The associated species at moderate elevations are: Engelmann spruce, alpine fir, grand fir, Douglas fir, western white pine, western hemlock, and ponderosa pine. At the lowest elevations its associates are: western redcedar, western hemlock, western white pine, grand fir, ponderosa pine, and Douglas fir. In the first rotation following a severe fire larch will appear with all species below 5,000 feet. (Larsen 1916). According to Larsen (1930) the vegetation found within or underneath larch stands is as follows:

Amelanchier alnifolia Nutt. June berry
Arctostaphylos uva-ursi (L.) Spreng.. Kinnikinnick

<u>Antennaria rosea</u> (D.C. Eat.) Green. . . . .	.Everlasting
<u>Antennaria racemosa</u> Hook. . . . .	.Everlasting
<u>Berberis repens</u> Lindl. . . . .	.Oregon Grape
<u>Calypso borealis</u> Salisb..- - - - -
<u>Castilleja miniata</u> Dougl. . . . .	.India paint brush
<u>Ceanothus velutinus</u> Dougl.. . . .	.Mountain balm
<u>Chimaphila umbellata</u> (L.) Nutt. . . . .	.Princess Pine
<u>Drymocallis glandulosa</u> (Lindl.) Rydb.- - - - -
<u>Fragaria</u> spp. . . . .	.Wild Strawberry
<u>Linnaea borealis</u> L. . . . .	.Twin Flower
<u>Lonicera utahensis</u> Wats.. . . .	.Honeysuckle
<u>Pachystima myrsinites</u> Raf.. . . .	.Goat brush
<u>Symphoricarpos racemosus</u> Mich.. . . .	.Snowberry
<u>Shepherdia argentea</u> Nutt. . . . .	.Silver brush
<u>Sorbus angustifolia</u> Rydb. . . . .	.Mountain ash

CLIMATIC AND EDAPHIC FACTORS

Temperature--Western larch is a tree of the cooler regions. Pinchot (1907) claimed the seasonal variation in temperature was from minus 30 degrees Fahrenheit to 100 degrees Fahrenheit, while Benson (1916) set the seasonal variation at minus 40 degrees Fahrenheit to 95 degrees Fahrenheit, with the period of extreme heat not over forty-five days in duration. Generally, two months in the middle of the growing season are frost free. Kirkwood (1922) is of the opinion that although larch endures a considerable diurnal range of temperature, it is distinctly a tree of the cooler regions.

Precipitation--Larch requires a minimum of sixteen inches of precipitation annually; optimum growth occurs where it receives thirty inches or more. (Benson 1916). According to Collingwood (1936) the larch region is characterized by long winters with moderate to heavy snowfall, frequent rains in the spring and fall, and hot dry summers. Whitford (1905) classified the larch-Douglas fir forest as a mesophytic plant formation.

Aspect--Larch seeks the mesophytic sites, avoids ridges and slopes exposed to drying winds and maximum ranges in temperatures. (Larsen 1916). Ideal sites are the lower north and east aspects. (Cunningham and Fullaway 1926). Benson (1916) found that slope has little influence on growth; a well watered southerly aspect is very favorable, and excellent growth is attained on flats and benches.

Soil--Larch makes better growth on a greater variety of soils than any of its associates. The best soils are well

watered, well drained, deep, sandy clay-loam. (Benson 1916).
Judworth (1918) found that the best growth is attained on
soils supporting Engelmann spruce, western redcedar, western
hemlock and western white pine.

FACTORS CONTROLLING THE INITIAL ESTABLISHMENT OF WESTERN LARCH

Natural regeneration of any species is desirable because it is the most economical way to reproduce a forest; it is not always the most dependable because many factors influence survival. Fisher (1935) believed that factors influencing survival were more important than factors affecting germination in determining the species composition of forests.

Seed Bed Requirements--Like all fire species, larch requires a burnt mineral soil for prompt regeneration. (Benson 1916, Larsen 1916). According to Benson (1916) unburned mineral soil and scorched duff are not as favorable as burnt mineral soil for seed beds. Duff is not a favorable seed bed for any species except in places where moisture does not become a critical factor. (Larsen 1924). In such places there usually is so little light that larch does not survive.

Drought--Moisture is one of the more critical factors in the survival of seedlings. (Haig 1936). Although larch is capable of developing an excellent root system during the first year, (Benson 1916) rapid drying of the surface layers of the soil often overtakes root penetration. (Haig 1936). According to Larsen (1940) it is certain that both larch and ponderosa pine possess a market advantage over western white pine, the firs, western hemlock and western redcedar in a more rapidly developed tap root. Haig (1936) shows Douglas fir and grand fir roots penetrating deeper than western larch on his part shade and full shade stations, but on the full

sun station larch had the deeper root system.

Haig (1936) conducted an extensive experiment at Priest River, Idaho, on the survival of seedlings in 1932 and 1933. The precipitation during the 1932 growing season, May through August, was 19.1 per cent below normal; precipitation during the 1933 growing season was 34.6 per cent below normal. These seasons were regarded as moderately severe to very severe from the stand point of seedling survival. The drought mortality from this experiment is indicated in Table 5.

Insolation--Haig (1936) found that heat girdling, caused by high soil surface temperatures, was the major physical causal agent of seedling mortality. In 1932 temperatures of 135 degrees Fahrenheit and over were reached fifty-six times on duff surfaces, sixteen times on mineral surfaces, and thirty times on burnt mineral soil surfaces. The highest daily maxima recorded were 160 degrees Fahrenheit on duff, 144 degrees Fahrenheit on mineral, and 151 degrees Fahrenheit on burnt mineral surfaces. In 1933 the number of days which the soil surface temperature exceeded 135 degrees Fahrenheit were: sixty-eight on duff, twenty on mineral, and thirty-eight on burnt mineral. The insolation deaths of seedlings are presented in Table 5.

Competition--Larch reproduction does not come in well on logged areas where there is considerable overhead shade and a heavy ground cover of brush and grass. (Brewster and Hansen 1915). Conditions may exist where individual herbaceous and other plants would reduce the effect of climatic

TABLE 5. SEEDLING MORTALITY¹ CAUSED BY PHYSICAL FACTORS
IN 1932 AND 1933. (HAIG 1936)

Factor & tree species		Mortality percentages, by surface soil material, in terms of residual seedlings								
		Station 1 100% Sunlight			Station 2 24.3% Sunlight			Station 3 4% Sunlight		
	Mineral	Burnt Mineral ²	Weighted Average	Mineral	Burnt Mineral ²	Weighted Average	Mineral ²	Duff	Weighted Average	
Insolation										
Western white pine.....	55	66	60	6	22	14	0	0	0	
Douglas fir.....	78	84	81	9	19	14	0	0	0	
Western larch.....	74	79	75	16	32	24	0	0	0	
Lowland white fir ³	91	86	88	6	12	8	0	0	0	
Western hemlock.....	62	56	58	33	41	37	0	0	0	
Western redcedar.....	71	80	75	38	35	37	0	0	0	
Average.....	72	75	73	18	27	22	0	0	0	
Drought										
Western white pine.....	8	6	7	7	1	7	47	34	41	
Douglas fir.....	6	4	5	1	1	1	16	20	17	
Western larch.....	4	4	4	1	3	2	90	94	93	
Lowland white fir ³	1	2	1	0	0	0	8	24	16	
Western hemlock.....	37	43	39	16	19	18	93	97	95	
Western redcedar.....	28	20	24	2	10	6	51	68	60	
Average.....	14	13	13	3	6	5	51	56	54	

¹Figures presented are averages of 1932 and 1933.

²Including charcoal quadrat values.

³1933 values only.

extremes and protect young larch. (Larsen 1940).

Pinchot (1907) believed that the chief competitor of larch is lodgepole pine, the soil conditions for reproduction of both are very similar. The order of reproduction depends upon which species seeds the area first. If lodgepole has the start it shades out the larch, but if both start together, larch preserves its position by more rapid height growth. Larsen (1940) claims that competition between larch and Douglas fir is chiefly for soil moisture, and that in competition between larch and ponderosa pine, lack of soil moisture favors the pine.

Light Requirements--Western larch reproduction may not be as intolerant of overhead shade as is commonly thought. Kirkwood (1922) found that larch seedlings made more rapid height growth in half shade than they did in the open. Brewster and Hansen (1915) made these interesting observations in the Flathead National Forest, Montana. One observed area had been culled for ties, and later (1910) burned over by a surface fire. In 1915 there was a well distributed, well stocked stand of three to five year old larch. A road through the area stopped the fire; beyond this road, although the cuttings were approximately the same, practically no reproduction was found. The other observation made by these men was under a mature stand of larch through which a ground fire had run. Larch reproduction was seen growing well into the timber where there was considerable shade. The writer has also observed larch reproduction growing under mature larch

where a ground fire had either prepared a seed bed or eliminated competition. Perhaps both factors are involved.

Haig (1936) found that larch seedlings when grown in full shade (1933), had roots 0.5 to 1.8 inches long at the end of the first growing season, while those grown on the full sun station developed roots 6.1 to 13.4 inches long in the same period. He concluded that lack of light is not a direct factor in initial mortality, although it may be an important indirect factor in survival through its effect on root penetration.

Full shade (five per cent sunlight) appears to adversely effect the root penetration of the tolerants as well as the intolerants. The writer, using Tables 39 and 41 in Haig (1936), calculated the per cent difference in root penetration between the full sun station and the full shade station on July 29, 1933. The root penetration of the full sun station was taken as one hundred per cent, these percentages are as follows: western white pine 25.8, western larch 13.4, Douglas fir 30.6, lowland white fir 31.8, western redcedar 37.9, and western hemlock 37.5. Apparently dense shade does not provide any of the species with sufficient light to synthesize carbohydrates at their full capacity; thus, root penetration is adversely effected.

Damping-off--Certain diseases generally grouped under the heading of damping-off cause serious seedling mortality. These diseases have been chiefly the concern of nurserymen, but the existence of the causal agent in the forest is well

known. (Hubert 1931). So many common soil fungi are capable of attacking coniferous stems that the total absence of such attacks would be surprising. (Rathbun-Gravatt 1925).

Some fungi can attack the unruptured seed, while others are capable of killing the seedling before it appears above the ground. (Rathbun-Gravatt 1931).

Frost Damage--Occasionally larch suffers from frost damage, but the damage does not noticeably extend beyond the current season. (Benson 1916).

Nursery Practice--There has been little reason to reproduce larch in nurseries, but it has been grown at the United States Forest Service nursery at Haugan, Montana, on more or less an experimental basis.

Wahlenberg (1926) found that the seed of western larch exhibited some delayed germination. According to Olson (1930) the average (1911-1927) germination of western larch seed was thirty per cent. He found that fall sowing in the field resulted in better germination, although larch could be satisfactorily germinated from spring sown seed if it were first soaked for five days in tepid water. The minimum time for satisfactory germination of larch from greenhouse tests at Savenac nursery was sixty days.

The results of Fisher's experiments were published in 1935. This experimental work on germination was done in a greenhouse with all types of natural soil surfaces used as seed beds. Fisher used one hundred days for the germination

period this, the writer believes, is too long to be significant for most nursery work. The results of Fisher's work are presented in Table 6.

TABLE 6. COMPARATIVE GERMINATION OF WESTERN LARCH AND SOME ASSOCIATED SPECIES ON VARIOUS TYPES OF SURFACE SOIL MATERIAL. (Fisher 1935).

Surface Material and Character of the Stand	Per cent Germination 100 Days			
	Western Hemlock	Western Larch	Western 1 yr.seed	White Pine 2yr.seed
Duff: Part.cut w.w.p.	4.6	8.8	13.8	2.2
Duff: Virgin w.w.p.	23.6	40.8	20.2	1.8
Duff: Virgin Mixed Stand	7.0	31.2	18.2	1.6
Duff: 80 Year w.w.p.	10.6	29.4	15.6	4.0
Bare Mineral Soil	7.8	11.2	21.6	4.4
Ashes	11.8	30.4	35.8	10.0
Duff	13.8	13.2	29.0	5.4
Rotten Wood	6.4	36.0	26.6	5.8
Sand	13.0	22.8	21.0	3.0
Average Germination	10.9	24.8	22.4	4.2
Viability Per Cent				
Knife Test.....	22.0	48.0	97.0	86.0

Wahlenberg (1926) found that drilling seed (planting in rows) resulted in more rapid germination, but he found that broadcasting (scattering) was better because it was cheaper, and a few more seedlings were produced per square foot of seed bed.

Kirkwood (1928), Wahlenberg (1926), and Olson (1930) agree that larch requires shade the first year in the seed bed. Wahlenberg (1926) said that no shade was required during the second year.

Kirkwood (1928) did some experimental nursery work at Montana State University in 1912-1916. The natural conditions

under which the nursery was established and conducted were those of the semi-arid grassland. Some irrigation was done during the dry part of the summer. In this experiment two types of lath shade were used, both types provided half shade. The low shade was eighteen inches above the seed bed, but after the first season it was removed entirely. The high shade was enclosed with half shade sides, this simulated a good forest shade and cut down reflected light as well as direct light. The data presented in Tables 7 and 8 were obtained from seed sown in 1912.

TABLE 7. THE RECORD OF SEED OF SIX SPECIES FROM TWELVE LOCALITIES SHOWING THE SURVIVAL AT THE END OF THE FIRST SUMMER. (Kirkwood 1928).

Species	Seed Source	Viabil. ¹	High Shelter		Low Shelter	
			Seed	Per Cent Survival	Seed	Per Cent Survival
West. Wh. Pine	N. Idaho	85	1 lb.	1.25	1 lb.	3.5
West. Wh. Pine	W. Mont.	91	1 lb.	0.70	1 lb.	3.3
Ponderosa Pine	Idaho	94	4 oz.	28.30	4 oz.	7.7
Ponderosa Pine	N. Calif.	91	8 oz.	40.00	24 oz.	10.4
Lodgepole Pine	Wyoming	96	4 oz.	0.60	3 oz.	3.6
Western Larch	N. Wash.	43	12 oz.	0.80	12 oz.	5.0
Engel. Spruce	Idaho	91	1 oz.	0.80	2 oz.	2.8
Engel. Spruce	E. Wash.	74	12 oz.	0.90	12 oz.	3.0
Engel. Spruce	Colo.	97	1½ oz.	1.60	2 oz.	9.9
Douglas Fir	W. Oregon	74	12 oz.	7.40	12 oz.	8.9
Douglas Fir	W. Wash.	94	7 oz.	4.80	8 oz.	6.3
Douglas Fir	Wyoming	46	3 oz.	9.50	4 oz.	5.5

¹ Viability apparent from physical examination.

The greatest height growth at the end of the first season was by Douglas fir (coast) with four and one half inches. At the end of the second season the Douglas fir was exceeded by larch with thirteen inches, which increased to fifty-nine inches by the end of the fourth season. The more significant average heights are presented in Table 8.

TABLE 8. AVERAGE HEIGHTS OF SEEDLINGS UNDER HIGH AND LOW SHELTER. AFTER THE FIRST YEAR THE LOW FRAMES WERE REMOVED LEAVING THE SEEDLINGS FULLY EXPOSED (Kirkwood 1928).

Species	Seed Source	Average Height--Inches					
		In 4 Months		In 2 Years		In 4 Years	
		High	Low	High	Exposed	High	Exposed
West. Wh. Pine	N.Idaho	0.75	1.25	2.5	3.0	10.0	9.0
West. Wh. Pine	W.Mont.	1.50	1.00	2.0	2.5	8.0	8.0
Ponderosa Pine	Idaho	1.50	2.00	5.0	4.0	14.0	18.0
Ponderosa Pine	N.Calif.	1.50	1.50	3.0	3.0	7.0	15.0
Lodgepole Pine	Wyoming	0.50	1.00	3.0	4.0	16.0	18.0
Western Larch	N.Wash.	1.00	1.00	10.0	8.0	----	40.0
Engel. Spruce	Idaho	0.25	0.37	1.5	2.0	6.0	6.0
Engel. Spruce	E.Wash.	0.37	1.50	1.5	3.0	9.0	9.0
Engel. Spruce	Colo.	0.50	1.00	1.5	1.5	6.0	6.0
Douglas Fir	W.Oregon	2.50	2.00	5.0	4.0	19.0	12.0
Douglas Fir	W.Wash.	2.00	2.00	8.0	--- ¹	25.0	13.0
Douglas Fir	Wyoming	1.00	1.00	4.0	4.0	10.0	10.0

¹ Tops winter killed.

After 1916 the seedlings were abandoned in the beds in which they were sown. Eleven years later (1927) there remained a number of ponderosa pine three to eleven feet high. The maximum height of lodgepole was twelve feet and the maximum height of larch was eight feet. Douglas fir had been practically eliminated, and none of the other species remained. Kirkwood said, "That larch has survived at all is noteworthy, sensitive as it is to drought."

Field Plantings--A very limited number of field plantings of larch have been made. Many of these plantings were made in 1911 and 1912, and some of these were planted out of the natural range of the species. The majority of the plantings were classed as failures. All classes of nursery stock were

used, 2-0, 3-0, 1-2, and 2-1. One plantation of 2-0 stock was classed as a partial success. (United States Forest Service Planting Records). Brewster (1918b) claimed that larch stock should be at least three years old, either seedlings or transplants. The writer believes that these limited number of plantings are not representative of the type of planting which is being done at present.

The writer believes that larch should be planted to a 12 x 12 foot spacing. With such a spacing a crop of poles could be removed, and the well spaced remaining trees could later be harvested for saw timber.

SILVICULTURE AND MANAGEMENT OF WESTERN LARCH

Western larch cannot be adapted to any of the silvicultural systems which perpetuate an all aged forest. Although western larch seedlings are not as intolerant as was once thought, the writer found no instance where larch was



Logged larch-Douglas fir and ponderosa pine forest. Note the larch reproduction in the center of the picture.

cast burning. Benson (1916) found that larch would satisfactorily restock an area for five chains from the parent tree.

reported as advanced reproduction. This, of course, does not imply that larch reproduction will not be found on logged areas where large openings have been made in the forest canopy.

The writer believes that there are several ways in which larch can be naturally perpetuated in the forest. The use of fire as a silvicultural tool is of prime importance in each case.

1. Clear cut in strips ten chains wide, and dispose of the slash by broadcast burning.

2. Clearcut leaving two or three vigorous seed trees per acre, broadcast burn the slash. Benson (1916) wrote that one seed tree would satisfactorily restock an acre within three years. The wind firmness, fire resistance, and long life of larch make it an excellent seed tree risk. These seed trees should furnish quality timber at the end of the rotation.

3. Broadcast a light surface fire over the area three to five years prior to logging. Clearcut when the reproduction is established. No slash disposal is necessary, since larch slash presents little fire hazard after the first year following logging.

The term clearcutting in the western United States is a figure of speech. It merely means that all merchantable timber is removed from the stand. The size of the remaining trees will vary, depending upon the price of lumber, from twelve to twenty inches d. b. h. The better a logging community is equipped to produce salable products from the available timber supply, the smaller the minimum diameter limit will be; thus, a community equipped to make lumber, veneer, treat poles and fence posts, produce pulp, and wood fuel products will utilize smaller trees, and all of the forest species. If all of the production of the forest can be utilized, the logged area will be ready to produce the more important intolerant lumber species without extensive seed bed preparation entailing liberation, cuttings, and/or, girdling and poisoning work.

Recovery After Release--One of the reasons for partially cutting a forest is to provide the reserve trees with a greater abundance of the essential growing factors to accelerate growth rate. (Roe 1948c). Larch shows various response to release. Benson (1916) found that larch would readily respond to release up to the age of eighty years, thereafter it decreased so that after two hundred years recovery is slight. Warner (1921) stated that larch on cut-over lands recovered from suppression, and responded to thinning. The increased growth rate was maintained for ten to thirty years, and in some cases the increase was from sixty rings per inch to eight rings per inch.

A study of representative cuttings made in the larch Douglas fir forests twenty to forty years ago in the vicinity of Kalispell, Montana, was published in 1937. (Anonymous). This study was based upon eighty-six sample plots located on fair to good sites. The results are presented in Table 9.

Roe (1948a) constructed a chart for classifying the vigor of western larch and Douglas fir trees. The factors affecting vigor, which are used in this classification are:

1. Position of the tree in the stand
2. Size and condition of crown
3. Age
4. Disease (Mistletoe)

The three classes of trees were designated as: (A) good vigor, (B) fair vigor, and (C) poor vigor. The classifications are shown in Table 10.

In a study of an old logging area Roe (1948b) found that larch made insignificant growth after logging. This was

TABLE 9. AVERAGE DIAMETER BREAST HIGH IN INCHES, BEFORE AND AFTER PARTIAL CUTTING OF THE STAND, FOR WESTERN LARCH, DOUGLAS FIR, AND ENGLEMANN SPRUCE, GROWING ON FAIR TO GOOD SITES (ANONYMOUS 1937)

Diameter at indicated number of years before cutting		Diameter at time of cutting	Diameter at indicated number of years after cutting			
20 years	10 years	of cutting	10 years	20 years	30 years	40 years
<u>Western Larch</u>						
5.2	5.7	: 4.0	: 5.2	6.6	7.9	
7.1	7.6	: 6.0	: 6.6	7.7	8.7	9.4
8.7	9.4	: 8.0	: 8.8	10.1	11.3	12.2
10.8	11.4	: 10.0	: 10.9	12.1	13.1	13.9
12.6	13.3	: 12.0	: 12.8	14.1	14.9	15.9
14.6	15.3	: 14.0	: 15.0	15.9	16.8	18.1
		: 16.0	: 16.9	18.1	19.0	19.7
<u>Douglas Fir</u>						
0.9	1.6	: 2.0	: 3.1	4.7	6.2	7.1
2.6	3.4	: 4.0	: 4.8	6.1	7.1	7.9
4.7	5.4	: 6.0	: 6.7	7.7	8.5	9.3
6.7	7.4	: 8.0	: 8.9	9.9	10.8	11.8
8.6	9.4	: 10.0	: 11.0	12.2	12.9	13.7
10.4	11.3	: 12.0	: 13.1	14.2	15.1	17.0
12.3	13.3	: 14.0	: 15.2	16.4	17.2	17.9
14.2	15.2	: 16.0	: 17.2	18.2	18.9	19.9
<u>Engelmann Spruce</u>						
0.7	1.5	: 2.0	: 3.9	5.8	7.8	8.7
2.9	3.6	: 4.0	: 5.1	6.9	8.5	9.4
4.5	5.3	: 6.0	: 7.3	9.3	10.6	11.8
6.4	7.3	: 8.0	: 9.4	11.1	12.2	12.8
7.7	8.9	: 10.0	: 11.5	13.0	13.9	14.4
10.4	11.2	: 12.0	: 13.5	14.9	15.7	16.7

TABLE 10. CHARACTERISTICS FOR CLASSIFYING THE VIGOR OF WESTERN LARCH AND DOUGLAS FIR RESIDUAL TREES IN LARCH-FIR TYPE IN WESTERN MONTANA (ROE 1948A).

Characters	VIGOR CLASS		
	A (Good vigor)	B (Fair vigor)	C (Poor vigor)
1. Position of crown	Usually dominant or codominant, occasionally intermediate.	Ordinarily codominant and intermediate, rarely dominant.	Usually intermediate or suppressed, occasionally codominant and rarely dominant.
2. Length of the crown	Crown length 10 percent of the total height or longer. Unusually wide crown may be shorter but not less than 30 percent.	Crown length usually from 20 to 40 percent of total height. In narrow crowns greater length may be allowed.	Crown length usually will not exceed 20 percent of total height. In extremely narrow crowns greater length may be allowed, but not to exceed 50 percent.
3. Width of the crown	Crown width average or wider.	Crown usually average width. May be narrow and long or wide and short.	Crown usually narrow or occasionally of average width.
4. Shape of the crown	Tip usually pointed or round, never flat or spike topped.	Tip usually round, occasionally pointed, and rarely flat topped.	Tip usually flat or spike top, rarely rounded.
5. Branching and foliage	Dead branches in the crown rare, branches and foliage moderately dense or better. Branches in upper half of crown usually strongly upturned and no drooping branches.	Occasional dead twigs present, usually no dead branches in the crown. Branches and foliage of moderate density. Occasionally large crowns of extremely open density. Usually the upper branches either upturned or horizontal, with drooping branches in the lower half of crown.	Dead twigs and branches showing through the crown. Often branches drooping to the tip. In western larch branches short and stout throughout the length of the crown.
6. Bark	<u>Western larch</u> - Bark is usually dark in color and ridged or only slightly scaly with deep fissures between scales. Bark appears rough. These bark characters apply to western larch only. Do not use on Douglas-fir. <u>Douglas-fir</u> - Bark usually has broad, corky ridges at the base, with light brown new bark prominently exposed in the fissures, becoming uniformly and finely ridged and dark above. The upper quarter or more of the bole usually has smooth or slightly checked light grey bark.	<u>Western larch</u> - Bark is usually dark around base of tree, becoming scaly above. Plates not well defined, but bark appears relatively smooth. These bark characters apply to western larch only. Do not use on Douglas-fir. <u>Douglas-fir</u> - Bark has corky ridges at the base of the tree, becoming uniformly and finely ridged above. New light brown bark not as prominent as in A vigor and usually extending only part way up the bark log. Dark, rough bark extends at least three quarters or more up the full length of the bole.	<u>Western larch</u> ^{2/} - Bark usually light in color with well-defined large, smooth bark plates and very shallow fissures between plates. Bark appears very smooth. These bark characters apply to western larch only. Do not use on Douglas-fir. <u>Douglas-fir</u> - Bark rarely has the light brown new bark exposed in the fissures. Bark bark usually extends to the tip. Frequently the entire bole has dark, finely ridged bark.
7. Disease	No mistletoe infection.	Rarely trees with light mistletoe infection.	Trees with visible indications of moderate to heavy mistletoe infection should be placed in this vigor class.

^{1/} Frequently in western larch, short, stout branches near the tip give it the appearance of being pointed. This should not be confused with a pointed growing tip which usually has numerous thin branches and is normally obtusely pointed.

^{2/} Trees with this type of bark are ornaments and usually growing slowly. They should be dropped one class below that in which they would otherwise classify. Thus, if a tree qualifies for A vigor, but possesses the light, smooth bark with well-defined plates and shallow fissures, it should be dropped to the B vigor class.

attributed to the type of selection cutting (economic selection) employed in the logging. Such cuttings remove the largest and better vigor trees which have the best growth potential.

In a later paper Roe (1948c) correlated a number of factors in a more complete study of the effects of release. Data from 124 one fifth acre sample plots were used. These plots were located on twenty different cut-over areas in Western Montana, and were representative of nearly the entire range of site conditions. The factors treated in this study were: competition expressed as reserve stand volume of trees ten inches d. b. h. and larger, species, and vigor class.

Vigor was found to be correlated with reserve stand volume and diameter growth. Diameter growth rates of ten years prelogging were compared with diameter growth rates of a similar postlogging period. The results of this study are presented in Figure 2. The space between the prelogging curve and the postlogging curve represents the response to release. For the most part the (A) and (B) vigor classes made a positive response, while (C) vigor trees made a positive response only in reserve stands of less than 3,000 board feet per acre. (Roe 1948c). Negative response has been cross hatched for better presentation.

The relative unimportance of western larch is again manifest by the limited number of thinnings which have been done. The writer knows of only two established thinning plots. One appears to have been established for too short a time to

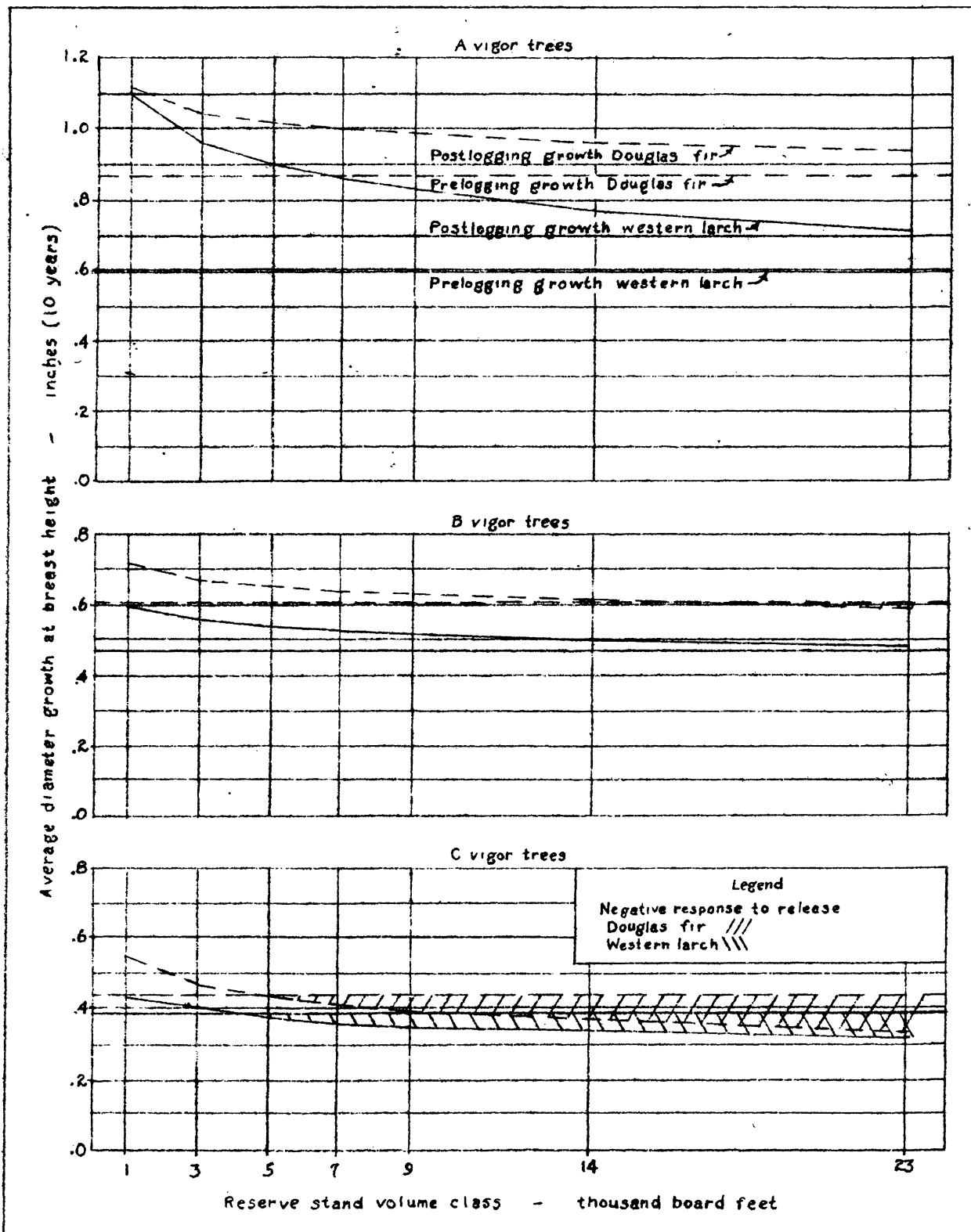


Figure 2. Growth response of western larch and Douglas fir by vigor class in relation to reserve stand volume (Roe 1948a)

produce any data. The data from the other was worked up and is presented as an integral part of this paper, although it is an entirety in itself.

This thinning experiment was discovered by the writer in his search for material on western larch. The following is a compilation of data obtained and procedures used.

Location--The thinned plot is located in T12N, R19W, about in the middle of sec. 11. It lies within the Fort Missoula Timber Reserve in Pattee Canyon southeast of Missoula. The approximate elevation of this area is 4,500 feet. The plot is on a gentle northerly slope.

History--This area was logged about 1900. The logging slash was burned.

Millard C. Evenson and Richard Whitaker, Montana State University forestry students, established this thinning plot during the autumn quarter of 1932. This improvement cutting was made as a part of a research problem. According to Evenson¹ the area was selected because it was as uniform of type as any he had found in the Pattee Canyon drainage. This plot was established to determine the effect on the growth of the residual trees when the intermediate and suppressed trees were removed.

The original plot contained 617 trees. After the thinning was accomplished 218 trees remained; this includes five ponderosa pine and two douglas fir. These trees were

¹ Memo to K. N. Boe, May 12, 1949.

of the dominant, codominant, and intermediate crown classes.

The standing trees were tagged at breast height with numbered galvanized tags. Diameter measurements were made with calipers above the tag; two caliper measurements, at right angles, were made on each tree. The average of these two readings was used as the diameter.

The total height of each tree was measured either with a pole or with abney and tape.

Each tree was classified according to the silvicultural classification of its crown.

Thirteen trees were picked at random and increment borings at one foot back were taken to determine the age of the stand.

A check plot was not established. According to Evenson¹ a plot about one hundred feet in a northerly direction from the thinned plot in a small draw would answer the requirements.

The plot boundary was not permanently marked.

An isolation strip around the plot was not made.

First Reading--M. C. Evenson and C. Wellner returned to the plot in March, 1941, (eight growing seasons later). The diameter of each tree was taken with a diameter tape placed around the tree above the tag nail. No other readings were

¹ Copy of the plan by M. C. Evenson, March 11, 1942.



THINNED PLOT-- Photographic point southwest corner of plot. Picture taken eastward. Border of plot indicated by line.



THINNED PLOT-- Photographic point southwest corner of plot. Picture taken northward. Border of plot indicated by line.

taken at this time. Evenson noted that some trees were bent over from the snow.

Second Reading--K. N. Boe and the writer revisited the plot in December, 1949, (nine growing seasons later). Each tree was measured with a diameter tape placed around the tree above the tag nail. The total heights of twenty per cent of the trees were taken. Each tree was reclassified according to its silvicultural crown class. The boundary of the thinned plot was reestablished, marked, and the area surveyed with compass and tape.

Check Plots--Both check plots were established in December, 1949, by K. N. Boe and the writer.

Check Plot No. 1--This plot is located in the general area indicated by Evenson ¹. The plot lies in a small draw about one hundred fifty feet northwest of the thinned plot; it is circular and encloses one-twentieth of an acre. The plot center was picked at random from a group of five marked plot centers.

The center of the plot was marked with a Douglas fir post five inches in diameter, blazed on four sides. The boundary was established with the aid of a metallic tape (radius 26.3 ft.). All living trees were tagged with aluminum tags at breast height.

Measurements taken:

1. D. b. h. of all live trees measured with diameter tape above the tag nail.

¹ Copy of plan by M. C. Evenson, March 11, 1942.

2. All dead trees were measured at d. b. h. and tallied on mortality sheet.
3. Total height measurements were taken with the aid of abney and tape. Trees with numbers ending in one and six were tallied.
4. Age was determined by boring trees with numbers ending in two at one foot with an increment borer.
5. Increment growth for the two periods, eight and nine years respectively, was determined by boring trees with numbers ending in zero and five at d. b. h.
6. Bark thickness was determined from trees with numbers ending in zero and five by gauging bark at d. b. h.
7. The silvicultural crown class of each tree was reported.

Check Plot No. 2. This plot is located about three hundred feet down the slope in a northerly direction from the thinned plot; it is circular, and encloses one-fiftieth of an acre. The plot was picked, established, and measured in the same manner as Plot No. 1.

Computation of Data

The average ages of the thinned plot, Check Plot No. 1, and Check Plot No. 2, were 44.5, 43.8, and 43.2 years respectively. The age of all plots was assumed to be 44 years.

Table 11 shows the average heights of the dominant, co-dominant, intermediate, and suppressed trees on the thinned plot in 1932 and 1949.

Table 12 shows the average diameters of western larch trees on the thinned plot in 1932, 1941, and 1949, and the periodic increase.



CHECK PLOT NO.1-- Photographic point blazed
seven inch larch south of plot. Plot center
indicated by arrow.



CHECK PLOT NO.2-- Photographic point blazed
four inch larch southwest of plot. Plot center
indicated by arrow.

TABLE 11. AVERAGE HEIGHTS IN FEET OF WESTERN LARCH TREES ON THINNED PLOT, 1932 AND 1949.

Crown Class	1932		1949		17 Year Increase
	Height Feet	No. Trees Used	Height Feet	No. Trees Used	
Dominant	36.15	34	54.29	7	18.14
Codominant	30.62	123	44.43	21	13.81
Intermediate	27.25	46	33.64	14	5.39
Suppressed	-----Removed--		23.00	3	-----

TABLE 12. AVERAGE DIAMETERS IN INCHES OF WESTERN LARCH ON THE THINNED PLOT 1932, 1941, AND 1949

Crown Class	1932		1941		1949		17 Year Increase	
	D.B.H. Inches	No. of Trees Used	D.B.H. Inches	No. of Trees Used	8 yr. D.B.H. Inches	No. of 9 yr. Trees Used		
Dominant	4.33	34	5.35	34	1.01	6.62	35	1.27
Codominant	3.29	123	4.01	122	.72	4.96	97	.95
Intermediate	2.51	46	3.00	45	.49	3.43	56	.43
Suppressed	Removed		----	---	----	2.49	19	.15 ¹

¹ This increase obtained by determining differences between 1941 d. b. h. and 1949 d. b. h. for these trees.

Difference in Growth Rates Between Thinned Plot and Check Plots.—The dominant and codominant trees are the only trees which can be expected to appear in the mature stand. In the following calculations only these classes were considered.

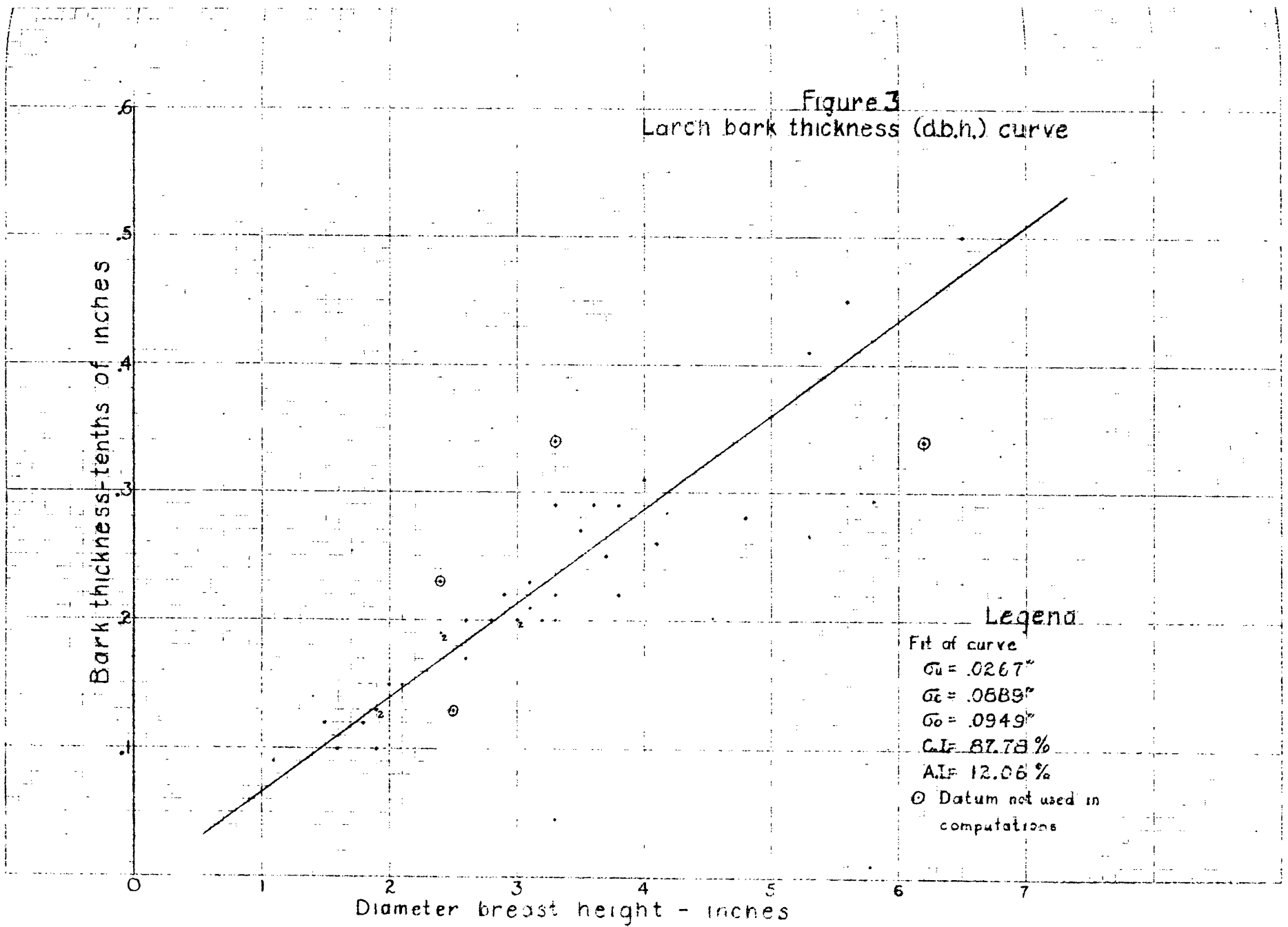
To determine if there was a significant difference between the diameters of the trees on the check plots and the thinned plot, the paired difference method was used. The diameters of the trees on the check plot to be compared were set down in the order they appeared on the tally sheet; the

crown class was noted. These diameters were paired with those on the thinned plot in the order they appeared on the tally sheet; dominants were paired first, then the codominants. A difference of over two is considered significant. The difference between the thinned plot and check plot No. 1 was found to be 8.79; between the thinned plot and check plot No. 2 was 11.99. The significant difference between check plot No. 1 and check plot No. 2 was found to be 4.02. The writer kept the two check plots separate because of this factor.

The bark thickness d. b. h. curve (Figure 3) was constructed using all the data from both check plots. Bark thickness was correlated with d. b. h., therefore, the writer believed that this data could be safely combined in constructing the curve. This curve was carefully checked for fit.

A bark thickness d. i. b. b. h. curve (Figure 4) was constructed using the data from both check plots. The original bark thickness was doubled and then subtracted from the d. b. h. to get the d. i. b.; the original bark thickness was then plotted over the calculated d. i. b.

The data from these curves (Figure 3 and Figure 4) were used with the increment growth of the two periods to project back the diameters of the dominant and codominant trees on the check plots to 1941 and 1932. These calculations are shown in Tables 13 and 14.



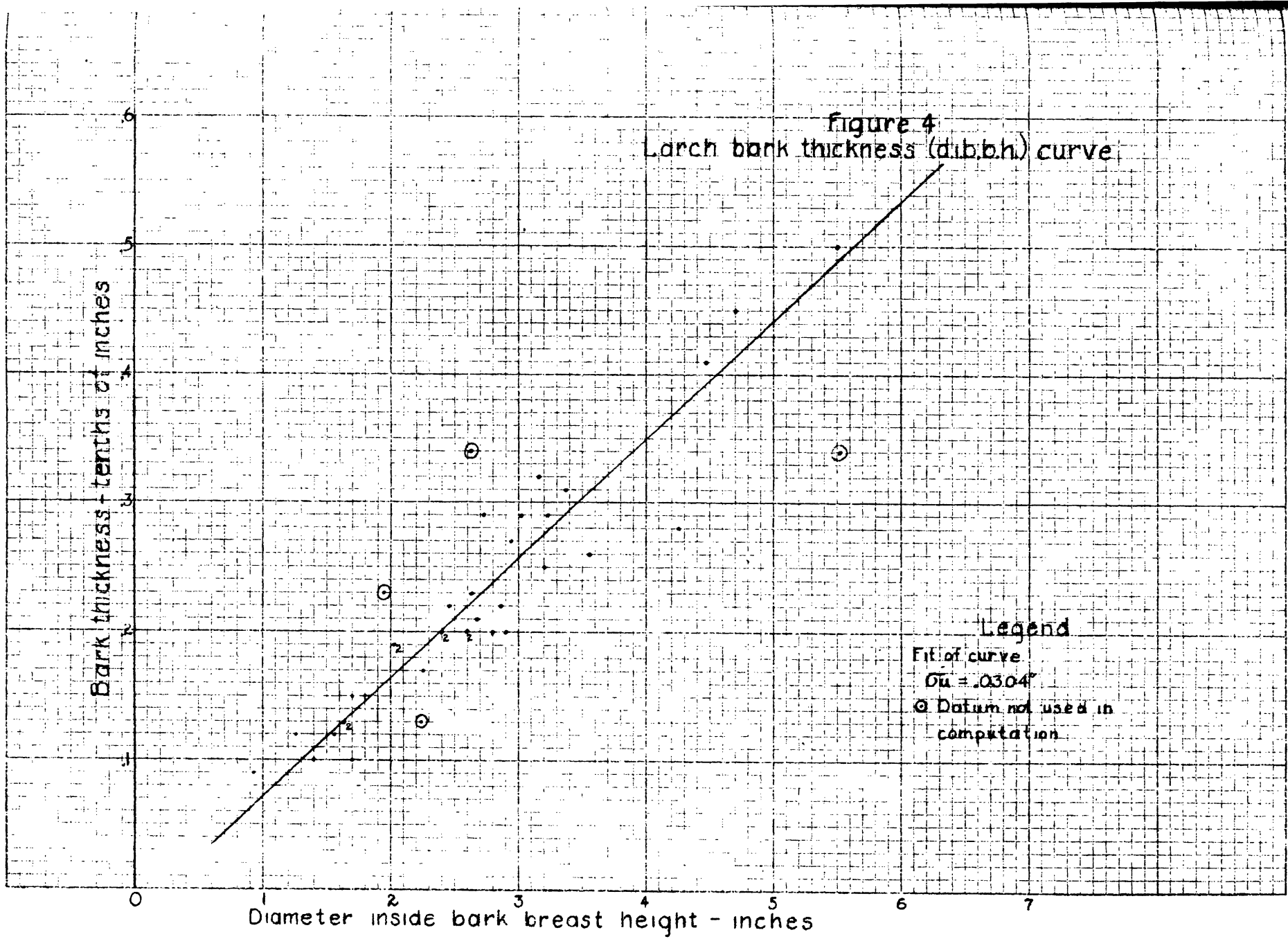


TABLE 13. AVERAGE DIAMETERS OF WESTERN LARCH ON CHECK
PLOT NO. 1 PROJECTED BACK TO 1941 AND 1932

D.B.H. 1949	Double Bark Thick. 1	Double Dia. Growth	D.I.B. 1941	Double Bark Thick. 2	D.B.H. 1941	Double Bark Thick. 1	Double Dia. Growth	D.I.B. 1932	Double Bark Thick. 2	D.B.H. 1932	
6.5	.94	.62	4.9	.86	5.8	.84	.50	4.5	.80	5.3	
4.8	.70	.60	3.5	.60	4.1	.60	.74	2.8	.48	3.3	
5.3	.76	.56	4.0	.70	4.7	.68	.50	3.5	.60	4.1	
3.6	.52	.28	2.8	.48	3.3	.48	.30	2.5	.42	2.9	
3.7	.54	.32	2.8	.48	3.3	.48	.36	2.5	.42	2.9	
5.6	.82	.44	4.3	.76	5.1	.74	.28	4.1	.72	4.8	
3.3	.48	.18	2.6	.44	3.0	.42	.16	2.4	.40	2.8	
3.3	.48	.16	2.7	.46	3.2	.46	.10	2.6	.44	3.0	
Mean					4.06	Mean					3.64

¹Obtained from Figure 3.

²Obtained from Figure 4.

TABLE 14. AVERAGE DIAMETERS OF WESTERN LARCH ON CHECK
PLOT NO. 2 PROJECTED BACK TO 1941 AND 1932

D.B.H. 1949	Double Bark Thick. 1	Double Dia. Growth	D.I.B. 1941	Double Bark Thick. 2	D.B.H. 1941	Double Bark Thick. 1	Double Dia. Growth	D.I.B. 1932	Double Bark Thick. 2	D.B.H. 1932	
4.1	.60	.40	3.1	.54	3.6	.52	.40	2.7	.46	3.3	
2.5	.36	.16	2.0	.32	2.3	.32	.20	1.8	.30	2.1	
2.4	.34	.16	1.9	.30	2.2	.30	.14	1.8	.30	2.1	
2.6	.36	.16	2.1	.34	2.4	.34	.14	1.9	.30	2.2	
3.8	.54	.50	2.8	.48	3.3	.48	.40	2.4	.44	2.8	
2.6	.36	.08	2.2	.36	2.6	.36	.16	2.1	.34	2.4	
3.1	.44	.26	2.4	.40	2.8	.40	.30	2.1	.34	2.4	
4.0	.58	.28	3.1	.54	3.6	.52	.24	2.8	.48	3.3	
3.0	.42	.32	2.3	.38	2.7	.38	.22	2.1	.34	2.4	
3.8	.54	.32	2.9	.50	3.4	.48	.32	2.6	.44	3.0	
6.2	.90	.32	5.0	.88	5.9	.86	.36	4.7	.82	5.5	
3.3	.48	.48	2.3	.38	2.7	.38	.36	2.0	.32	2.3	
Mean					3.13	Mean					2.82

¹Obtained from Figure 3.

²Obtained from Figure 4.

The average diameters of both of the check plots and the thinned plot are compared graphically in Figure 5. Note that the average diameter of check plot No. 1 exceeds that of the thinned plot in 1932.

The average heights of both of the check plots and the thinned plot are compared graphically in Figure 6. The point of demarcation by the check plots has been arbitrarily taken as 1932. No past data on height growth could be obtained except by methods which would require the destruction of the trees.

A number of computations were made in an attempt to explain the significant difference between check plot No. 1 and check plot No. 2.

The number of trees per acre was determined. The total number of living and dead trees on the sample plots were used for the 1932 stand estimate.

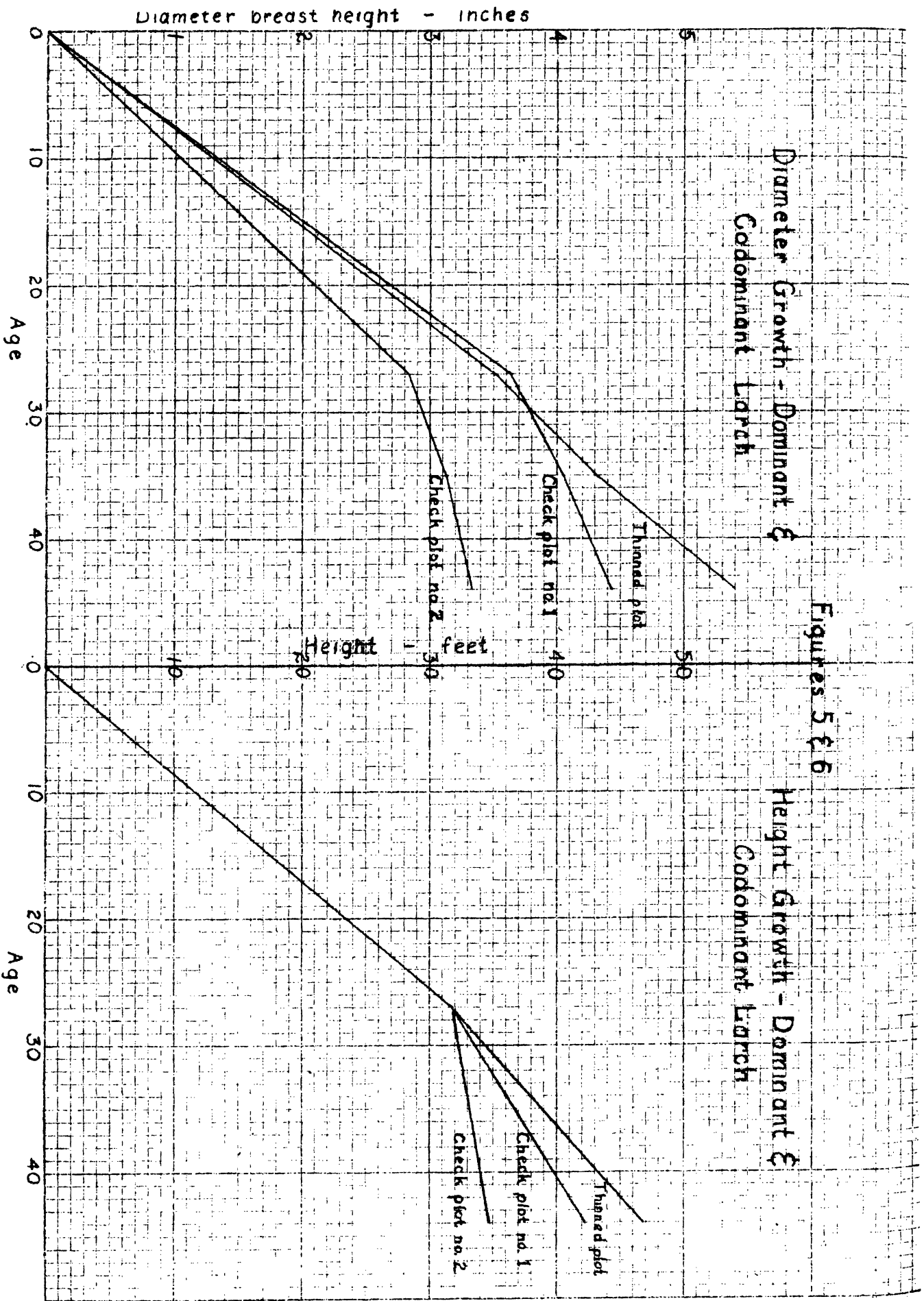
TABLE 15. NUMBER OF TREES PER ACRE AND MORTALITY FOR SEVENTEEN YEAR PERIOD

	1932		1949	
	Trees per Acre	All Trees	Dom. & Co-dom. only	Mortality Per Cent
Thinned	8,528 ¹	911	580	1.83 ²
Check No. 1	3,020	2,240	780	25.83
Check No. 2	7,500	4,900	1,300	34.67

¹ Trees per acre before thinning

² 64.67 per cent removed by thinning

The basal areas of the trees on the plots were calculated



and converted to an acreage basis. These values are shown in Table 16.

TABLE 16. BASAL AREA, IN SQUARE FEET PER ACRE, OF THE LIVING TREES (ALL SPECIES) IN 1949

Plot	Basal Area All Trees	Basal Area Dom. and Codom. only
Thinned	119.01	98.91
Check No. 1	135.95	97.40
Check No. 2	127.88	83.94

The average area occupied by each tree was calculated. The values for 1932 were computed using both the living and dead trees found on the check plots, and the total number of trees found of the thinned plot before thinning. These values are shown in Table 17.

TABLE 17. AVERAGE AREA, IN SQUARE FEET, OCCUPIED BY EACH TREE

Plot	1932 All Trees	1949 All Trees	1949 Dominants and Codominants
Thinned	16.59	47.61	75.27
Check No. 1	14.42	14.31	55.85
Check No. 2	5.81	8.89	33.51

DISCUSSION

Site--The writer believes that the thinned plot and check plot No. 2 are on comparable sites; check plot No. 1 is on a slightly more favorable site due to its location in the small draw.

Growth--This thinned plot has produced trees of larger diameter and greater height than either of the check plots

of comparable age.

Thinned Plot--The original and subsequent work on this plot has been carefully done, but the fact remains, there is no isolation strip around the plot. This may still be accomplished by reducing the size of the plot. Evenson ¹ said that the original thinning was not heavy enough. This is more apparent today; there are seventy-eight trees in the intermediate and suppressed crown classes. Most of these trees should be removed from the plot to preserve the present growth rate. Although the spacing of the dominants and co-dominants approximates an 8.5 x 9 foot planted spacing, this is not a comparable spacing because these trees are not equally distributed over the area.

Check Plots--Check Plot No. 1 was comparable to the thinned plot in 1932 (pre-thinning) as to the number of trees per acre, and in basal area per acre in 1949.

Check plot No. 2 had the equivalent of 7,500 trees per acre in 1932. This was about two and one half times as many trees as were on the thinned plot (pre-thinning), and over twice as many trees as were on check plot No. 1. Competition between individual trees on this plot began at an earlier age; this, the writer believes, accounts for the suppression of diameter and height growth.

¹ Memo to K. N. Boe, May 12, 1949.

Figures 5 and 6--These figures are not growth curves. The average diameters (Figure 5) and the average heights (Figure 6) were plotted and these points connected.

CONCLUSIONS

This larch thinning experiment indicates that increased diameter and height growth can be expected in thinned stands.

Larch should be thinned after the stand has become well established, and the dominance of the individual trees has been displayed.

If no subsequent thinnings are planned, the initial thinning should be heavy, leaving no more than 300 stems per acre.

Only well spaced dominants and codominants should remain; there is little tendency for suppressed and intermediate trees to gain in vigor and advance into the desirable crown class.

ENEMIES OF WESTERN LARCH

larch has comparatively few natural enemies; as can be expected, the most potential diseases and pests are those which have been introduced from Europe.

Needle Diseases--Schmitz (1923) made a study of larch leafcast (Hypodermella laricis Tubeuf.) in northern Idaho. This disease appears to be endemic, increasing to epidemic proportions when climatic conditions are favorable. The infected needles instead of being deciduous remain on the tree until the following spring. Besides killing needles it also kills a great number of the short leaf bearing spurs, and possibly a limited number of larger branches. The attacks of leafcast appear to be more severe on sapling and small pole stands. Although Schmitz made no study of the growth rates, he surmised that reduction of the leaf-surface must retard it.

One of the rusts (Melampsora bigelowii Thum.), has been discovered on western larch; this disease does insignificant damage to the needles of the leading shoot. (Weir and Hubert 1918).

Wood Rotting Fungi--The common wood rotters of larch as listed by Miller and Cunningham (1927) are: Fomes pini (Thore) Lloyd, Fomes laricis (Jack.) Murr., Polyporous Schweinitzii Fr., and Polyporous sulphureus (Bull.) Fr. Fomes pini and Fomes laricis are usually confined to the main and upper part of the bole, and are the most destructive. Polyporous Schweinitzii and P. sulphureus are butt rotters; hence, most

of the rot is usually removed when the tree is long butted. Pinchot (1907) stated that larch usually remains sound for one hundred fifty years. If this is the case, larch grown on short rotations should have little rot.

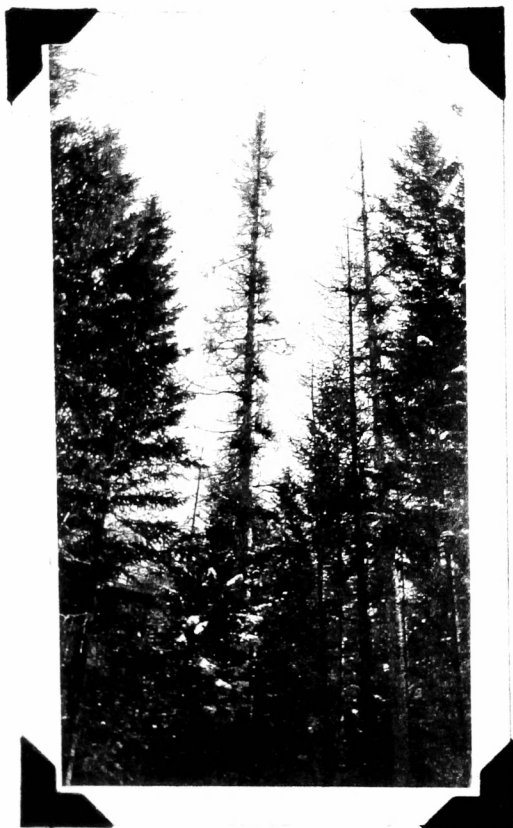
Canker--Hahn and Ayers (1943) inoculated five dormant specimens of western larch with European larch canker (Lasi-scypha willkommii Hart.), and found one tree susceptible to the disease. Henry (1922) wrote that canker attacks were one of the reasons why western larch was not a successful introduction in England. Boyce (1938) found no instance of larch canker growing on western larch in the United States.

Insects--The larch sawfly (Lygaeonematus erichsonii Hartig) is occasionally found destroying the terminal shoots of western larch. This insect is not found in great numbers in western United States, but its presence must be considered a threat to larch. According to Hewett (1912) this insect was introduced from England.

Mistletoe--The dwarf mistletoe (Arceuthobium campylopodum Engelm. forma laricis (Piper) Gill) is one of the worst pests of larch. Weir (1916a) found that no tree of any age was safe from infection. He also observed that suppressed trees were seldom damaged. This was attributed to the protection afforded by the overtopping trees, since mistletoe is positively phototropic, and to the fact that fewer vulnerable points of easy infection exist.

Trees which escape suppression by more rapid height growth are usually infected when the crown begins to spread.

Once mistletoe is established, the characteristics of the infection are manifested by the thinning and shortening of the needles, and the formation of brooms by the branches. These brooms catch and hold old needles and snow which adds to their weight. The greatest damage to larch is caused by the wind pruning these over loaded branches. (Weir 1916a).



Mistletoed larch near
Missoula, Mont.

Large burls develop where the infection occurs near the base of the branch. This infected wood is weaker, and the branches are wind-pruned as rapidly as they are regenerated. The exposed heartwood provides an entrance for fungi and insects which further reduce the merchantable portion of the tree. (Weir 1916a).

Weir (1916b) found that both height and diameter growth was reduced by infection to nearly half that of uninfested trees. Severe infes-

tations can kill trees by reducing the volume of the crown. Spike top is almost a universal characteristic of heavily infested larch.

The writer made no intensive study of mistletoe, but field observations in several areas have led him to believe

that either the misteltoe of larch or the mistletoe of Douglas fir (A. campylopodum Engelm. Forma douglasii (Piper) Gill) is capable of infecting both tree species. Mistletoe in the vicinity of Missoula, Montana, is spotty, and invariably on these spots one will find both larch and Douglas fir infected.

Control of Diseases and Pests--Most native diseases and pests do not present much of a control problem; some do so little damage that control is not feasible; and many probably will be controlled when the forests are managed under shorter rotations. Weir (1916b) advocated that mistletoe be controlled by clauses in timber sales contracts which required the cutting of all mistletoed trees large and small.

Exotic diseases are at all times a potential threat. Several severe infestations of the larch sawfly have occurred on the tamarack in eastern North America. Boyce (1938) wrote that there had been two outbreaks of larch canker in eastern United States, but both had been successfully controlled.

PROPERTIES AND USES OF WESTERN LARCH

Western larch heartwood is a pleasing russet or reddish brown. The straw or cream-colored sapwood is usually so thin it is practically all removed when the log is slabbed. Narrow, uniformly spaced annual rings with sharply contrasting dark summerwood and light springwood gives larch lumber a distinctive grain. The slightly resinous wood has no distinctive odor or taste. (Johnson and Bradner 1932). Cunningham and Fallaway (1926) claimed that carefully sawn larch logs should yield twenty-five per cent select lumber, while Anderson (1923) found one mill producing over thirty per cent selects.

Characteristic Defects--Knots in larch are small, sound, and frequently occur in clusters; in mill run lumber the average size is less than one half inch in diameter. Shake occurs in about six and one half per cent of the lumber. The practice of long butting in the woods is responsible for this small amount of shake. Pitch pockets occur in about five per cent of the boards. Pitch streaks are found less frequently in larch than in any of the softwoods that are subject to pitch. (Johnson and Bradner 1932).

Splits are the most common defect of larch lumber, about twenty per cent of the boards are split, but practically all of these are of the short or medium type. (Johnson and Bradner 1932).

Strength--Western larch is one of the strongest softwoods. The writer finds that a wide discrepancy exists in

the strength properties of the published United States tests and the published Canadian tests. The United States results are invariably much lower than the Canadian. Drow (1949) stated that the tests made over forty years ago at the University of Washington were probably not representative of the main body of western larch available or now being produced. Results of recent extensive tests by the Forest Products Laboratory, Madison, Wisconsin, show a substantially higher strength in most properties of old-growth western larch. The recent study also shows some difference in the strength of materials from second-growth and old-growth trees, with the younger trees slightly stronger, on the average, than mature trees.

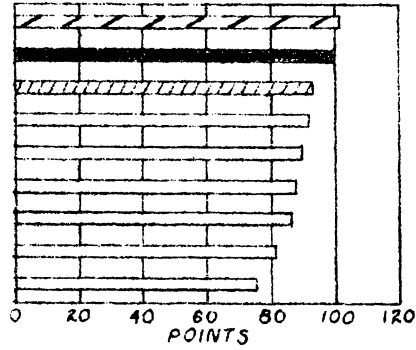
In Figure 7 the revised values for larch are taken as one hundred points, and are represented by the solid bars. As may be seen in the charts, shock resistance and stiffness are the strength properties which show the greatest increase.

Resistance to Decay--The durability of western larch is readily noted in the forest. On areas ravaged by fire where all timber has been killed larch remains standing for many years after the other species have decayed and fallen. (Ross) The writer found that it is not uncommon for larch snags to remain standing and sound for twenty-five years and longer after death.

The relative durability of untreated heartwood is presented below. The durability of commercial white oak was taken as one hundred points. (Anonymous undated).

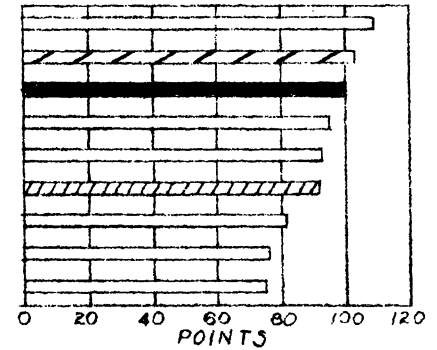
VOLUMETRIC SHRINKAGE

- Western Larch-Canadian Data
- Western Larch-Revised Data
- Western Larch-Old Data
- Loblolly Pine
- Longleaf Pine
- Douglas-Fir, Coast Type
- Western Hemlock
- Douglas-Fir, Intermediate Type
- Douglas Fir, Rocky Mountain Type



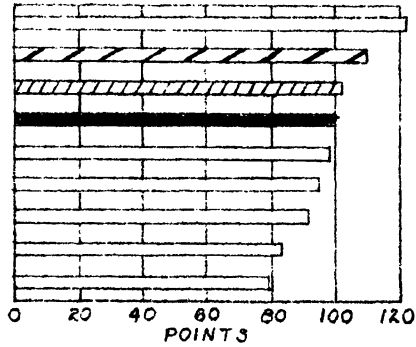
BENDING STRENGTH

- Longleaf Pine
- Western Larch-Canadian Data
- Western Larch-Revised Data
- Loblolly Pine
- Douglas Fir, Coast Type
- Western Larch-Old Data
- Douglas-Fir, Intermediate Type
- Douglas-Fir, Rocky Mountain Type
- Western Hemlock



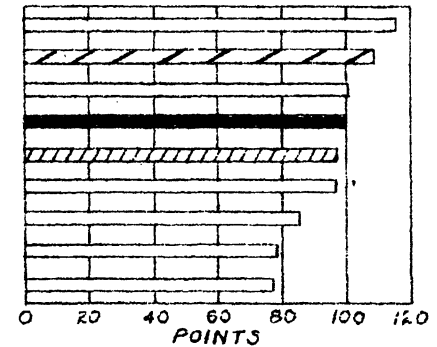
HARDNESS

- Longleaf Pine
- Western Larch-Canadian Data
- Western Larch-Old Data
- Western Larch-Revised Data
- Loblolly Pine
- Douglas-Fir, Coast Type
- Douglas-Fir, Intermediate Type
- Douglas-Fir, Rocky Mountain Type
- Western Hemlock



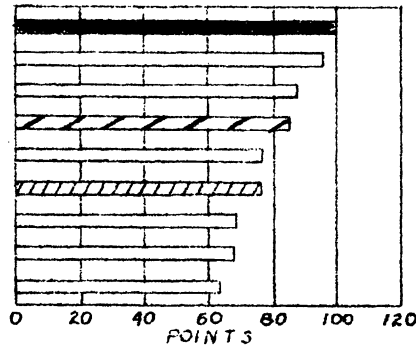
COMPRESSIVE STRENGTH-ENDWISE

- Longleaf Pine
- Western Larch-Canadian Data
- Douglas-Fir, Coast Type
- Western Larch-Revised Data
- Western Larch-Old Data
- Loblolly Pine
- Douglas-Fir, Intermediate Type
- Western Hemlock
- Douglas-Fir, Rocky Mountain Type



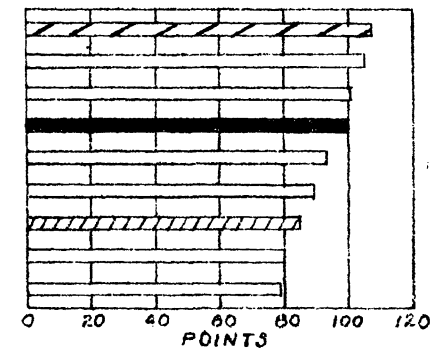
SHOCK RESISTANCE

- Western Larch-Revised Data
- Longleaf Pine
- Loblolly Pine
- Western Larch-Canadian Data
- Douglas-Fir, Coast Type
- Western Larch-Old Data
- Western Hemlock
- Douglas-Fir, Intermediate Type
- Douglas-Fir, Rocky Mountain Type



STIFFNESS

- Western Larch-Canadian Data
- Longleaf Pine
- Douglas-Fir, Coast Type
- Western Larch-Revised Data
- Loblolly Pine
- Douglas-Fir, Intermediate Type
- Western Larch-Old Data
- Western Hemlock
- Douglas-Fir, Rocky Mountain Type



(Figure 7) Comparative Strength Properties of Western Larch and a Few Other Softwoods as Determined From Small, Clear Specimens Revised From Drow (1949)

<u>Species</u>	<u>Points</u>
Western redcedar	125-175
Western larch	75- 85
Douglas fir (mill run)	75- 85
Western white pine	65- 80
Western hemlock	35- 55
Ponderosa pine	35- 50
Lodgepole pine	35- 50
Grand fir	25- 35

Shrinkage--The graph in Figure 7 indicates that western larch is high in volumetric shrinkage. High shrinkage is, as a general rule, a characteristic of the denser woods. Volumetric shrinkage of larch is approximately 13.5 per cent. Johnson and Bradner (1932) stated that when once dry, larch responds slowly to moisture changes, and because of its straight grain generally does not warp.

Weight--Western larch is one of the densest softwoods. An approximate average of the specific gravities based upon green volume and oven dry weight is .50. At twelve per cent moisture content the wood weighs thirty-six pounds per cubic foot. (Anonymous 1948). Since western larch is heavier than any of the western commercial softwoods, the transportation charges are somewhat higher.

Nailability--A great deal of trouble is experienced when nailing western larch. The wood has a tendency to split when too large a nail is used, but this is common to most dense species. Splitting can be safely reduced by the use of smaller, blunt-pointed nails because of the excellent nail holding ability of larch. (Johnson and Bradner 1932). The nail holding power of some of the western softwoods is presented in Table 18.

TABLE 18. NAIL HOLDING POWER OF A SEVEN PENNY CEMENT COATED NAIL DRIVEN $1\frac{1}{2}$ INCHES INTO 2 x 2 x 6 INCH SPECIMENS AND PULLED AT ONCE. (Anonymous 1931).

Species	Specific Gravity ¹	Moisture Content	Average nailholding power, in pounds, for one nail driven into:		
			End surf.	Radial Surface	Tang. Surface
Western larch	.58	4.4	180	299	319
Doug.fir (Coast)	.51	6.3	183	273	296
West. wh. pine	.45	8.2	134	255	246
Ponderosa pine	.44	6.6	132	224	233

¹ Based upon volume and weight of oven dry wood.

Paintability--Larch like Douglas fir takes and holds ordinary paint poorly, but a lasting finish can be obtained if the wood is well seasoned, and following directions adhered to. The priming coat should be thick, tough, and flexible. A time tested formula recommended for priming larch is as follows:

One hundred pounds of soft paste white lead
 Four to six gallons of linseed oil
 Three quarts of turpentine
 One pint of liquid drier

This formula will make eight to ten gallons of paint. Aluminum paint makes a good priming coat, but the manufacturer's directions for priming should be rigidly followed. Whatever covering is used should be well brushed out to force the paint into the wood in order to provide a well anchored base for the subsequent coats. A three coat covering is recommended for all new surfaces. (Anonymous 1948).

All types of stains can be applied to larch without special precaution. Stains will bring out the beautiful

design of flat grained paneling or wood work. (Anonymous 1948).

Machining--Smooth surfaces are easily obtained on western larch, but the power requirement is relatively high. The tendency of quarter sawn boards to feather is usually the result of working the wood when wet, or dull knives on the machine. Planing the wood when wet or green tends to loosen the grain. (Johnson and Bradner 1932).

Gluing--Western larch glues satisfactorily. Joints as strong as the wood in shear and tension perpendicular to the grain can be readily made. (Johnson and Bradner 1932). The strength of larch and its good gluing characteristics makes it an excellent material where glued or laminated material is required. (Anonymous 1948).

USES OF WESTERN LARCH

Lumber--Western larch lumber can be utilized in many ways. It is an excellent framing, sheathing, and subflooring material for dwellings since it possesses the desirable qualities such as rigidity, strength, nailholding ability, and minimum shrinkage. (Anonymous 1940).

For wall sheathing No. 4 common is the most economical to use. Tests by the Western Pine Association Research Laboratory have proven conclusively that lumber grades do not have as much bearing on strength properties as do the fastenings which hold the board in place. Number 3 or No. 4 common is recommended for subfloors. (Anonymous 1948).

Good siding lumber can be made from larch. When properly seasoned, then properly installed, painted, and maintained, larch will resist weathering as long as the building will give the service. Hotel Margaret in Bonner, Montana, was constructed entirely of larch in 1898. The building is still in good condition, and is still being used for its original purpose. (Anonymous 1948).

The pleasing color and grain of western larch makes it desirable for interior trim and paneling. If it has been properly seasoned it will take and hold any paint made by a reputable manufacturer. Larch flooring has the ability to take ~~abuse~~ and maintain a good appearance. Edge grain larch is probably the most durable of all softwood flooring. (Anon. 1948).

Industrial Uses--Larch has the strength, durability, and ability to resist abrasion which are the prime prerequisites for good service in industrial and heavy construction use. When used as bridge plank and factory flooring tests have shown that it should be laid with the convex side of the annual ring as the wearing surface. For factory flooring larch should be dry and surfaced before laying to provide a smooth even surface for hand truck traffic. (Anon. 1948).

The strength of western larch implies that it is an excellent material for trusses. Long clear roof spans are possible when Teco connectors are employed. The writer feels that this field has not been explored to its fullest degree; probably due to the ridiculously low modulus of

elasticity which was shown by the 1913 tests. When the new working stresses are published, western larch will probably gain in popularity for this use.

Larch lumber is suitable for many other uses; concrete forms, pallet stock, railroad car construction, silos, tight cooperage, irrigation flumes, heavy duty crates, tanks, pole cross arms, sash and frames, doors, and stadium seats are most of them. (Anon. 1948, Johnson and Bradner 1932).

Poles--In recent years larch has been recognized as a pole species, although it has been used occasionally for this purpose in the larch region for years. An outstanding example of this use is found near Baker, Oregon where a transmission line of untreated larch poles were set in 1904. These poles were stubbed off at the ground line in 1946 and reset because the tops were still sound. The writer feels that forty-two years is a good service record for any untreated pole.

Drow (1949) stated that shock resistance and stiffness are the strength properties of larch which are highly desirable in poles. The writer found that the straight grained character of the species is also an attribute in poles; once set in place, they have little tendency to twist.

In the bulletin by Wilson (1946) new fiber stress ratings for poles were advocated. These new ratings were based on the fact that lodgepole pine has been giving satisfactory service at a strength rating which was twenty per

cent above the modulus of rupture of small green specimens. These fiber stress ratings are presented in Table 19 under the lodgepole pine basis. According to Drow (1949) the American Standards Association approved a revision of their specifications for wood poles (A. S. 15.1-1948) in which the fiber stress of western larch was established at 8,400 pounds per square inch.

Wilson (1946) made up another table based upon the National Electrical Safety Code figures for western redcedar. Western redcedar is rated about ten per cent higher than the average modulus of rupture of small green specimens. These fiber stresses are also shown in Table 19 under the western redcedar basis.

TABLE 19. ULTIMATE FIBER STRESSES FOR WOOD POLES DERIVED BY TWO PROCEDURES. (Wilson 1946).

Species	Ultimate Fiber Stress	
	Lodgepole Pine Basis Pounds per sq.inch	West. Redcedar Basis Pounds per sq.inch
Engelmanns spruce	5,600	5,200
Ponderosa pine	6,000	5,200
Western white pine	6,000	5,200
Western redcedar	6,000	5,600
Lodgepole pine	6,600	6,000
Western hemlock	7,400	6,600
Douglas fir (Mtn.)	8,400	6,600
Douglas fir (Coast)	8,400	7,400
Western larch	8,400	7,400
Southern yellow pine	8,400	7,400

The writer believes that the weight of larch poles cannot

be considered a disadvantage for its use or shipment. A smaller larch pole will have the same strength properties which a larger pole of some other species will have; thus, if the specifications called for a larch ten inches in diameter at ground line, it would require a twelve inch lodge-pole pine or a thirteen inch western redcedar to fulfill them.

Durability is a desirable feature in poles, but with modern preservative treatment almost any species will give satisfactory service. The sapwood of larch is easily penetrated by any method of treatment, but the heartwood is penetrated with difficulty. (McLean 1935). Care must be exercised in preparing larch poles for treatment. Only a small amount of the thin sapwood can be removed in the peeling process or difficulty will be experienced in getting proper depth of preservation treatment.

Since the thickness of sapwood is an important factor in the treatment of poles, the writer examined the sapwood of a small selected sample of young rapidly growing larch. No sapwood was found to be less than one inch in thickness, the average was approximately 1.2 inches. These trees were growing at a rate of slightly more than two inches d. b. h. per decade. The average d. b. h. was 7.2 inches, and the average age at breast height was slightly over thirty years.

Piling--W. R. Ross believes that western larch is unsurpassed as a piling species. It can be obtained in any dimension required, it is exceedingly tough and strong,

drives easily without shattering, and has the desired durability. According to Johnson and Bradner (1932) larch has the strength necessary to withstand driving, and the hardness to resist mashing under the driving hammer. Larch can be used untreated, but under conditions favorable to decay, if long life is desired it should be treated. Western larch, Douglas fir, and the southern pines are classified as the softwood species best adapted to use as piling.

Cross Ties--The writer found that western larch is rapidly becoming the preferred tie species in the Inland Empire. Preframing and boring have practically eliminated splitting. Splitting is so common in all tie species that recently the Northern Pacific Railroad made it a policy to place end irons in every tie regardless of species. Ross wrote that western larch ties were preferred by the British Columbia railroads because many years of experience had demonstrated their ability to withstand rail cutting.

Side hardness is the property of a wood which indicates its ability to withstand rail cutting. Table 20 shows the side hardness of a number of western softwoods used for ties.

Practically all ties produced today are given a preservative treatment of some type prior to installation in the road bed. McLean (1935) classified the species with respect to penetrability of the heartwood by pressure. These groupings are as follows:

- Group 1. Heartwood easily penetrated
Ponderosa pine

- Group 2. Heartwood moderately difficult to penetrate
Douglas fir (coast)
Western hemlock
- Group 3. Heartwood difficult to penetrate
Engelmann spruce
Grand fir
Lodgepole pine
Western larch
- Group 4. Heartwood very difficult to penetrate
Douglas fir (Mountain)
Western redcedar

TABLE 20. SIDE HARDNESS OF SUITABLE WOODS FOR CROSS TIES

Species	United States Data ¹		Canadian Data ²	
	Specific Gravity ³	Side Hardness ⁴	Specific Gravity ³	Side Hardness ⁴
Western larch	.48	450 ⁵	.55	585
Douglas fir (Coast)	.45	480	.47	525
Douglas fir (Mtn.)	.41	470	.43	440
Western hemlock	.38	430	.41	460
Lodgepole pine	.38	330	.40	360
Ponderosa pine	.38	310	.44	420

¹ Markwardt 1931.

² Rochester 1933.

³ Based on oven dry weight and green volume.

⁴ Pounds required to embed a 0.444 inch ball one half its diameter into green wood.

⁵ Old data.

Veneer--Western larch has been both peeled and sliced, but never on a commercial basis. In reply to a questionnaire, Mr. R. F. Huffman of Potlatch Forests Inc., stated that western larch was experimentally peeled several years ago with the following results:

No preheating of the peeler block is required, but heating may be desirable for slicing.

The minimum diameter of the block is about twenty or twenty-one inches; minimum diameter of the core is seven inches.

A better recovery of face stock can be obtained from a smaller diameter larch than from any other species.

Larch is very easy to peel; the power required is no greater for it than for other species.

Rotary cut veneer has a beautiful pattern.

In the drying process the sugars in the wood come out on the surface in the form of crystals. These crystals prevent a good glue bond, and gum-up the face sanders.

The veneer splits easily in handling.

The resulting plywood is attractive, but would not be competitive with any plywood higher in price than coast Douglas fir.

1. Pulp--Wells and Rue (1927) said that western larch can be pulped by the sulphite, sulphate, soda, and ground-wood processes. Larch pulp is difficult to bleach; therefore, it is best suited to the sulphate process which manufactures unbleached products such as kraft wrapping paper and fiber board. Larch is heavier than most pulpwoods, this fact tends to increase the yield of pulp per cord. The wood is readily pulped by the sulphate process, and yields nearly 1,300 pounds of strong, good quality pulp per one hundred cubic feet of wood.

Derived Products--Galactan, a water soluble polysaccharide is found in the wood in amounts varying from eight to twenty-five per cent of the weight of the dry wood. (Betts 1945). The average yield of galactan found by Wise and Peterson (1930) was nine to ten per cent of the weight of air dry wood. Galactan can be hydrolized into the sugar

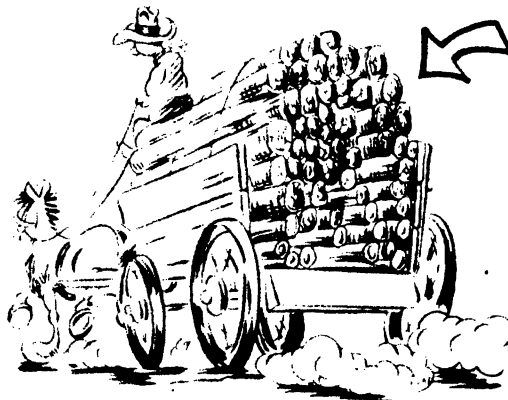
galactose, and this in turn can be oxidized into music acid which has been used commercially in the manufacture of baking powder.

Galactan may prove to be interesting from the stand point of both paper making and veneer making, since it can be extracted with water and then easily converted into ethyl alcohol. Johnson and Bradner (1932) claim that higher yields of ethyl alcohol are obtained from western larch than from any other softwood, because both the galactan and the wood can be fermented. Sherrard (1922) found that an average of 39.9 gallons of ethyl alcohol could be produced per ton of dry wood.

The derived products of western larch long butts are shown in Figure 8.

WESTERN LARCH*.. A RICH SOURCE OF CHEMICAL PRODUCTS

A GRAPHIC STORY OF THE PRODUCTS OBTAINED FROM ONE CORD OF WOOD



ONE CORD (3200 lbs.)

SUGARS

6-CARBON SUGAR
GALACTOSE AND
OTHER SUGARS

6-CARBON SUGAR
GLUCOSE AND
OTHER SUGARS

GALACTOSE
350 lbs.

OTHER SUGARS
95 lbs. LOST

Makes..
400 lbs. MUCIC ACID

Makes..
800 lbs. BAKING POWDER

WOOD SUGAR
1150 lbs.
This will produce

LIGNIN
1050 lbs.

POSSIBLE USES: PLASTICS
DISPERSION AGENTS, SOIL-
CONDITIONERS, HIGH GRADE
CHARCOAL & FUEL BRIQUETS.

FODDER
YEAST
90 lbs.

ETHYL
ALCOHOL
75 gals.

by-Product
GYPSUM
320 lbs.

240 GALLONS
MOLASSES FOR
STOCK FEED

480 lbs. OF
FODDER YEAS
FOR STOCK FEED

PRODUCTS FROM ONE CORD OF LARCH	
LIGNIN	1050 lbs.
MUCIC ACID	400 lbs.
ETHYL ALCOHOL	75 gal.
FODDER YEAST	90 lbs.
or } MOLASSES	240 gal
or } FODDER YEAST	480 lbs.
GYPSUM	320 lbs.

*Figure 8. Anderson 1947

WOOD FROM LONG BUTTS

DISCUSSION

The western timber producers have reached the point where more intensive management and utilization of the forest resources will be required to produce the volume of timber necessary to supply the demand.

With the present price of stumpage, the landowner cannot practice forestry if the incurred expenses are capitalized over the rotation period. The writer believes that no stumpage should be sold for less than ten dollars a thousand. Higher stumpage rates should not be reflected in exorbitant lumber prices, since the costs of logging and milling would remain the same.

The writer believes that the necessity for long butting larch to remove ring shake and radial check will be eliminated by shorter rotations. Benson (1916) found that these defects were usually not present in larch until the tree reached the age of two hundred years. Long butts are obviously worthless for lumber, and ring shake precludes their use for rotary cut veneer.

The undesirable practice of selling larch green is still prevalent. A majority of the retail lumbermen are not prepared or equipped to season lumber; hence, the green product is retailed to the ultimate consumer. If the lumber is unsatisfactory, the customer is not likely to request larch again. Another undesirable practice of the industry is mixing larch and fir lumber. Each species has different properties, and each should be represented

and sold on the merits of these properties.

Growth--Slow growth may or may not be an inherent characteristic of larch. The writer believes that it is not. The branches of larch are intolerant to side shading; thus, trees growing in dense stands are continually losing the lower portion of their crown. Apparently this is not a serious factor when the trees are making rapid height growth. When height growth abates the loss of crown becomes serious because the branches of larch do not increase appreciably in size to recover crown volume.

Large numbers of competing trees on an area inhibits growth. Dense even aged stands are a characteristic of larch. The thin foliage of the dominant and codominant trees admit enough light to the overtopped trees to sustain life, but not enough to permit any appreciable growth. These trees deprive the crop trees of a portion of the available soil moisture and soil nutrients until their metabolism reaches a point where respiration exceeds photosynthesis.

Silviculture--The writer believes that we should strive to obtain approximately three hundred larch per acre in plantings and thinnings. The theory that trees should be planted close together does not have a place in the normal western forest economy. For our purposes we need a stand which will not require thinning, and will not be unduly suppressed by closely spaced trees.

One man can plant approximately one thousand trees

a day; thus one man will plant 1.2 acres at a 7x7 foot spacing, 1.84 acres at a 9x9 foot spacing, and 3.2 acres at a 12x12 foot spacing (approximately three hundred trees per acre). This initial savings will reduce the amount which should be capitalized throughout the rotation period. The rotation will be shortened, because the wider spaced trees can grow for a longer period before any competition occurs. In addition, no thinning should be necessary until the stand will produce a crop of commercial poles. The writer believes that a stand of three hundred larch per acre should begin to self prune when the trees are from seven to ten inches in diameter. The ideal time to thin larch is when the dominants are twenty to twenty-five feet in height.

Prunings should be combined with thinngs wherever possible. Perhaps instead of only considering sixteen foot logs we should examine the possibilities of eight foot logs. In many places where select lumber is now used an eight foot length would suffice. An eight foot length is also ample for veneer manufacture. Such logs would bring a premium price if the buyer knew that he could get face stock down to a minimum diameter core.

Dead larch branches are small in size and relatively brittle. This makes them easily removed from the bole with a pruning club. Live branches are surprisingly limber, and cannot be removed in this manner. Pruning the first nine or ten feet of the bole can be done quickly

and economically.

Seed trees must be selected with care, only the best specimens must be left to regenerate the area. Engler (1905) found that poor form European larch had a strong tendency to transmit this characteristic to succeeding generations. Apparently other tree species exhibit this tendency, because Wibeck (1912) wrote of scotch pine forests which were becoming poorer and scrubbier where they had been subjected to long-continued unregulated cutting which left only an inferior population to regenerate the area.

SUMMARY

The resources of western larch are in excellent condition. The annual cut can be increased approximately fifty million feet, and still remain within the allowable annual cut.

Western larch is one of the strongest commercial softwoods. If properly seasoned, it is a good durable building material; recommended uses are for framing members, sheathing, and subflooring. The writer was unable to find any reference to many of the so-called undesirable characteristics of larch. The tendency for it to split appears to have been emphasized, since splitting can be reduced by intelligent handling and the use of smaller blunt-pointed nails. Larch poles have a fiber stress rating of 6,400 pounds per square inch; the highest strength classification given to softwood poles. Larch also appears to be a suitable material for veneer, truss construction, and sulphate pulp.

Western larch is intolerant. It is one of the first species to invade an area after a fire, and is definitely a secondary species in forest succession. Larch attains its best development in the western white pine type. Burnt mineral soil is the best seed bed, regeneration is prompt, and once the seedling is established, it makes rapid growth. Controlled burning may be necessary for natural regeneration of larch stands.

Larch is the most windfirm and fire resistant species

in the Inland Empire. Response to thinning is good, and the better vigor classes respond to partial cutting. Relatively few insects and diseases attack larch, although in some areas dwarf mistletoe is a very destructive pest.

Larch is a large tree, and normally it contains a higher percentage of clear material than any of its associates. The wood has its limitations, as does the wood of most species, but considering everything, the writer believes that western larch is a good timber species.

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