Effect of Cutting Methods on Logging Costs in Larch—Douglas-Fir[1]

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Silviculturists tend to overlook financial aspects of cutting methods in their desire for greater understanding of purely biological factors. Reporting in a study made in the larch—Douglas-fir type in the northern Rocky Mountains, the authors discuss some effects of cutting method upon logging costs.

FINANCIAL aspects frequently cause modification of cutting practices. Often the best cutting methods, from an ecological standpoint, are restricted by high cost of application. In such instances a compromise is necessary—the biological advantages must be weighed against the business advantages. Silviculturists have in many instances failed to give adequate consideration to the financial factors. Studies of cutting methods to fully answer the question, "What is the best cutting practice?", must recognize the financial as well as the biological feasibility of the methods.

A study of cutting methods was initiated in the western larch—Douglas-fir timber type on the Coram Experimental Forest in Montana in 1950. In order to provide a complete appraisal of the several methods being tested, the study was designed to encompass financial aspects of timber management in addition to the purely biological factors. This report features one phase of the financial aspects—the effect of different cutting systems upon the cost of logging.

Three plots on a 137-acre tract of mature and overmature western larch—Douglas-fir timber were cut under different marking rules. Cutting under these rules resulted in differences in the quality, size, and amount of timber removed. Logging costs were recorded in detail. Summary and analysis of these costs showed how, in this instance, logging costs were affected differently by (1) a seed-tree cutting, (2) an economic selective cutting, and (3) a two-cut shelterwood system.

Description of Area and Timber Stand

The study was conducted in an overmature larch-Douglas-fir stand on a northwest facing slope where larch made up about 73 percent of the volume and Douglas-fir most of the remainder. Engelmann spruce, white pine, and lodgepole pine occurred in minor numbers. Stand density averaged 20.400 board feet (net volume) per acre in trees 12 inches d.b.h. and larger.

The stand composed of two age classes: 500-year-old veterans scattered throughout the stand and 300-year-old trees which made up the major part of the stand in number of stems per acre. The stand was reasonably uniform except that the trees were somewhat smaller than average in the shelterwood cutting and larger than average in the economic selective cutting. These differences were caused chiefly by uneven distribution of the old trees in the 500-year age class. The stocking of trees by average diameter and number of stems larger than 11.5 inches d.b.h. is shown:

	Av. d.b.h. (inches)	Trees per acre (number)
Economic selective logging	19.3	58
Seed-tree cutting	17.2	70
Shelterwood cutting	17.0	84

The topography was reasonably favorable for logging. Slopes averaged about 20 to 25 percent and reached a maximum of about 35 to 45 percent in a limited portion of each of the plots. Occurrence of windfalls and shrub cover was moderately light for the larch—Douglas-fir type.

Marking Rules

Marking rules employed in each of the cutting plots were:

Seed-tree method (40.8 acres).

a. Reserve as seed trees four to five dominant, vigorous well-distributed larch trees per acre.

b. Cut the balance of the stand to the minimum commercial limit of 1½-log height to a 9-inch top diameter.

Economic selective cutting method (40.3 acres).

a. Cut 75 percent of the larch trees 18 inches d.b.h. and larger, and 25 percent of the larch trees under 18 inches d.b.h.

b. Cut all Douglas-fir, spruce, lodgepole pine, and white pine 18 inches d.b.h. and over, and 50 percent of those under 18 inches d.b.h.

Shelterwood method (55.6 acres).

a. Cut all merchantable larch trees of poor vigor and those of undesirable form in the better vigor groups.

b. Cut all merchantable Douglas-fir, lodgepole pine, white pine, and alpine fir.

c. Thin crowded groups by removing merchantable trees to provide free growing space around the crown of each reserve tree favoring moderate to good vigor larch trees.

d. Cut all merchantable trees that are visibly infected with dwarf mistletoe.

e. Reserve, in general, about 50 percent of the volume in an open residual stand composed of well-spaced, thrifty trees that appear capable of producing abundant seed, growing well, and withstanding uprooting or breakage by wind.

[1]The authors wish to acknowledge the assistance received from cooperating individuals and organizations. The F. K. and L. Lumber Company of Martin City, Montana, maintained daily logging cost records and manifested an active, helpful interest in the progress of the job. Assistant Forest Supervisor John R. Castles and Ranger Bert A. Bealey of the Flathead National Forest administered the sale and cooperated in many other ways.

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Silvicultural Objectives

The three harvest cutting methods being tested possess certain silvicultural objectives.

Seed-tree method.—The seed-tree cutting method has long been recognized as a sound silvicultural system to apply to relatively intolerant species such as larch and Douglas-fir. It provides conditions favoring immediate even-aged natural regeneration, and good conditions for juvenile development of the new stand. However, seed trees may be lost if they do not survive until the next cut and if relogging the area for such small volumes is not feasible. Changing utilization practices, however, may permit later recovery of the seed trees.

Economic selective cutting. — Economic selective cutting removes the more valuable trees and leaves chiefly the smaller trees for one or more cuts in 10 to 50 years. It harvests most of the value in the first cut but leaves a small nucleus of residual timber for further growth and future harvest. The numerous small residual trees and relatively few scattered larger reserve trees comprise the seed source for natural regeneration. Cuttings of this general type often open stands sufficiently for establishment and development of reproduction. On the other hand, the smaller trees in even-aged larch—Douglas-fir stands are usually low in vigor and probably will grow poorly. They may also be generally undesirable as seed producers.

Shelterwood cutting.—The principal objectives in shelterwood cutting are to open the stand enough to induce even-aged larch regeneration and provide an adequate seed source to reproduce the stand in a minimum period of time. The total stand is removed in two cuts, with about half the volume taken in the first cut. Reserve trees are selected from the best-vigor, apparently mistletoe-free trees. The principal advantages of this method are believed to be (1) an adequate seed source, (2) best quality parent trees as a seed source, and (3) provision for harvesting seed trees in an attractive cut in 10 to 15 years. On the other hand, the risk of windthrow on some sites and the possibility of tolerant species, which may be undesirable, reproducing the area under the relatively heavy overstory, are possible disadvantages.

All three plots were logged by similar methods, with the same type of equipment and crew organization. Trees were felled and bucked by one- and two-man crews, using small one-man chain saws. Logs were jammer skidded near the roads and tractor skidded in locations beyond reach of the jammer. All the logs were loaded with a power-driven swing boom jammer. Three tractors, an Allis Chalmers HD-7, a Caterpillar D-4, and a Caterpillar D-7, were used for the tractor skidding and jammer and main haul road construction.

Cost Keeping

The study was based on gross cost and production figures. The operator recorded man-hours, machine hours, and materials costs in reasonable detail. Nevertheless, data obtained in the study are sufficiently detailed to permit determination of relative differences between cutting methods. These data represent cost values for the kind of crew and equipment organization used and conditions found in this particular operation.

Analysis of Cost Data

Cutting methods influence the cost of logging chiefly through their effects upon such physical factors as volume of material removed, size of trees cut, and the amount of defect included in the cut. Therefore the analysis was concerned first with the influence of volume, tree size, and defect upon cost. Then these effects were interpreted in the light of how the cutting methods affected these physical factors both in the present cut, and possible future cuts.

Effect of Cutting Method Upon Cost of Present Cut

The results of the study show that the seed-tree cutting was, in nearly all cost elements, the least expensive to log. Direct logging costs per M.b.m., adjusted for original stand differences, are summarized in Table 1. The economic selective and shelterwood cuts cost 30 and 50 percent, respectively, more than the seed tree cut. These cost differences reflect the direct effect of the cutting methods upon the physical factors, particularly volume removed per acre and the size of the trees cut.

Volume cut per acre.—The highest volume was cut in the seed-tree method, essentially a clear-cutting, where all but 4 or 5 seed trees per acre were removed. The economic selective cutting ranked next and the shelterwood cutting yielded the smallest cut. Volume cuts per acre, adjusted for differences in original stand, were 19.3, 12.3 and 9.2 M board feet, respectively. Costs averaged higher per M.b.m. where

TABLE 1.—SUMMARY OF DIRECT COSTS PER M.B.M.[1] ADJUSTED TO COMPENSATE FOR DIFFERENCES IN ORIGINAL STAND STRUCTURE AND DEFECT[2]

Cost Elements	Seed tree	Economic Selective	Shelterwood
	Dollars	*Dollars*	*Dollars*
Development costs (roads & landings)	1.11	1.64	2.37
Felling, bucking, and swamping	2.57	3.67	4.24
Skidding (exclusive of jammer and skid road construction)	3.20	4.12	5.00
Jammer and skid road construction	1.23	2 04	1.73
Loading	1.59	1.21	1.25
Supervision and miscellaneous	0.79	0.96	1.13
Maintenance and depreciation (general)[3]			
Social security, insurance, etc.	0.62	0.79	0.88
Scaling	0.18	0.23	0.29
Direct logging costs exclusive of transportation to mill	11.29	14.66	16.89

[1]All costs are based upon log scale.

[2]Total unadjusted direct logging costs exclusive of transportation to the mill for the seed-tree, economic selective and shelterwood cuts were $11.04, $13.44, and $18.03, respectively.

[3]These costs are included in the equipment rates used.

smaller volumes were removed and lower where larger volumes were cut. For example, reduced volume cut in the economic selective and shelterwood cuts increased the cost of logging by $3.62 and $5.22 per M.b.m., respectively, over the cost of the seed-tree cutting (Table 2).

Size of trees.—The resulting differences in average size of trees cut on the three plots could, after adjustment for original stand differences, be attributed to the cutting system. The larger trees were removed by the economic selective cutting and the smaller by the shelterwood cutting, while the average size of the trees removed by the seed-tree cut was intermediate. Compared with the seed-tree cutting, the cost of logging the shelterwood plots was increased 38 cents per M.b.m. because of its smaller tree size (Table 2). On the other hand, the larger average diameter of the cut trees in the economic selective method caused a saving of 25 cents per M.b.m. over the seed-tree method.

Defect.—Defect increased the cost of logging although it did not significantly alter relationships between methods of cutting. The cost of felling cull trees, long butting, and handling defect in removing merchantable logs was determined in the unadjusted data. The following tabulation shows the amount of cull by cutting methods and the cost of handling cull material:

	Economic selection	Seed-tree	Shelter-wood	Weighted average
Defect, percent	16.1	8.6	15.1	12.3
Cost of handling cull material, dollars per M.b.m.	0.86	0.54	1.22	0.79

The amount of defect was comparatively high in the shelterwood cutting because principally poor-vigor trees were removed, and these could be expected to be more defective than the average. Contrary to expectation, the percent of defect in the economic selective cutting was also high. This may be explained by the fact that trees in the 500-year age class, which tend to be highly defective, occurred more abundantly in that area and were, therefore, represented in larger numbers in the cut. The percent of defect was low in the seed-tree method because there were fewer trees in the 500-year age class in that stand.

TABLE 2.—EFFECT UPON LOGGING COSTS OF TREE SIZE AND VOLUME PER ACRE, USING SEED-TREE CUTTING AS THE BASE FOR COMPARISON

Method	Total cost Per M.b.m.	Saving or extra cost due to: Tree size	Volume Per acre
	Dollars	*Dollars*	*Dollars*
Seed-tree (d.b.h. 18.6, cut 19.3 M.b.m.	11.29	-------	-------
Economic selective (d.b.h. 19.2, cut 12.3 M.b.m.)	14.66	−0.25	+3.62
Shelterwood (d.b.h. 17.9, cut 9.2 M.b.m.	16.89	+0.38	+5.22

TABLE 3.—CURRENT LOGGING COSTS COMPARED WITH ESTIMATED COST OF REMOVING RESERVE IN ONE ADDITIONAL CUT[1]

	Economic selective			Seed-tree[2]			Shelterwood		
Cutting	Net vol.	Av. d.b.h.	Direct logging cost[3]	Net vol.	Av. d.b.h.	Direct logging cost[3]	Net vol.	Av. d.b.h.	Direct logging cost
	M.b.m.	*Inches*	*Dollars*	*M.b.h.*	*Inches*	*Dollars*	*M.b.m.*	*Inches*	*Dollars*
Current	12.3	19.2	14.66	19.3	18.6	11.29	9.2	17.9	16.89
Second:									
In 10 years	8.8	16.1	15.67	----	----	----	12.3	18.1	12.78
In 15 years	----	----	----	----	----	----	12.8	18.4	12.35
In 50 years	12.8[4]	16.6	14.90	----	----	----	----	----	----

[1]All costs are adjusted for original stand differences.

[2]Second cut not shown because it is assumed that the seed-tree area will not be relogged.

[3]Exclusive of transportation to mill.

[4]This volume includes 566 board feet of ingrowth or 11 board feet per annum in addition to 86 board feet per annum on reserve trees. Because of the shorter periods involved the other volumes shown in the table do not include ingrowth.

Probable Effect of Cutting Method Upon the Cost of Future Cuts

The effect of cutting methods upon logging costs cannot be completely appraised by a comparison of the cost of the initial harvest cuts only. Foresters have speculated that the cost of additional cuts in the reserve timber will be less because of the existence of improvements such as roads installed for the initial logging. So far the discussion has been concerned chiefly with the initial cut.

Further analysis has shown that the relative cost of additional cuts is related to the original cutting. The size and number of trees removed in the initial harvest largely determine what can be recovered in additional cuts. Growth also affects subsequent cuttings.

The study showed that logging costs in future cuts in the reserve timber on the economic selective cutting area will probably be as high or higher than in the initial cut (Table 3). The first cut took the larger trees and the greater part of the volume. The second cut, therefore, must come from the small reserve trees plus growth on them and ingrowth, if any. Some ingrowth will develop during the 50-year period, but ingrowth trees will be small and their contribution will amount to only 14 percent of total growth, or 11 board feet per acre per year. However, no ingrowth of merchantable size will develop during the 10-year period. Smaller sized timber and less volume in the future cuts than in the initial cut, therefore, will make future logging more expensive, despite the savings caused by existence of certain improvements.

On the other hand, the analysis showed cheaper logging costs for the second cut than for the initial cut in the shelterwood. The light initial cut (9.2 M.b.m.) left a large reserve volume of vigorous dominant trees. Hence, the future cut will contain larger trees and a larger volume than the initial cut, thus reducing the costs of logging.

The second cut will cost less in the shelterwood than in the economic selective cutting (Table 3). This disparity is caused by differences in volume and tree size and largely disappears when the cost of the initial cut and future cut are averaged, as shown in the following tabulation:

	Average cost per M.b.m.
Seed-tree cut	
Original cut only (19.3 M.b.m. cut)	$11.29
Shelterwood cut	
Original cut and reserve in 10 years (21.5 M.b.m. cut)	14.54
Original cut and reserve in 15 years (22.0 M.b.m. cut)	14.25
Economic selective cut	
Original cut and reserve in 10 years (21.1 M.b.m. cut)	15.08
Original cut and reserve in 50 years (25.1 M.b m. cut)	14.78

However, logging by the seed-tree method remains the least costly at $11.29 per M.b.m. The future stand volume and cost of logging were not determined for the seed-tree cut because it is believed that the cost of logging such small volumes would be excessive.

Future logging costs are based upon current rates and dollar value.

Application

Cost of logging is one of several important factors which the forest manager must consider when selecting a method of cutting. Increased logging costs result in reduced stumpage returns to the landowner or in lower profits to the logger. Consequently, in the light of logging costs alone, the landowner and the logger would normally favor the seed-tree or clear-cutting method. However, before they can judge the merits of a cutting method, they should look at the whole problem. Some additional factors which should be considered are:

The cost of successfully regenerating the stand.—Seedbed preparation and other regeneration measures may cost more in partially cut stands with abundant reserve timber than in the more heavily cut stands. Heavy cutting is believed to be imperative for establishment and development of larch reproduction. On the other hand, artificial regeneration may be necessary under some conditions. Further studies are under way to shed more light on the regeneration phase of the problem.

Earning from or loss of reserve trees.—Reserve stands in the shelterwood system will probably grow best, especially in stands 180 years of age or younger, because the better-vigor and better-formed trees are left. The seed trees left in the seed-tree cutting may be lost because the cost of logging such small volumes is prohibitive and these trees may not survive until the next crop is harvested. Thus, the stumpage value of 1 500 to 2,000 board feet in seed trees must be charged to the cost of obtaining regeneration. The extra cost caused by the loss of seed trees might amount to about $21.00 to $28.00 per acre (at $14.00 per M.b.m. stumpage) or $1.00 to $1.50 per M.b.m. on the volume removed. The effect of growth and mortality of reserve trees is being studied in another phase of the experiment.

Special management objectives.—In some forests partial cutting may be used as a mechanism for balancing age-class distribution of timber or to harvest high-risk trees over large areas in advance of mortality. Thus silvicultural and business principles may have to be compromised to meet the management objectives. In addition, correlation with other land uses such as watershed management, wildlife management, and recreation may require further modification or special cutting methods.

The quality or value of the logs produced.—A complete analysis of the consequence of the marking would have required an evaluation of the logs because different kinds of marking affect the size and quality of logs produced. However, no log grading standards for larch in western Montana have been developed to provide for pricing the logs. Furthermore, an actual mill scale and lumber grade recovery study would have required work and facilities beyond those available for the project. Hence, readers should be mindful that the authors have not attempted to determine whether the logs from the different plots were of equal value at the mill. As pointed out, the economic selective cutting produced logs of somewhat larger size than the average, and the shelterwood cutting produced smaller than average size logs. In the second cut, the shelterwood should yield larger and probably better quality logs.

Summary

Analysis of the effect of the seed-tree, economic selective, and shelterwood cutting methods on logging costs in a larch—Douglas-fir stand showed that partial cutting increased the costs:

Initial cut.—The logging costs were lowest in the seed-tree cutting at $11.29 per M.b.m. (direct logging cost excluding cost of transportation to the mill.) The economic and shelterwood cuttings cost $2.37 and $5.60 per M.b.m. or 30 and 50 percent, respectively, more than the seed-tree method. Less volume per acre removed in these cuttings and smaller trees cut in the shelterwood cutting contributed principally to the added cost.

Future cut of reserve timber.—Estimates of costs of removing reserve stand in the economic and shelterwood plots in one additional cut in the future indicate that the decrease in improvement costs and increase in volume through reserve stand growth will probably not be great enough to offset the greater initial cost due to removing only part of the stand in the first cut. The average cost of removing the total merchantable stand in two cuts on the economic and shelterwood cuttings exceeded the cost of logging the seed-tree cutting even when the seed trees are considered lost and their stumpage value added to the cost of logging. Cutting methods, however, cannot be selected on the basis of logging cost alone. Other factors such as silvicultural requirements and cost of obtaining successful regeneration, earning from or loss of reserve trees, and special management objectives should also be considered.