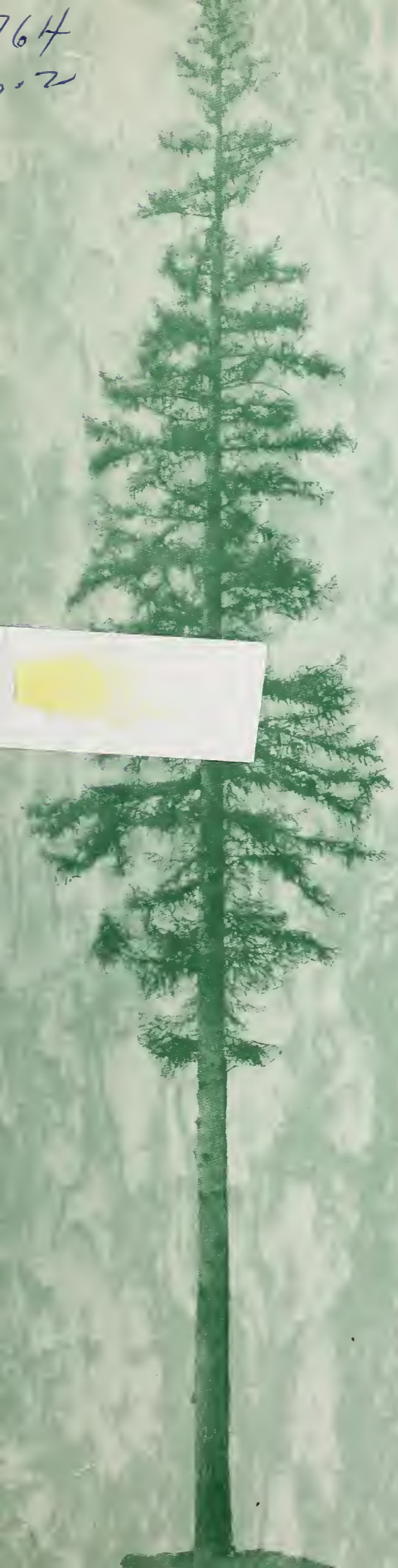

SILVICS of WESTERN LARCH

Botanical range of western larch.

Misc. Pub. No. 16 June 1958

SILVICS OF WESTERN LARCH

By

Kenneth N. Boe
Forester

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U. S. Department of Agriculture
Ogden, Utah
Reed W. Bailey, Director

FOREWORD

As intensive forest management becomes progressively more widespread, silviculture will be the means by which the forest may be systematically and carefully manipulated. Silviculture can be fully successful only as the silvics of the species are available, appreciated, and applied in the process of removing mature tree crops and starting new ones.

The silvics of the more important North American tree species are being collected and published by the U. S. Forest Service experiment stations. This report is the second of seven including western white pine, ponderosa pine, lodgepole pine, western larch, western redcedar, grand fir, and black cottonwood being prepared by the Intermountain Forest and Range Experiment Station. The U. S. Forest Service is planning a single publication that will include the entire series for the United States.

Information in this publication is based on selected references and unpublished data through 1956. The author will appreciate having any omissions or apparent misinterpretations called to his attention.

CONTENTS

	Page
HABITAT CONDITIONS	1
Climatic	1
Edaphic	2
Physiographic	2
Biotic	2
LIFE HISTORY	3
Seeding habits	3
Vegetative reproduction	5
Seedling development	5
Sapling stage to maturity	8
Injurious agencies	12
SPECIAL FEATURES	13
RACES	13
LITERATURE CITED	14

SILVICS OF WESTERN LARCH

By

Kenneth N. Boe[1/]

Western larch (Larix occidentalis), a deciduous conifer, occurs naturally only in the Upper Columbia River Basin of North America. This largest of American larches ranges from southeastern British Columbia throughout western Montana west of the Continental Divide to an area in the Bitterroot Mountains, 30 to 40 miles south of Missoula, thence to that part of Idaho generally north of the Salmon River and to northeastern Washington. Its range continues along the east slopes of the Cascades in Washington and north-central Oregon and in the Wallowa and Blue Mountains of northeastern Oregon and southeastern Washington (16, 32, 40).[2/]

First discovered on the upper Clearwater River in Idaho by the Lewis and Clark expedition in 1806, the tree was next reported by the Scottish explorer David Douglas on the Columbia River in northeastern Washington in 1827. Thomas Nuttall recognized the tree as a new species after observing it in the Blue Mountains of northeastern Oregon in 1834 and classified it in 1849 (41).

HABITAT CONDITIONS

CLIMATIC

Larch grows in a climatic zone having cool temperatures and an average annual precipitation of 28 inches, of which only 20 to 30 percent falls in summer (8, 19, 25). The minmum annual precipitation tolerated is about 18 inches. Rainfall of 35 inches is known in a few larch forests. Minimum precipitation of 2 to 3 inches occurs in July and August. The four months of May through August receive 5 to 7 inches. Peak precipitation of about 4 inches per month occurs in December and January in western Montana and just over 4 inches per month in November, December, and January in northern Idaho. Snowfall ranges from 40 to more than 80 inches (25). Mean temperatures in western Montana range from a low of 21° F. in January to 41° F. in April, and reach a peak of 60° F. in July. They then decline slightly to 57° F. in August, 43° F. in October, and about 23° F. in December. The same temperature pattern prevails in northern Idaho, but respective values are 2° F. to 3° F. higher. For 160 to 175 days during the year, mean air temperatures are above 43° F. (25). Frost is likely during every month of the year. However, the last spring frost usually occurs about the first week in June, and first fall frost occurs about the last of August or first of September (19). Temperature extremes range from -49° F. to 107° F. (25).

1/ Forester, formerly on the staff of Intermountain Forest and Range Experiment Station, U. S. Forest Service, Ogden, Utah.

2/ Underlined numbers in parentheses refer to Literature Cited.

EDAPHIC

Western larch grows best on deep, porous soils of mountain slopes and valleys that range in texture through gravelly, sandy, and all classes of loam soils (32). Extensive soil surveys within the type have not been made, but the soil association is generally classified as gray-brown podzolic (44). Moisture equivalent of the top 20 inches of soil in northern Idaho and adjacent Washington ranges from 23 to 45 percent, and pH from 5.50 to 6.40 (11).

PHYSIOGRAPHIC

This species characteristically occupies northerly exposures, valley bottoms, benches, and rolling topography. Southwest exposures ordinarily are not favorable sites for larch (8). It occurs in the middle elevation zone at 2,000 to 5,500 feet in the north and up to 7,000 feet in the southern part of its range (19, 32, 25, 41). Upward extension probably is limited by temperatures.

BIOTIC

Western larch occurs throughout the transition forest that is described as a peninsula of tree associates extending eastward across northern Washington and southern British Columbia and expanding north and south on the west slope of the Rockies (9, 30, 46). It has been classified as the climax Larix-Pinus association of the Thuja-Tsuga formation (46), but elsewhere as a subclimax species held rather indefinitely, chiefly by fire (30). Another ecologic concept is that western larch is a seral or temporary species at least in northern Idaho and adjacent Washington and perhaps in western Montana (11). In this area larch is considered a major seral species in the following associations, or basic units of climax vegetation that are named for the distinctive vascular plant groups of vegetation, or unions, comprising each: (1) Picea-Abies/Pachistima; (2) Thuja-Tsuga/Pachistima; (3) Thuja/Pachistima; (4) Abies grandis/Pachistima; and (5) Pseudotsuga/Calamagrostis. It is a minor seral species in (1) Picea-Abies/Menziesia; (2) Picea-Abies/Xerophyllum; and (3) Pseudotsuga/Physocarpus.

Classified on the basis of forest cover type now occupying the ground, larch is an important dominant in the larch--Douglas-fir (Pseudotsuga menziesii), grand fir (Abies grandis)-larch--Douglas-fir, and ponderosa pine (Pinus ponderosa)-larch--Douglas-fir cover types. It is an important associate in the western white pine (Pinus monticola) cover type (39). Within these types larch is generally regarded as a subclimax species owing its maintenance to fire, although in places it tends to remain rather stable.

The larch--Douglas-fir forests are found commonly in northern Washington, Idaho, Montana, and southeast British Columbia. Minor associates in the stand are lodgepole pine (Pinus contorta), grand fir, western white pine, ponderosa pine, western redcedar (Thuja plicata), and subalpine fir (Abies lasiocarpa). Along the eastward limits of the type, western larch is replaced by interior Douglas-fir. Of the many shrubs and herbs, Pachistima myrsinites, Vaccinium membranaceum, Menziesia ferruginea, Chimaphila umbellata, Rubus pariflorus,

and Linnaea borealis are usually numerous and characteristic in this cover type.

The grand fir-larch--Douglas-fir combination is found along the east slopes of the Cascade Range, the Okanogan highlands in northern Washington, and in Idaho, Montana, and northern Blue Mountains of Oregon. Associates are usually western hemlock (Tsuga heterophylla), western white pine, Engelmann spruce (Picea engelmannii), and ponderosa pine. Pachistima occurs in this type as well as Berberis nervosa, Corallorrhiza maculata, and Physocarpus malvaceus.

In the mixture of ponderosa pine-larch--Douglas-fir, ponderosa pine is an indicator species present in significant amounts but not predominating. It occupies intermediate zones in western Montana, Idaho, eastern Oregon, and Washington between the ponderosa pine and moister larch--Douglas-fir. Grand fir, western white pine, and lodgepole pine are sometimes present in minor amounts. Characteristic shrubs and herbs are Physocarpus malvaceus, Calamagrostis rubescens, Amelanchier alnifolia, and Arctostaphylos uva-ursi.

Finally, in the western white pine type of northern Idaho, Montana, and British Columbia, larch is often an important associate. Pachistima is present as a characteristic shrub together with Rubus parviflorus, Vaccinium membranaceum, and the herbs Clintonia uniflora and Adenocaulon bicolor.

LIFE HISTORY

SEEDING HABITS

Flowering and fruiting.--Male and female flowers, borne singly and separately from each other on the same branches or twigs of the previous or an earlier year's growth, appear with the new leaves. Pollen-bearing flowers are budlike yellow-green organs about the size of a small pea. Female flowers are similarly small, elongated, purple or red, and composed of tiny scales each bearing two minute ovules (41). Flowering was observed to be well advanced in one instance on May 11 at 3,000 feet elevation on rolling terrain at latitude 48°20' N., near Kalispell, Montana.

Cones, which mature in a single season, average 1 to 1½ inches long. They ripen by the end of August and early September, and seed is shed during favorable periods afterwards. Cones fall from the trees throughout the following winter, but frequently substantial numbers remain through the next summer.

Seed production.--Seed is produced only infrequently before age 25 (29), but at age 40 to 50 larch bear abundantly and continue to bear for 300 to 400 years (41). In any stand only the codominant and dominant trees produce significant amounts of seed.

Although about 80 seeds may be produced by a mature cone, the number of full-sized, sound seed characteristically totals fewer, frequently only one-half this number. During an excellent seed year sawtimber-size trees produce

22,000 sound seeds per tree (37). Trees averaging 22-inch d.b.h. potentially will produce five times the volume produced by trees averaging 14 inches (36). At the rate of 143,000 seeds per pound (45), sawtimber trees may average one-seventh pound of seed in an excellent seed year.

Based on frequency of cone crops, larch rates as a good seed-producing species. Records over a 22-year period, covering a major portion of the larch type, indicate that a ratio of one fair or good cone crop to one poor crop is characteristic (4). This same ratio prevailed for a 6-year period on the Coram Experimental Forest in northern Montana. Nevertheless, a fair or good crop does not always immediately follow a poor crop. As many as five consecutive fair or good crops and four consecutive poor crops may develop (4). Intervals between good crops averaged 4.7 years over a 14-year period in the western white pine type (15), but at Coram Experimental Forest an outstanding crop in 1954 matured after an interval of one year following the good crop in 1952.

The amount of sound seed available per acre depends on such factors as abundance of cones, whether seed is weeviled or empty, and number of cone-bearing trees per acre. Seed-tree cuttings on Coram Experimental Forest, on which there were 4 to 5 codominant and dominant trees plus an additional 12 smaller trees per acre, produced as follows:[3/]

Year	Number sound seeds per acre
1949	43,000
1950	17,400
1951	400
1952	400,078
1953	5,600
1954	701,726

Percent soundness of larch seed probably correlates directly with size of crop. From the yields reported above, only 9 percent of the poorest seed crop was sound, but the percentages increased progressively to 16 and 30 percent for fair crops and to 32 and 38 percent for the best crops produced.

Seed dissemination.--Most seed is normally shed in the fall soon after ripening. At Coram Experimental Forest, latitude 48°25' N. and for an average elevation of 3,700 feet, 19 percent of the sound seed was dispersed by mid-September, another 65 percent by mid-October, 15 percent throughout the remainder of the fall, winter, and spring, and 1 percent the following summer.[4/] Seasonal dispersal of larch seed in northern Idaho paralleled these findings that two-thirds or more of the seed is shed by late fall. Additional evidence may be needed to verify whether the greater percentage of seed dispersed

3/ Unpublished results from seed dispersal study on the Coram Experimental Forest.

4/ Ibid.

earlier by a young stand, as shown in the following tabulation (15), is a consistent characteristic.

Period	Seasonal dispersal of seed from: 300-year-old stand	75-year-old stand
	Percent	Percent
Midsummer to August 31	5	24
September, October	61	54
November 1 to midsummer	34	22

The small seed (143,000 per pound) aided by a favorable wing-seed ratio is carried substantial distances by wind, the principal dispersal agent. The quantity of sound seed decreases rapidly from a timber edge to an effective seeding distance of 400 feet (three tree heights) and then remains somewhat constant at a very low level at least to 792 feet from the source. Only about 5 percent of the total sound seed produced is likely to reach beyond 400 feet (3).

VEGETATIVE REPRODUCTION

Larch does not reproduce by sprouts. Although techniques for rooting cuttings have not been reported, it seems likely they could be developed. A few successful veneer grafts have been produced by the Intermountain Station.

SEEDLING DEVELOPMENT

Establishment.--Western larch seed rates fair in viability. An average germination percent of 39 for fresh seed was calculated from four reported germination tests: the average percentages reported were 30 (28), 60 (22), 47 (23), and 19 (43). In comparison, Douglas-fir averaged 45 percent based on reported germination percentages of 49 (22), 49 (23), and 41 (28). Elsewhere, germinative capacity of 27 percent, ranging from 0 to 65 percent, was calculated from 25 tests (45).

Larch seed loses vitality under artificial storage at about the same rate as its important associates. Germination of seed stored in glass-stoppered bottles in a room heated during cold-month days and unheated at night decreased 6 percent annually for 5 years after collection. Douglas-fir decreased 7 percent annually for 4 years and Engelmann spruce 2.5 percent for 5 years (23).

Germination is little affected by seedbed under controlled greenhouse environment (12) but greatly affected by seedbed in the forest. Based on duff as 100 percent, germination of larch was reported as 199 on burned-over seedbed and 320 on mineral soil (15). In contrast, Douglas-fir germination was about equal on all seedbeds. Elsewhere, both larch and Douglas-fir were reported to have germinated best on burned surfaces. Only 4 percent germinated on duff, 13 percent on mineral soil, and 20 percent on ashes (24, 26). Poor germination

on duff, especially of the small-sized larch seed, likely is caused by the rapid drying of the organic material.

Germination of larch seed is believed to begin when soil temperatures reach 60° F. and proceeds rapidly at temperatures of 70° to 80° F. All associates of larch responded similarly in these temperature ranges (23). In northern Idaho germination began April 28 in the open and May 20 in full shade and was mostly completed by June 5 and July 15, respectively (15). Germination probably starts a week to a month later at higher elevations and on shaded north slopes.

In the first critical growing season, survival of larch ranges from nil to about 80 percent; it averaged 54 percent in one test (15). Biotic agents cause principal mortality soon after germination. Later deaths are caused primarily by environmental factors. The effects vary by seedbed, topographic situation, and character of occupying vegetation.

Early first-year seedling losses to fungi, the greatest biotic factor, rank unusually high on duff (as compared to mineral soil) in full sun and part shade on river flats and benches. The reverse appears to be true under full shade. Douglas-fir is affected similarly under full sun and full shade, but differs under part shade as shown in the following tabulation (14):

	Mortality from fungi in percent of total seedlings on each seedbed					
	Full sun		Part shade		Full shade	
	Duff	Mineral	Duff	Mineral	Duff	Mineral
Larch	96	14	70	7	30	61
Douglas-fir	97	33	37	38	19	66

Larch succumbs to other biotic agents, but insolation usually ranks as the second major cause of death as the growing season advances. Furthermore, duff is again the least desirable seedbed. Lethal temperatures occur earlier and for many more days on duff during the growing season. Duff temperatures reached 120° F. on 76 days and 135° F. on 43 days. On mineral soil 120° F. occurred for only 8 days, and 135° F. was never recorded in full sun on slight north slopes. The tabulation below indicates the probable losses for the different conditions except duff in full sun, for which there were no residuals. Of course, no insolation losses were experienced in full shade (14).

	Mortality from insolation in percent of residual seedlings			
	Full sun		Part shade	
	Mineral	Duff	Mineral	Duff
Larch	75	No	24	52
Douglas-fir	81	resid-	14	44
		uals		

Later in the growing season and after stems harden, larch losses are generally due to drought. Anomalously, losses are greatest where moisture depletion is least in the heavily shaded condition. As shown in the tabulation below, the large losses in full shade are undoubtedly due to extremely short roots. Douglas-fir, grand fir, and white pine survive much better in shade. Root penetration averaged 1 inch for larch compared to 2½ inches for Douglas-fir. But in full sun and part shade roots of both larch and Douglas-fir frequently penetrate below soil layers that have depleted moisture (14).

Mortality from drought in percent of residual seedlings

	Full sun	Part shade	Full shade
Larch	4	2	93
Douglas-fir	5	1	17

Representative larch seedling losses computed by averaging counts from all sedbeds on cutover areas in northern Idaho approximate 46 percent the first year and 67 percent for 6 years. Douglas-fir losses are similar to these (15).

Survival of larch is poor to nil on xeric southwest exposures within the geographic zone of its occurrence (21). On these same slopes Douglas-fir becomes established successfully as the dominant species.

Not only is mineral soil a superior seedbed, but reduced vegetative competition also favors larch. Numbers of seedlings have been reported to be doubled on habitats supporting light-density, low vegetation over heavy-density cover; they were tripled on areas where shrubs and small trees had been removed, as compared with areas where they had not been removed (35). Furthermore the average number of sound larch seed needed to produce one established seedling varies from 26 on mineral seedbeds to 191 on the forest floor (37).

Natural regeneration of larch is favored, then, by cutting methods that provide substantial to complete removal of overhead growth and exposure of considerable mineral soil. Such harvest cutting methods as seed-tree, shelterwood, and clear cutting in blocks or strips are appropriate. Removal of vegetative competition and exposure of favorable seedbed can be accomplished by prescribed burning, bulldozer piling of slash and burning, and normal logging disturbance. The superiority of one method over another depends on conditions within a given stand. When successfully completed, all these methods produce desirable even-aged stands.

Early growth.--One-year-old larch averages about 2 inches in height. Shaded seedlings are puny and have only inch-long roots, but sturdier seedlings growing in part shade and full sun have roots about 9 inches long. Top growth of partly shaded seedlings is generally twice that of plants growing in full sun. Partly shaded Douglas-fir and grand fir also are larger than seedlings

grown in full sun. However, total weight of tops and roots of seedlings growing in full sun probably averages more than those in part shade (14). Larch, in common with other seedlings, initially grows faster on burned seedbeds because of availability of additional nutrients. Characteristically, after the first few years, larch, lodgepole pine, Douglas-fir, and white pine all grow best under full sun.

In favorable situations, western larch grows rapidly in height beginning the second year; sometimes it attains a height of 4 feet in 4 years. Only lodgepole pine can match juvenile height growth of larch where both are growing on the same site. Early height growth of Douglas-fir is about one-half and Engelmann spruce about one-fourth the growth of larch (16, 19).

Needle and shoot growth starts in April or May and is practically complete by July (6). Single needles on new seedlings persist for one or more years. Single needles on new shoots, however, are mostly deciduous, as are the needle clusters of 14 to 30 needles each on older shoots.

SAPLING STAGE TO MATURITY

Growth and yield.--Larch grows rapidly in height and moderately in diameter until ages 75 to 100 years. On the same site, only lodgepole pine equals larch in height growth during early years, but eventually larch outstrips the pine. Annual height growth averages 1.5 feet between ages 14 and 20 (6). Both larch and lodgepole may attain 19 feet in 15 years, since they may add as much as 30 inches annually (8). Average heights of larch attained at different ages are as follows (21):

Age (years)	10	30	50	70	90	120
Height (feet)	12	33	50	65	77	90

Diameters may reach 16 inches at 80 years under favorable conditions, but radial increment characteristically declines thereafter. Frequently 250-year-old stands average only 16 to 24 inches in diameter (41) and 400-year-old stands 30 inches (21).

Radial growth begins at low altitudes usually in April, but is delayed a month or more at high altitudes and cool sites. Growth began April 19 at an elevation of 3,238 feet in Idaho in 1942; it did not begin until May at an elevation of 4,822 feet. Growth at low levels substantially surpassed that at higher levels; however, seasonal culmination occurred about mid-July at both elevations. During the dry period in late summer, radial shrinkage occurred, but original dimensions were regained and surpassed after fall rains (10).

Larch is a long-lived tree and may attain large sizes. Many trees in the Seeley Lake grove in Montana are more than 700 years old and measure more than 60 inches d.b.h. The largest tree measured was 88 inches d.b.h. One windthrown monarch was determined to be 915 years old. Two medium-sized trees had 595 and 715 rings (20). The largest tree reported, however, was found on the

An extensive stand of immature western larch and lodgepole pine which became established following a fire.

Kootenai National Forest in northwestern Montana. It measured 91 inches d.b.h. (1). Trees 175 feet in height have been measured on growth plots at Coram Experimental Forest. In a 380-year-old stand, tallest trees were 175 feet high and 55 inches d.b.h. (21).

The expected yield of larch stands probably ranks high. A volume of 60,000 board feet per acre for a 380-year-old stand has been reported (21). However, many other stands have contained volumes of 20,000 board feet and less. The following tables of available yield information show that estimation varies widely and indicate the need for some additional checking to establish the approximate range of yields.

Reaction to competition.--Larch is intolerant of shade through its entire life except in the early seedling stages; then it tolerates partial shade (2, 15). It is the most intolerant of its associates. Unless full sunlight is provided by removal of overhead competition, larch loses dominance to the more tolerant species (15). Where advance growth of other species is husbanded as future growing stock, decline of larch from a dominant position is hastened. Harvest cuttings tend to favor establishment of larch, but the rapid development of any advance growth precludes much of the new reproduction becoming dominant (31).

Table 1.--Probable average yield of larch stands (42)[1/]
(Minimum size not given)

Site class	Average height dominant and codominant age - 100	Volume per acre at:		
		100 years	140 years	200 years
	Feet	Bd. ft.	Bd. ft.	Bd. ft.
I	92	23,500	38,000	--
II	84	15,500	26,000	--
III	75	9,100	15,000	--

1/ Data from Kootenai National Forest.

Table 2.--Probable average yield of larch stands in the larch--Douglas-fir type (7)

(Trees 13.0 inches d.b.h. and larger--fully stocked)

Site class	Average height dominant and codominant age - 100	Volume per acre at:		
		100 years	140 years	200 years
	Feet	Bd. ft.	Bd. ft.	Bd. ft.
I	121	43,500	69,800	94,600
II	107	25,400	51,200	74,500
III	94	11,200	29,100	51,600
IV	80	4,000	10,200	23,100
V	66	300	2,000	6,000

Trees more than 200 years old respond to cutting release. Where cutting is heaviest, individual trees make the greatest response, but within a wide release category afforded by a seed-tree or shelterwood cutting, response is correlated directly with vigor (34). Larch makes relatively better response than Douglas-fir in fair- and good-vigor classes; however, Douglas-fir usually exceeds larch in actual growth. Trees in the best-vigor group grow nearly one and one-half times as much volume as the average; medium-vigor grow slightly less than the average; and the poorest group grow only one-half of average volume (33).

A pure stand of mature western larch.

Larch competes not only with trees of similar size but also with the tolerant understory that develops under the somewhat open-crowned trees. Diameter growth of residual larch on a seed-tree cutting increased 67 percent over prelogging growth. Cutting of all understory trees resulted in an additional increase of 36 percent of prelogging. Douglas-fir accelerated 42 percent over prelogging after cutting but did not make an additional response after removal of the understory because it probably already fully occupied the site (38).

Trees 50 years old respond to release by growing new branches from adventitious buds. The rate of occurrence and degree of regrowth are correlated directly with amount of release. Adventitious branches developed on pruned sections of 54 percent of larch crop trees released by a heavy grade of thinning, but only on 24 percent released by a medium grade. Branches tended to develop in the upper half of pruned sections of the former group and in the upper quarter of the latter. Before pruning, fine dead branches persisted throughout the butt log.[5/]

INJURIOUS AGENCIES

Fire resistance of mature and older larch exceeds that of any of its associates. However, young trees of sapling and pole size are killed readily by fire. The basal bark of older trees is at least 3 to 6 inches thick and affords protection against fire (8, 41).

Larch trees are moderately resistant to windthrow because of excellent anchorage afforded by their deep, wide-spreading root system (16).

Dwarfmistletoe (Arceuthobium campylopodum forma laricis) is a serious disease of larch. It may infect trees from 3 to 7 years of age, continuing throughout the life of the tree. Mistletoe enters shoots 4 years old or younger (47). "All mistletoe infections interfere with normal functioning of a tree and are therefore detrimental" (13). Slight infections may reduce growth to three-fourths of average, and severe infections may reduce growth to one-half of normal in young trees (13). Infected trees 144 years old averaged 63 feet in height and 11.5 inches d.b.h., while uninfected trees averaged 115 feet in height and 19.5 inches d.b.h. Besides reducing growth, mistletoe kills outright, causes spiketops, creates entrances for insects and fungi, causes burls and brashness, and reduces vitality of seed (47).

Larch is afflicted by three other important diseases: the brown trunk rot caused by the quinine fungus, Fomes laricis; red ring rot caused by Fomes pini; and needlecast caused by Hypodermella laricis (5).

Among the most damaging insects to larch are the sawfly, Pristiphora erichsonii and bark beetle, Dendroctonus pseudotsugae. The spruce budworm (Choristoneura fumiferana) infrequently attacks larch, and the larch bud moth (Zeiraphera griseana) damages extensively but sporadically. The western larch sawfly (Anoplonyx occidens) has been credited with a single damaging attack. The sawtooth pine engraver (Ips integer) usually attacks dying and felled trees (18). Other minor pests cause infrequent damage.

5/ Unpublished results of crop tree thinning and pruning experiment in a 50-year-old larch stand, Missoula Research Center, Intermountain Forest and Range Experiment Station.

SPECIAL FEATURES

Galactan, a water-soluble gum that is present in western larch, distinguishes this wood from other softwoods. This gum is concentrated in the basal portions. The end product of galactan, mucic acid, can be used in manufacturing baking powder (17).

The oleoresin produced by western larch can be used commercially in the same ways that the oleoresin of European larch is used. The western larch product has the consistency of honey, is light amber in color, and has a slightly bitter taste but an agreeable odor. It contains 16 percent volatile pinene and limonene. The nonvolatile portion is a resin possessing acid properties but yielding no crystalline product (27).

RACES

Races of western larch have not been reported. Few, if any, races seem likely because larch grows within a rather narrow geographic range.

LITERATURE CITED

1. American Forestry Association.
   1951. American tree monarchs. American Forests 57(6): 26, illus.

2. Baker, Frederick S.
   1949. A revised tolerance table. Jour. Forestry 47: 179-181.

3. Boe, Kenneth N.
   1953. Western larch and Douglas-fir seed dispersal into clearcuttings. Northern Rocky Mountain Forest and Range Expt. Sta. Research Note 129, 3 pp., illus.

4. _____
   1954. Periodicity of cone crops for five Montana conifers. Mont. Acad. Sci. Proc.14: 5-9.

5. Boyce, John Shaw
   1938. Forest pathology. 600 pp., illus. New York and London.

6. Brewster, D. R.
   1918. Relation between height growth of larch seedlings and weather factors. Jour. Forestry 16: 861-870, illus.

7. Cummings, L. J.
   1937. Larch--Douglas-fir board foot yield tables. Northern Rocky Mountain Forest and Range Expt. Sta. Applied Forestry Notes 78, 5 pp.

8. Cunningham, R. N., S. V. Fullaway, Jr., and C. N. Whitney
   1926. Montana forest and timber handbook. Mont. Univ. Studies No. 1, 162 pp., illus.

9. Daubenmire, R. F.
   1943. Vegetational zonation in the Rocky Mountains. Bot. Rev. 9(6): 325-393, illus.

10. _____
   1946. Radial growth of trees at different altitudes. Bot. Gaz. 107(4): 462-467, illus.

11. _____
   1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monog. 22: 301-330, illus.

12. Fisher, George M.
   1935. Comparative germination of tree species on various kinds of surface-soil material in the western white pine type. Ecology 16: 606-611.

13. Gill, L. S.
1935. Arceuthobium in the United States. Conn. Acad. Arts and Sci. Trans. 32: 111-245, illus.

14. Haig, Irvine T.
1936. Factors controlling initial establishment of western white pine and associated species. Yale Univ. School of Forestry Bul. No. 41: 149 pp., illus.

15. _____, Kenneth P. David, and Robert H. Weidman
1941. Natural regeneration in the western white pine type. U. S. Dept. Agr. Tech. Bul. 767, 99 pp., illus.

16. Harlow, William M., and Ellwood S. Harrar
1937. Textbook of dendrology. 527 pp., illus. New York and London.

17. Johnson, R. P. A., and M. I. Bradner
1932. Properties of western larch and their relation to uses of the wood. U. S. Dept. Agr. Tech. Bul. 285, 93 pp., illus.

18. Keen, F. P.
1952. Insect enemies of western forests. U. S. Dept. Agr. Misc. Pub. 273. 280 pp., illus.

19. Kirkwood, J. E.
1922. Forest distribution in the northern Rocky Mountains. Univ. of Montana Studies, Series 2, Bul. 247, 180 pp., illus. Missoula, Montana.

20. Koch, Elers
1945. The Seeley Lake tamaracks. Amer. Forests 51(1): 21, 48.

21. Larsen, J. A.
1916. Silvical notes on western larch. Soc. Amer. Foresters Proc. 11(4): 434-440.

22. _____
1918. Comparison of seed testing in sand and in the Jacobsen germinator. Jour. Forestry 16: 690-695.

23. _____
1922. Some characteristics of seeds of coniferous trees from the Pacific Northwest. Natl. Nurseryman 30(9): 146-149.

24. _____
1924. Some factors affecting reproduction after logging in northern Idaho. Jour. Agr. Res. 28: 1149-1157.

25. Larsen, J. A.
1930. Forest types of the northern Rocky Mountains and their climatic controls. Ecology 11: 631-672, illus.

26. _____
1940. Site factor variations and responses in temporary forest types in northern Idaho. Ecol. Monog. 10: 1-54, illus.

27. Mahood, S. A.
1921. Larch (Venice) turpentine from western larch (Larix occidentalis). Jour. Forestry 19: 274-282.

28. Olson, D. S.
1930. Growing trees for forest planting in Montana and Idaho. U. S. Dept. Agr. Cir. 120, 92 pp., illus.

29. _____
1932. Germinative capacity of seed produced from young trees. Jour. Forestry 30: 871.

30. Oosting, Henry J.
1948. The study of plant communities. 389 pp., illus. San Francisco.

31. Polk, R. Brooks, and Kenneth N. Boe
1951. Succession of trees in cut-over larch--Douglas fir stands in western Montana. Mont. Acad. Sci. Proc. 10: 31-37.

32. Preston, Richard J., Jr.
1940. Rocky Mountain trees. 285 pp., illus. Ames, Iowa.

33. Roe, Arthur L.
1948. A preliminary classification of tree vigor for western larch and Douglas-fir trees in western Montana. Northern Rocky Mountain Forest and Range Expt. Sta. Research Note 66, 6 pp., illus.

34. _____
1950. Response of western larch and Douglas-fir to logging release in western Montana. Northwest Sci. 24: 99-104., illus.

35. _____
1952. Larch--Douglas fir regeneration studies in Montana. Northwest Sci. 26: 95-102.

36. _____
1955. A seedbed preparation test in the larch--Douglas-fir timber type in northwestern Montana. Montana State University, School of Forestry, Master's Thesis, 62 pp., illus.

37. Roe, Arthur L.
1955. Cutting practices in Montana larch--Douglas fir. Northwest Sci. 29: 23-34, illus.

38. _____
1956. The effect of competition in old-growth western larch--Douglas-fir stands. Mont. Acad. Sci. Proc. 16: 41-45.

39. Society of American Foresters, Committee on Forest types
1954. Forest cover types of North America (exclusive of Mexico). 67 pp., illus. Washington, D. C.

40. Sudworth, George B.
1908. Forest trees of the Pacific slope. U. S. Dept. Agr. Forest Serv. 441 pp., illus.

41. _____
1918. Miscellaneous conifers of the Rocky Mountain region. U. S. Dept. Agr. Bul. 680. 44 pp., illus.

42. Terry, E. I.
1910. Yield tables of western forests. Forestry Quart. 8(2): 174-177.

43. Toumey, James W., and Clark L. Stevens
1928. The testing of coniferous tree seeds at the School of Forestry, Yale University 1906-1926. Yale Univ. School of Forestry Bul. 21, 46 pp., illus.

44. U. S. Department of Agriculture
1938. Soils and men. Yearbook of Agriculture. 1232 pp., illus.

45. U. S. Forest Service
1948. Woody-plant seed manual. U. S. Dept. Agr. Misc. Pub. 654, 416 pp., illus.

46. Weaver, John E., and Frederic E. Clements
1938. Plant ecology. 601 pp., illus. New York and London.

47. Weir, James R.
1916. Mistletoe injury to conifers in the Northwest. U. S. Dept. Agr. Bul. 360. 39 pp., illus.