United States Department of Agriculture

Forest Service

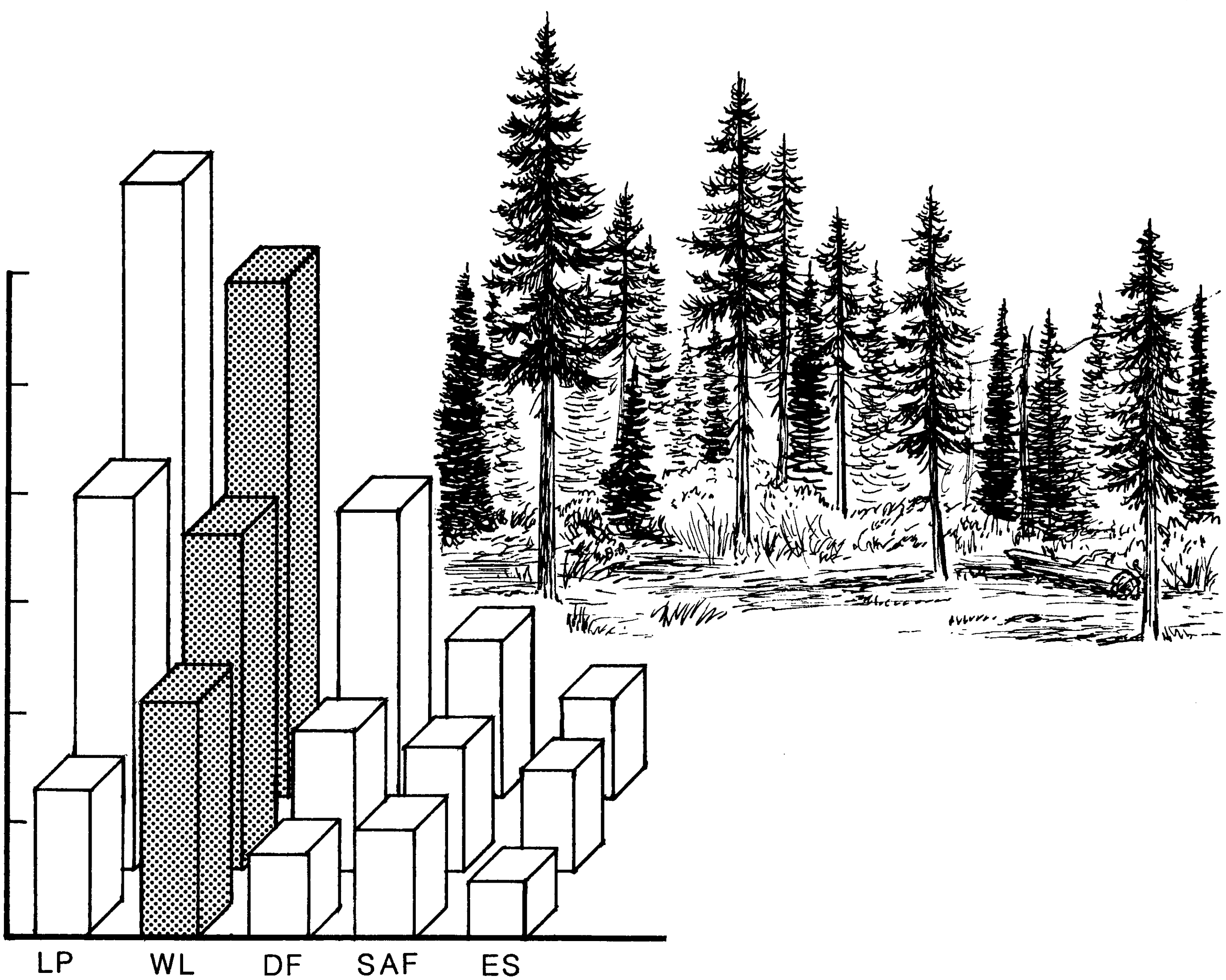
Intermountain Research Station

Research Paper INT-364

June 1986

Site Treatments Influence Development of a Young Mixed-Species Western Larch Stand

Dennis M. Cole
Wyman C. Schmidt



THE AUTHORS

DENNIS M. COLE is a research silviculturist with the Silviculture of Conifers in Montane and Subalpine Forest Ecosystems of the Intermountain and Northern Rocky Mountain West research work unit at the Forestry Sciences Laboratory, Bozeman, MT. His studies have focused on lodgepole pine silviculture, particularly growth and yield relationships, culture of immature stands, and management of the species in the face of major insect and disease problems.

WYMAN C. SCHMIDT is a research silviculturist and Project Leader of the Silviculture of Conifers in Montane and Subalpine Ecosystems of the Intermountain and Northern Rocky Mountain West research work unit at the Forestry Sciences Laboratory, Bozeman, MT. Dr. Schmidt's research has focused on the ecology, regeneration processes, stand development, and related cultural practices in coniferous forests of the Intermountain West. Much of his research has centered on the interrelationships of timber, water, and other resources as well as the interaction of cultural practices with insect pests such as western spruce budworm.

ACKNOWLEDGMENTS

We gratefully acknowledge previous researchers involved in the initial planning, installation, and subsequent remeasurements of this study, including Kenneth N. Boe, Steven A. Haglund, Ward W. McCaughey, Arthur L. Roe, Jack A. Schmidt, Raymond C. Shearer, and Anthony E. Squillace.

July 1986
Intermountain Research Station
324 25th Street
Ogden, UT 84401

Site Treatments Influence Development of a young Mixed-Species Western Larch Stand

Dennis M. Cole
Wyman C. Schmidt

INTRODUCTION

More intensive management could be applied to many young stands in conifer forests of the Northern Rockies. Vast areas are stocked with stands that contain a mixture of conifer species. An important mixed species cover type in this region is the western larch type (formerly called the larch—Douglas-fir type)(Society of American Foresters 1980). It is usually dominated by western larch (*Larix occidentalis* Nutt.) and Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn.] Franco); but also has appreciable amounts of Engelmann spruce (*Picea engelmanii* Parry) and subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.). Species sometimes occurring in the cover type are lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.), western white pine (*Pinus monticola* Dougl.), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), and western redcedar (*Thuja plicata* Donn ex D. Don). The exact species composition in the western larch type is determined largely by the successional stage of the stand and the physical environment in which the stand occurs. Usually the above-mentioned mixture of conifer species occurs in habitat types of the *Pseudotsuga menziesii* and *Abies lasiocarpa* successional series (Daubenmire and Daubenmire 1968; Pfister and others 1977).

Mature and overmature forests of the western larch type, containing appreciable amounts of larch, Douglas-fir, spruce, and white pine in the overstory, have long been sought for timber harvest. Many of the accessible mature stands have been harvested and regenerated to young mixed-species stands that show the influence of the particular cutting system and site preparation methods that were used. Knowledge of the effects on future stands of cutting systems and various site preparation and vegetation-manipulation treatments is an important consideration for proper management of stands still to be harvested.

Because of its rapid growth, excellent wood, desirable esthetic qualities, and low incidence of insect attacks, disease, and defects, western larch is usually featured in management of the western larch type. But because most managers seek to maintain a mixture of species, Douglas-fir, Engelmann spruce, and lodgepole pine are also encouraged in the regeneration process. These objectives usually result in even-age management of stands of the western larch type, including either clearcutting, shelterwood, or seed-tree methods of regeneration (Schmidt and others 1976). Each of these cutting methods can provide favorable conditions for natural regeneration of the favored species—but depending on seedbed and understory vegetation conditions following cutting, the composition, density, and growth of the future stand can vary widely (Polk and Boe 1951; Roe 1955; Schmidt 1969).

Polk and Boe (1951) and Roe (1955) concluded that desired composition of the future stand can neither be attained nor maintained through cutting method alone; seedbed preparation and later stand improvement practices are necessary. Specifically, practices are required that obtain establishment of desired tree species before shrubs and other vegetation overwhelm the site. Roe (1955) studied the relative need for sunlight and mineral-soil seedbeds of larch and its common associates in the western larch type at Terrace Hill on the Coram Experimental Forest in northwestern Montana. He described the relationships among method of cutting, proportion of ground surface in favorable seedbed, and resultant stocking percentages of each species.

Schmidt (1969) later reported on seedling and early sapling development and concluded that site preparation—in the form of mechanical scarification, prescribed burning, and slashing of competing shrubs—influenced not only regeneration establishment, but subsequent seedling development. He found, after 12 to 15 years, that larch regenerated abundantly, grew rapidly, and became dominant where prescribed burning or mechanical scarification provided a sufficient area of ash or mineral soil seedbeds and reduced the amount of competing vegetation. Spruce seedlings also required mineral soil for successful establishment but grew slowly on the exposed seedbeds favored by larch. In contrast, Douglas-fir was insensitive to seedbed condition in the regeneration phase, but tended to dominate the stands where seedbeds had little or no preparation and larch competition was light.

From the above observations, Schmidt (1969) predicted that the direct effects of seedbed and understory would continue to diminish and the effects from differences in stand density and shade tolerance would increase as the stand grew past the early sapling stage. This report tests this hypothesis by comparing subsequent growth patterns against site treatments in the 25-year-old stand.

STUDY DESCRIPTION AND PROCEDURES

This study was established at Terrace Hill on Coram Experimental Forest in northwestern Montana within a large, recently logged stand of western larch and Douglas-fir. The stand was located on a lower northeast slope and had a larch site index of 58 ft at 50 years—a medium site. The original stand consisted primarily of western larch (WL) and Douglas-fir (DF), but contained small numbers of spruce (ES), western white pine (WWP), lodgepole pine (LP), subalpine fir (SAF), and western hemlock (WH). The stand was logged in 1943, leaving about five healthy, well-distributed dominant larch seed trees per acre and a heavy residual understory of trees (chiefly subalpine fir and tall shrubs such as yew [*Taxus brevifolia* Nutt.]). Slash was piled and burned in 1944. In 1945, the residual understory of trees and tall shrubs was slashed on an area of 8 acres and an equal-size area left unslashed. The ground surface after logging and burning included undisturbed forest floor and mineral soil exposed by tractor skidding, road construction, and slash burning. These operations left four generalized combinations of seedbed-vegetative competition conditions for study: (1) unslashed-unscarified, (2) unslashed-scarified (scarified only), (3) slashed-unscarified (slashed only), and (4) slashed-scarified. It is important to understand that unslashed and unscarified treatments still received some soil disturbance in the course of the logging process.

Fifteen milacre (0.0004-ha) plots were randomly established for each of the four seedbed/competing vegetation conditions, making a total of 60 sample plots. In 1949, after several years had been allowed for adequate seedfall, reproduction was tallied by species. Following the reproduction tallies, the study was converted to a stand development study and the initial seedling establishment and early seedling development results were reported (Roe 1955). Upon conversion to a stand development study, all tree seedlings on the milacre study plots were recorded by species and measured for height to the nearest 0.1 ft (3 cm) and their vigor subjectively classified as good, fair, or poor, on the basis of crown length and density, needle color and length, and prior growth. As the trees grew into and beyond the sapling stage at the third and fourth measurements, crown class of trees on the milacre plots was also recorded. At the fourth measurement at 25 years, diameter at breast height (d.b.h.) was also measured on all trees exceeding 4.5 ft (1.37 m) in height.

Data from this completely randomized study were subjected to analysis of covariance to determine the statistical significance of treatments on growth of the different species. Trees-per-acre stocking at establishment in 1949 was used as the covariate in these analyses. Trends in stocking, composition, vigor, and dominance were also analyzed.

RESULTS

A brief review of the 15-year results shows that the seed trees, adjacent timber, and small understory trees left after logging produced enough seed to adequately stock, and in most cases overstock, the study area. The mineral soil seedbeds were especially overstocked, primarily with larch and spruce (Schmidt 1969). Nonscarified forest floor seedbeds had only about one-third the stocking of the mineral soil seedbeds and had higher proportions of Douglas-fir and subalpine fir in comparison to larch and spruce. These treatment-related differences in stocking density and composition provided the basis for earlier forecasts of significant differences among the species in future survival, growth, vigor, and relative expression of dominance in the stand (Schmidt 1969).

The earlier report (Schmidt 1969) of growth differences among species featured dominant trees, but after 25 years many dominant sample trees were dead. Therefore, growth results presented here are in terms of all trees surviving on the quadrats at the last measurement. Height growth from 15 to 25 years of age and breast height diameter at 25 years of age were analyzed for the major species regenerated in the study area: western larch, lodgepole pine, Douglas-fir, Engelmann spruce, and subalpine fir. With the additional 10 years of stand development, growth effects have become more evident, earlier conclusions can be tested, and still stronger inferences for future stand development can be made.

Diameter Growth

Several treatments had produced no Engelmann spruce or subalpine fir of breast height at the time of the last measurement; therefore only western larch and Douglas-fir were analyzed for diameter growth differences among species and treatments. Treatment effects differed significantly ($p=0.05$) between western larch and Douglas-fir. Scarification resulted in greater diameters among western larch than Douglas-fir (fig. 1). Slashing promoted growth of larch more than Douglas-fir, but only on unscarified plots (fig. 1). The largest diameters were registered for larch on unscarified, slashed plots; the smallest diameters were also larch, but where no slashing or scarification had occurred. The slow diameter growth of larch in unscarified areas likely results from the intolerance of larch to competition from overtopping residual vegetation in the unslashed plots. The rapid diameter growth of larch is likely a consequence of limiting competition by slashing but not scarifying seedbeds.

In contrast to larch, slashing on unscarified plots reduced diameter growth of Douglas-fir. This effect seems to be related to the strong growth performance of the larch; the higher densities and faster growth of larch apparently suppress diameter growth of Douglas-fir established at the same time. Slashing had virtually no effect on either larch or Douglas-fir on scarified plots.

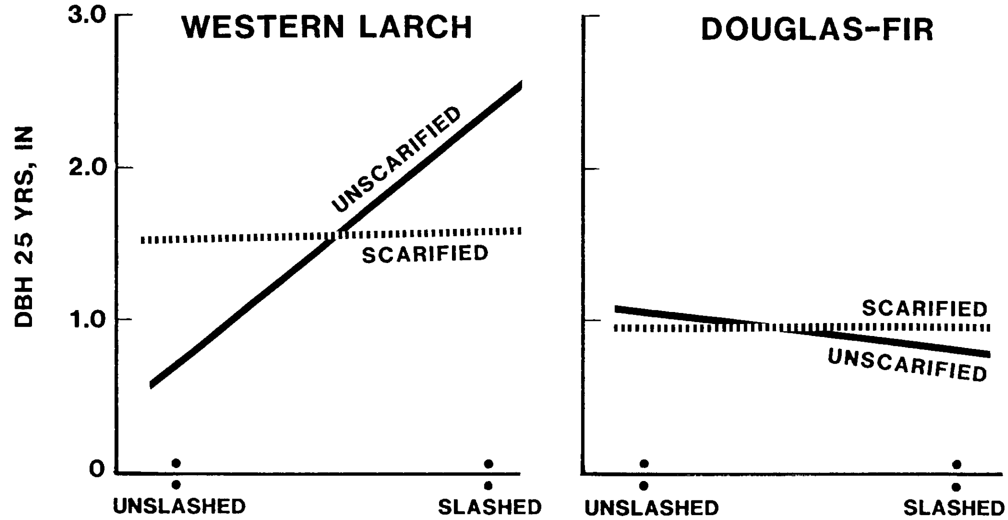


Figure 1.—Effect of scarification and slashing on diameter growth to 25 years of age.

Height Growth

Height growth differences among western larch, Douglas-fir, Engelmann spruce, and subalpine fir were not significant when adjusted for stand density, but treatments did significantly affect ($p=0.05$) height growth of all species (fig. 2). Slashing of understory shrubs and trees left after the seed tree harvest resulted in significantly greater height growth of regeneration than when left unslashed, while scarification significantly reduced height growth only in plots where slashing had occurred. The best height growth occurred where no scarification occurred but where residual trees and shrubs were slashed. In contrast, the poorest height growth occurred where scarification had occurred, but where no slashing was done.

Seedling vigor—classified on the basis of early growth, foliage density, and needle color and length—was a good indicator of subsequent height growth in earlier measurements of this study (Schmidt 1969). For example, from age 10 to 15, good-vigor larch, lodgepole pine, Douglas-fir, and subalpine fir grew about two and six times faster than their fair-vigor and poor-vigor counterparts. Good-vigor spruce grew only about twice as fast as their poor-vigor counterparts. Each vigor class of western larch and lodgepole pine grew about twice as fast as other species of corresponding vigor classes during that period.

Tree vigor at the last measurement was again considered as a means of evaluating height growth. A discriminant analysis was made to determine whether vigor could be classified using species and treatment variables; however, no effective discriminator involving treatments was found. Therefore, vigor was evaluated as before as an influence on growth, irrespective of treatments.

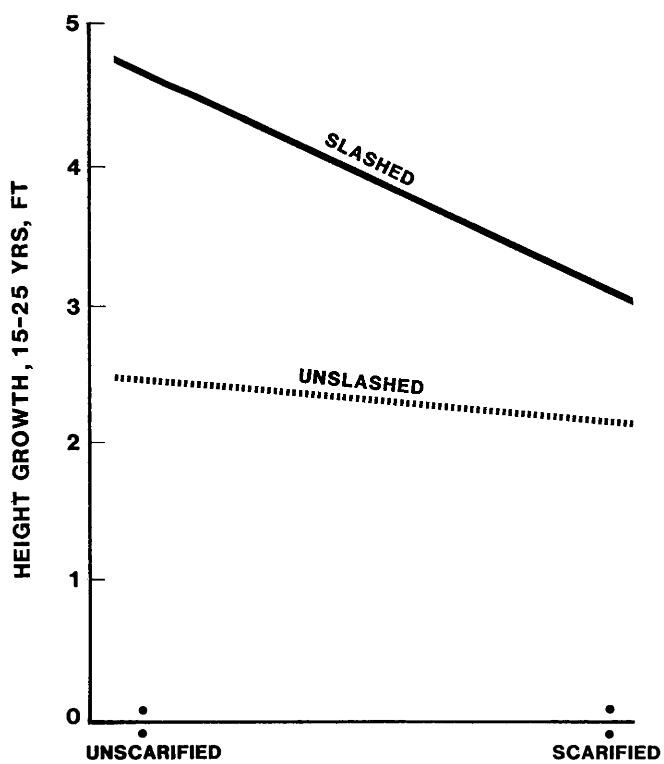


Figure 2.—Effect of scarification and slashing on height growth of major species from age 15 to 25 years.

The same general height growth relationships apparent in the 10- to 15-year age period among and between species and vigor classes were also apparent in the 15- to 25-year age period (fig. 3). On the basis of average periodic annual increment (PAI), however, growth rate differences of the good-vigor class lessened for most species, as did differences between species within the same vigor class. Douglas-fir was the exception; trees in the good-vigor class at 15 years of age increased in height PAI from 15 to 25 years of age, suggesting that favorably located Douglas-fir seedlings of good vigor can be expected to gradually increase their growth rate and maintain their vigor in the first 25 years of stand development. The two seral species, larch and lodgepole pine, continued to exceed other species in rate of height growth, but trees originally noted for good vigor grew substantially slower from age 15 to 25 than they had from age 10 to 15. Differences in PAI between the two growth periods were less apparent and less consistent for the fair and poor vigor trees. Major seral species, in particular, were influenced in the regeneration stage by seedbed conditions and competing vegetation; with time this becomes less important than intertree competition.

A composite of the total 25-year period shows the two seral species—lodgepole pine and western larch—making the greatest total height growth (fig. 4). Even the fair-vigor lodgepole pine and western larch had greater height growth than the good-vigor trees of all other species, but the good-vigor Douglas-fir were accelerating. The shade-tolerant subalpine fir and spruce lagged behind in keeping with their normal understory positions in this forest type. How differential species performance influenced the character of the stand at age 25 is discussed in the following section.

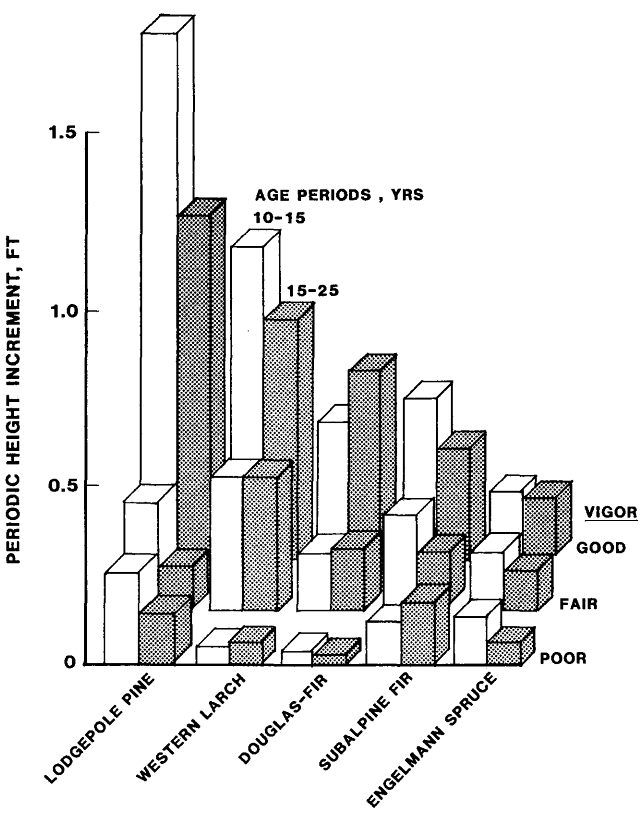


Figure 3.—Periodic annual height increment for the age periods 10 to 15 and 15 to 25 of five conifers in three different vigor classes.

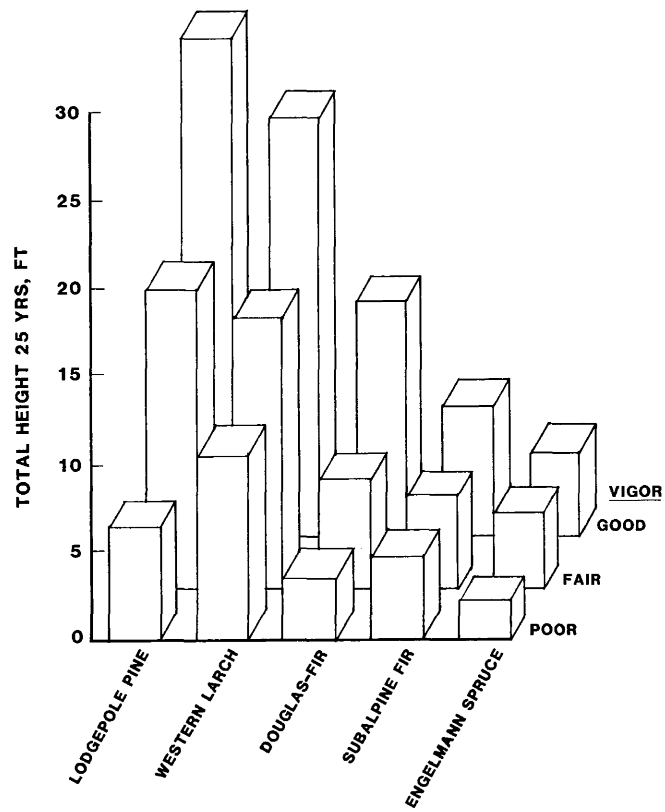


Figure 4.—Total height at age 25 of five different conifers in three different vigor classes.

Stand Character

Western larch and spruce comprised two-thirds or more of the large number of trees per acre established on seedbeds that had been scarified; Douglas-fir and subalpine fir comprised about two-thirds of the less-dense regeneration in the treatments where the forest floor was unscarified (Schmidt 1969). But total stand density, species stocking frequency, and stocking frequency of dominant trees have changed markedly during the 25 years of study (table 1). Where the forest floor was not scarified, initially modest stand densities increased by about 1,000 trees per acre. Where scarified, stand densities increased substantially where understory had not been slashed—apparently due to continued regeneration of the more tolerant species from the residual seed source. Where scarified and slashed, stand density peaked at age 15 but by age 25 declined below the density at age 10, due mainly to mortality of western larch from interspecies competition. At age 15, larch

Table 1.—Stand density and stocking frequency of all trees and dominants by age and treatment

Treatment	Age	Density of regeneration	Stocking frequency WL[1]	DF	ES	SAF	Other[2]
		Trees/acre	*Percent*				
Unslashed, unscarified	10	3,140	[3]33(33)	67(53)	7(0)	20(7)	(7)
	15	4,210	40(40)	73(40)	13(0)	20(7)	(13)
	25	4,267	40(40)	73(36)	7(0)	33(7)	(17)
Unslashed, scarified	10	13,390	100(93)	80(0)	80(0)	60(0)	(7)
	15	17,330	100(93)	80(0)	100(0)	87(0)	(7)
	25	16,733	87(67)	73(13)	93(0)	80(0)	(20)
Slashed, unscarified	10	3,270	67(47)	73(53)	20(0)	33(0)	(0)
	15	4,410	73(47)	67(46)	40(0)	33(0)	(7)
	25	4,067	53(33)	67(40)	47(0)	33(0)	(7)
Slashed, scarified	10	10,470	93(73)	80(13)	73(0)	7(0)	(14)
	15	12,800	87(66)	80(7)	80(0)	20(0)	(27)
	25	9,467	87(59)	67(7)	80(0)	20(0)	(34)

[1]Relative shade tolerance ranking of species is from left to right, least (WL) to most (SAF).
[2]Other species were primarily lodgepole pine and a few western white pine.
[3]Frequencies in parentheses are the percentages of milacre quadrats in which dominant trees of the species occur.

occurred uniformly on scarified areas and dominated up to 90 percent of such areas, but by age 25 their stocking distribution had declined and they dominated only about two-thirds of scarified area. Most of the decline in larch dominance on scarified seedbeds occurred where competitive shrubs and understory trees were not removed. Larch only stocked 40 to 50 percent of the unscarified areas, but where they were able to establish, they usually became dominant.

Like larch, spruce was well-distributed, stocking at least 50 percent of the area where slashing had occurred and over 80 percent of the area where scarification had occurred. Because of its slow juvenile growth, spruce was overtopped by other species and exhibited no dominance in any treatment.

Douglas-fir was well-distributed at age 25, indicating little establishment preference for any treatment. In unscarified treatments, Douglas-fir was able to express dominance about equally with larch, apparently because of significantly lower larch stocking densities there; but it expressed little dominance in scarified areas where larch and lodgepole pine dominated.

Tree Vigor

Considering the treatment-related differences in stocking and dominance, changes in the relative vigor status of the species were expected. Initially larch, Douglas-fir, spruce, and subalpine fir each had about 60 percent of seedlings classified as good vigor, but by age 25 each except subalpine fir had declined to about 30 percent high-vigor trees. Overstocking was taking its toll on vigor.

The vigor of subalpine fir increased slightly to about 65 percent classified as good vigor. This slight increase occurred on the scarified-only treatment, but was offset by a similar decrease on the treatments where slashing had occurred. These effects are consistent with the relative shade tolerance ranking of subalpine fir.

At 25 years of age, more than three-fourths of the good-vigor larch occurred on the treatments receiving scarification. Conversely, the percentage of poor-vigor larch there increased from 5 to over 25 percent. More than three-fourths of poor-vigor larch occurred on scarified plots—an apparent consequence of the high stand densities on scarified treatments.

The reduction in numbers of good-vigor spruce at age 25 occurred almost exclusively on scarified treatments, even though such sites supported nearly all of the remaining good-vigor spruce. Like larch, these reductions in vigor indicate that the heavy stand densities in the scarified treatment areas reduce spruce vigor, despite the encouragement of spruce establishment by scarification.

Initially, good-vigor Douglas-fir occurred at about the same frequency on all treatments, but by age 25, two-thirds of the good-vigor Douglas-fir were found on unscarified treatments. Poor-vigor Douglas-fir increased from 10 percent to more than 35 percent of trees at age 25. The highest proportion of good-vigor trees and the lowest proportion of poor-vigor trees occurred on the slashed-only treatment.

DISCUSSION AND CONCLUSIONS

The Terrace Hill study demonstrates that seed-tree cutting in the western larch type allows considerable flexibility in guiding the composition and development of the new stand, depending on seedbed and understory vegetation treatment in the establishment phase. It also demonstrates the consequences of failing to control density through the late sapling-early pole stage—in terms of height and diameter growth, dominance, and vigor.

As pointed out earlier (Schmidt 1969), precise regulation of stocking is difficult in natural regeneration systems because of yearly variations in seed production, germination, and seedling survival among species; therefore, cleaning or thinning in the sapling stage assumes critical importance for guiding the composition and growth of the future stand. Because this study was neither thinned nor cleaned, the known benefits of these practices for furthering stand development and management objectives could not be quantified. On the other hand, at age 15 longer term consequences of the overstocking on the different species could only be speculated upon by extrapolating trends in the first 15 years of stand development. The additional 10 years of natural stand development to age 25 provided a better basis for testing of earlier conclusions on the apparent course of mixed species stand development in overstocked natural regeneration in the western larch type.

Results of this study to age 15 suggested that where there had been little or no scarification or removal of understory vegetation, intolerant species—especially larch—were disadvantaged and expected to decline further in vigor and generally be poor prospects for future management. At age 25, this expectation is less clear. Western larch and lodgepole pine, both very shade-intolerant species, have maintained their relative positions of dominance and growth in the stand even where no scarification or removal of competing understory vegetation occurred. Apparently, once established with other species in the western larch type, larch are able to express dominance as well or better than other species. This is not to suggest that choice and timing of seedbed and competing vegetation treatments is not important. Composition and relative growth of the different species are strongly affected by seedbed and competing vegetation conditions and their resultant stand density effects.

From a management perspective, considerable flexibility is provided managers by seed-tree cutting in this forest type, when seedbed and vegetation conditions are manipulated in the regeneration process. If the objective is to maximize timber production on a short rotation, scarification and removal of competing vegetation will ensure prompt and predominant larch regeneration with significant representation of spruce and Douglas-fir. But growth rates will not meet short rotation objectives unless stand density is controlled at an early age. Because larch and lodgepole pine have regeneration and growth advantages on disturbed sites, they have strong timber production advantages; but the beginning of growth decline due to overstocking during the 15- to 25-year age period demonstrates the need for early cleaning and spacing to enhance vigor and growth. On the other hand, a delay in cleaning and thinning does not appear as critical for the more shade-tolerant Douglas-fir, subalpine fir, and spruce. Even though the treatment areas that had not been scarified but had competing vegetation removed had the best overall vigor and growth after 25 years, it is possible that, had stand density been reduced, the early height growth advantage of larch on scarified areas might have been maintained.

Several conclusions are drawn from the study:

1. Seed-tree cutting in the western larch type generally leaves interspersed areas of scarified soil and undisturbed forest floor, on which regeneration of mixed species generally ranges from adequate to overstocked.
2. For all species in general, slashing of residual understory trees and shrubs results in greater height growth. The greatest height growth occurs in the slashed-unscarified areas where both effects of stand density and understory vegetation are minimized.
3. Larch is dominant or codominant in early stand development, particularly on scarified areas. Douglas-fir is codominant with larch in early stand development where no scarification occurs.
4. After 25 years, good-vigor larch and lodgepole pine were able to maintain significantly faster height growth on all treatments than the other major species; all vigor classes of larch grew significantly faster in diameter than Douglas-fir, except on the unslashed-unscarified treatment.
5. Although considerable flexibility is possible in the seed-tree system in guiding initial species composition, density of regeneration, and early growth through scarification and understory vegetation control, the best opportunity for long-lasting influence on composition and growth of the stand is through early cleaning and thinning operations.
6. The first 25 years is a dynamic period in the life of a stand in this forest type, and it is then that managers have the greatest opportunity to shape the character of the future forest in terms of density, composition, structure, and timber yield.

REFERENCES

Daubenmire, R.; Daubenmire, Jean B. Forest vegetation of eastern Washington and northern Idaho. Technical Bulletin 60. Pullman, WA: Washington Agricultural Experiment Station; 1968. 104 p.

Pfister, R. D.; Kovalchik, D. B.; Arno, S. F.; Presby, R. C. Forest habitat types of Montana. General Technical Report INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1977. 174 p.

Polk, R. Brooks; Boe, Kenneth N. Succession of trees in cutover larch—Douglas-fir stands in western Montana. Montana Academy of Science Proceedings. 10: 31-37; 1951.

Roe, Arthur L. Cutting practices in Montana larch-Douglas-fir. Northwest Science. 29: 23-34; 1955.

Schmidt, Wyman C. Seedbed treatments influence seedling development in western larch forests. Research Note INT-93. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1969. 7 p.

Schmidt, Wyman C.; Shearer, Raymond C.; Roe, Arthur L. Ecology and silviculture of western larch forests. Technical Bulletin 1520. Washington, DC: U.S. Department of Agriculture, Forest Service; 1976. 96 p.

Society of American Foresters. Forest cover types of the United States and Canada. Eyre, F. H., ed. Washington, DC; 1980. 148 p.

*U.S. GOVERNMENT PRINTING OFFICE: 1986-0-676-039/41,000

Cole, Dennis M.; Schmidt, Wyman C. Site treatments influence development of a young mixed-species western larch stand. Research Paper INT-364. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station; 1986. 6 p.

Four treatments, all combinations of leaving or removing residual trees and shrubs or scarifying or not scarifying seedbeds, were evaluated for species differences in growth, vigor, and expression of dominance. Western larch was the dominant species in regeneration and growth but had begun to lose some of its advantage by age 25, particularly on scarified areas where overstocking commonly occurred. Douglas-fir was less sensitive to the treatments and, although significantly slower in absolute growth than larch, began to accelerate after 15 years of age. This study confirms that early cleaning and thinning will be necessary to achieve composition, density, and performance goals.

KEYWORDS: western larch, mixed species, stand development, regeneration treatments, site preparation, vegetation control

INTERMOUNTAIN RESEARCH STATION

The Intermountain Research Station provides scientific knowledge and technology to improve management, protection, and use of the forests and rangelands of the Intermountain West. Research is designed to meet the needs of National Forest managers, Federal and State agencies, industry, academic institutions, public and private organizations, and individuals. Results of research are made available through publications, symposia, workshops, training sessions, and personal contacts.

The Intermountain Research Station territory includes Montana, Idaho, Utah, Nevada, and western Wyoming. Eighty-five percent of the lands in the Station area, about 231 million acres, are classified as forest or rangeland. They include grasslands, deserts, shrublands, alpine areas, and forests. They provide fiber for forest industries, minerals and fossil fuels for energy and industrial development, water for domestic and industrial consumption, forage for livestock and wildlife, and recreation opportunities for millions of visitors.

Several Station units conduct research in additional western States, or have missions that are national or international in scope.

Station laboratories are located in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Ogden, Utah

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)