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# Strip Thinning and Selective Thinning In Douglas-Fir

Douglas D. McCreary and David A. Perry

**ABSTRACT**—Tree growth was compared on plots that had been strip thinned, selectively thinned, and not thinned in a 35-year-old Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] stand. The ratio of basal area increment five years after thinning to basal area increment five years before thinning was larger for all thinning treatments than for the control. However, trees farther than 10 feet from the edges of thinned strips did not respond. Individual tree growth and net stand basal area increment were greater in selectively thinned plots than strip-thinned ones after similar percentages of initial basal area were removed in each. Net stand basal area increment after five years was greater in selectively thinned plots than in strip-thinned ones even where 20 percent more trees had been removed. Nevertheless, lower logging costs and increased

*silvicultural flexibility may make strip thinning a desirable alternative in some cases.*

A net increase in yield generally has been observed from thinning natural Douglas-fir stands in the Pacific Northwest (Berg 1978). However, the magnitude of increase is highly dependent on initial stand structure, stand age at the time of thinning, intensity and frequency of thinning, and thinning method.

In commercial thinning operations, logs are usually removed with heavy ground equipment. Although undeniably efficient, this equipment can increase soil compaction greatly and damage residual trees substantially. Considerable evidence points to reduced stand productivity caused by soil compaction (Froehlich 1973). Logging wounds, especially those near the base of the tree, invite rot that further diminishes yield.

Compared with tractor operations, thinning with a skyline system caused substantially less soil compaction and reduced damage to residual stems in young-growth Douglas-fir stands (Aulerich et al. 1974). Skyline costs, however, were approximately 1½ times those of tractor logging. These costs could be lowered if thinning practices were modified so that trees were removed in strips. Strip thinning decreased overall felling time and lessened average turn time by approximately 17 percent compared with random skyline thinning (Kellogg 1980). Although strip thinning seems operationally efficient, it is still not clear how residual trees will respond. Because trees are not individually selected in strip thinning, some large, vigorous trees are removed while some suppressed or damaged ones are retained. This indiscriminate approach will, no doubt, affect stand growth.

To determine better how strip thinning affects Douglas-fir stands, we compared responses of individual trees and net stand basal area increment among strip-thinned plots, plots selectively thinned at two intensities, and a control plot.

### Thinning Sites

Our project was conducted on an even-aged, site III stand in the Oregon State University forest about 5 miles north of Corvallis, Oregon. Plots were thinned in summer of 1972 when trees were 35 years old. Diameters at breast height (d.b.h.) averaged 10 inches and ranged from 3 to 18 inches. Stand volume averaged 10,500 board feet (Scribner log rule) per acre.

Strip-thinned plots had main trunk lines approximately 30 feet wide and 400 feet long. Notches or strips approximately 30 feet wide and 100 feet long were cut at an angle to these trunk lines, producing leave rows approximately 50 feet wide and 100 feet long. All trees were removed within the notches and trunk lines. In summer 1978, we randomly selected one leave row on each side of two of the main trunk lines; each row had between 35 and 39 trees. Trees in all four leave rows were numbered and their d.b.h. recorded. Average yearly radial increments for five years before and five years after thinning were determined for each tree from two cores taken at right angles to each other at breast height.

Average spacing of residual trees was 16 feet on plots selectively thinned at low intensity and 25 feet on those thinned at high intensity. Defective trees were thinned first, but spacing—not size or condition—was the primary consideration for tree removal. Approximately 35 percent of the merchantable stems were removed in the low-intensity plots and 55 percent in the high-intensity plots. Thirty-nine residual trees in the low-intensity and fifty-five in the high-intensity plots were selected randomly for measurement.

Forty control trees in an unthinned stand adjacent to the strip-thinned plots were also selected randomly, measured, and cored.

Where treatment averages were compared, we first

used analysis of variance to determine if differences among the treatments were significant. If they were, we compared individual means using a least significant difference test. Throughout this paper, differences are considered significant if  $P \leq 0.05$ .

### Growth Rate

Because stands differed in growth rate before thinning, we made comparisons using the ratio of basal area increment (BAI) five years after thinning to BAI five years before thinning for each tree. Large ratios indicated an accelerated growth rate. Use of ratios diminished the influence of tree size as a factor in our analysis because tree size was correlated with BAI ( $R^2 = 0.78$ ) but not with basal area increment ratio (BAIR) ( $R^2 = 0.07$ ).

Differences in BAIR among control, strip-thinned, and selectively thinned plots were significant (table 1). Average yearly radial increment decreased after 1972 in the control plot, remained almost identical to what it had been during the five years before thinning in the strip-thinned plots, and increased dramatically after thinning in the selectively thinned plots of both intensities. Trees in both selectively thinned plots had significantly larger BAIRs than those in strip-thinned plots, and trees in strip-thinned and selectively thinned plots had significantly larger BAIRs than those in the control plot.

To understand better why trees in the strip-thinned plots did not respond more after thinning, we examined the relationship between BAIR and distance to the nearest opening created by strip thinning for each tree. Regression analysis indicated that distance to the nearest opening was negatively related to BAIR ( $BAIR = 1.20 - 0.025 \text{ distance}$ ), though only 20 percent of the variation in BAIR could be explained by variation in distance alone. We then divided the trees into three groups according to their distance to the nearest opening—less than 10 feet, 10 to 16.4 feet, or 16.4 feet and greater—and compared these groups with control trees.

BAIRs of control trees and those 10 feet or farther from an opening were similar, but there was a significant difference between control trees and those within 10 feet of an opening (table 2). However, these edge trees

**Table 1. Basal area increment ratio (BAIR) as affected by treatment.**

Treatment	BAIR	
	Mean <sup>1</sup>	Standard error of mean
Control	0.84 <sup>a</sup>	0.035
Strip thinning	.99 <sup>b</sup>	.033
Selective thinning		
Low intensity	1.64 <sup>c</sup>	.061
High intensity	1.65 <sup>c</sup>	.079

<sup>1</sup>Means in these tables with the same letters are not significantly different ( $P \leq 0.05$ ), Fisher's protected LSD test (Steel and Torrie 1980).

**Table 2. BAIR of strip-thinned plots—as affected by trees' distance from strip edges—and of the control.**

Distance in feet from edge	BAIR	
	Mean	S.E. of mean
<10	1.12 <sup>a</sup>	0.048
Control	.84 <sup>b</sup>	.035
≥16.4	.82 <sup>b</sup>	.042
≥10, <16.4	.79 <sup>b</sup>	.045

**Table 3. BAIR of strip-thinned plots—as affected by tree diameter and tree distance from strip edges—and of the control.**

Distance in feet from edge	1978 d.b.h.	BAIR	
		Mean	Standard error of mean
	<i>Inches</i>		
<10	≥11.8	1.13 <sup>a</sup>	0.036
<10	<11.8	1.11 <sup>a,b</sup>	.097
Control	≥11.8	.94 <sup>b,c</sup>	.042
≥10	≥11.8	.91 <sup>c</sup>	.029
Control	<11.8	.75 <sup>c,d</sup>	.048
≥10	<11.8	.69 <sup>d</sup>	.052

still had BAIRs significantly smaller than those of trees that had been selectively thinned at either intensity. A strip-thinning study in Sweden found a similar difference in response for Scotch pine (*Pinus sylvestris*) of edge and interior trees in 52.5-foot-wide rows (Bucht and Elfving 1977). The authors reported greatly increased diameter increment of trees less than 9.8 feet from the strips; trees farthest from the strips, however, showed no thinning response.

Because tree size might also influence response to strip thinning, we added d.b.h. to our regression model. This independent variable was also significant, explaining an additional 6 percent of the total variation. The revised regression model, now  $BAIR = 0.91 + 0.025 \text{ d.b.h.} - 0.25 \text{ distance}$ , indicated that larger trees had larger average BAIRs. The interaction between size and distance was not significant.

To compare the response of trees of various sizes and distances from the strip edges to similar-sized control trees, we divided strip-thinned trees into four groups on the basis of distance from an opening (greater or less than 10 feet) and d.b.h. (greater or less than 11.8 inches, approximately the median diameter). Control trees were divided into two groups according to d.b.h. (greater or less than 11.8 inches). Both size classes of trees less than 10 feet from the strip edges had significantly larger BAIRs than similar-sized trees in the control plot (table 3). The BAIRs of interior trees, on the other hand, were not significantly different from control trees for either size class.

We also calculated the relative net stand BAI for each treatment for the five years after thinning. We gave the net stand BAI of the control plot a reference value of 100. The value for each thinning treatment was calculated by multiplying the percentage of stems remaining after thinning by the ratio of that treatment's BAIR to the BAIR of the control. Net BAI of selectively thinned plots of low intensity was much greater than that of strip-thinned plots, even though the same initial percentage of merchantable stems was removed in each (table 4). Net BAI was greater even in the plots thinned at high intensity, where 20 percent more stems were removed, than in strip-thinned plots. These large differences in net BAI between selective thinning and strip thinning probably would have been even greater if trees selectively thinned had been chosen more on the basis of size and vigor than on spacing. The substantial differences in net BAI between plots thinned at high and low intensities are attributable solely to differences in the amounts of residual growing stock after thinning. Although trees were growing at the same average rate in each plot, plots thinned at low intensity simply had more trees per acre.

**Table 4. Relative net stand basal area increment (BAI) for the five years after thinning.**

Treatment	Merchantable stems removed, 1972	Relative net stand BAI
	----- Percent -----	
Control	0	100
Strip thinning	35	77
Selective thinning		
Low intensity	35	113
High intensity	55	88

### Effectiveness of Strip Thinning

Recommendations regarding any thinning treatment require economic analyses of logging costs, market values, interest rates, and expected future stumpage prices. These considerations are beyond our scope here. However, we can draw certain basic conclusions from our data.

Most important, strip thinning under similar conditions in a young-growth Douglas-fir stand such as ours is less effective than selective thinning of similar intensity in stimulating residual tree growth. This is at least partly because trees farther than 10 feet from the strip edges do not respond at all to thinning. Our data also indicate that selective thinning can remove a much higher percentage of the initial basal area than can strip thinning while selective thinning still produces a similar net BAI after five years. However, these conclusions may not apply to stands older or younger than ours or to stands growing under different conditions. We also would expect an increase in average growth if strip thinning were modified so that the width of leave strips was 20 feet or less. Although this change probably would not increase growth and yield sufficiently to equal the growth and yield of selectively thinned plots of similar intensity, lower logging costs could still make such a practice desirable.

Other potential benefits from strip thinning are reduced logging damage to residual trees, increased opportunities for whole-tree utilization and advanced regeneration planting, and the possibility of interplanting Douglas-fir with nitrogen-fixing species. Continued research in this area is needed to establish costs and benefits of strip thinning and other alternative thinning practices. ■

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THE AUTHORS—Douglas D. McCreary is research assistant and doctoral student and David A. Perry is associate professor, Department of Forest Science, Oregon State University, Corvallis 97331. They thank D. Edward Aulerich, who originally established the thinning plots used in this study. This is Paper 1450 of the Forest Research Laboratory, Oregon State University.