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THE EFFECT OF PARTIAL CUTTING IN EVEN-AGED LODGEPOLE PINE STANDS

by
A. W. Blyth

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Project A.28

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A. W. Blyth*

Introduction

Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) grows on approximately one-quarter of the forested area of Alberta. In the mountainous subalpine region (5), pine covers large areas as almost a pure type, while extending east into the boreal region the species intermingles with poplar, black and white spruce, balsam fir, and occasionally birch. It is in this latter locality that the growth of lodgepole pine probably reaches its optimum and it is also in this locality that most of the merchantable stands are found. In covering such a range, pine stands exhibit a diversity of characteristics. In and close to the subalpine region, high density in number of trees is the general rule, and although cubic volume yields may be as high as elsewhere, the individual trees are of small diameter. In the boreal region, stands tend to be less dense and consequently the individual trees grow at a faster rate and larger material is produced.

The logging of pine has been concentrated for many years in the areas where open-grown pine is the general rule. The town of Edson, Alberta, is located in the approximate centre of the area where most of the pine has been harvested in the past and is presently being harvested. The main products produced are pulpwood, lumber, railway ties, mine timbers, and poles, with minor quantities of small products such as fence posts, and building logs. With the exception of pulpwood, practically all material is harvested by some form of partial cutting.

PURPOSE OF THE STUDY

The purpose of this study was to determine the effect of partial cutting in lodgepole pine on the diameter and volume growth of residual stands. Regeneration following logging was also studied in order that partial cutting could be assessed as a method of perpetuating pine stands.

Before describing the study it is necessary to define several terms which appear frequently in the text of this report. These terms and their definitions are as follows:

Partial cutting: a cutting by which the merchantable portion of the stand is removed. It usually implies a series of such cuttings.

Original stand: the stand as it existed immediately prior to logging.

Cut: that portion of the original stand removed during the logging operation.

Residual stand: the stand as it existed immediately following logging. The original stand minus the cut.

Present stand: the stand as it existed at time of measurement. The residual stand plus the net growth for the period elapsed since logging.

Mortality: that portion of the residual stand which has died since logging.

*Forest Engineer, Forestry Branch, Alberta District Office, Calgary.

CUTTING METHODS

The early cutting in pine in Alberta was controlled only by an economic diameter limit. Each operator removed those trees which were merchantable and which he knew from experience would realize a profit. As time progressed, more rigid controls were introduced in the form of a minimum stump diameter limit. This method of control is still in force on many areas and the operator is not permitted to cut trees of less than a specified stump diameter as set by the Forest Service for a particular stand. This minimum diameter varies from 10 to 14 inches depending on the particular stand conditions. On certain current pole operations, only trees of pole dimensions are cut and any poles culled because of interior defects are manufactured into lumber.

The net result of these cutting controls is the same, in that to varying degrees the largest and best trees in the stands are removed and the smaller trees left to provide future cuts.

There are many areas in the Edson district which have been cut over two or three and even four times in the last 40 years.

NATURE OF STANDS

The sampling was restricted to stands which had been partially cut only once and which were primarily pure pine. Occasionally sparse understories of black and/or white spruce were present with occasional spruce forming part of the crown canopy. In most areas there were some aspen, black poplar, or birch present in the canopy.

The stands sampled were cut from 12 to 30 years ago with an average elapsed period of 22 years. (See Table 1 for complete distribution.)

TABLE 1

Distribution of Samples by Number of Years Since Logging

Years since logging	Number of samples
11-15	4
16-20	13
21-25	18
26-30	10
	45

The year of logging was determined from Forest Service records whenever possible, and checked by chopping into logging scars or making ring counts of release growth on individual spruce trees.

The majority of the areas had been logged for railway ties, although some were cut for lumber or building logs. The mean age of the stands when cut was 84 years. The rather narrow range in age at logging is apparent from Table 2, with 80 per cent of the samples falling in the 80- and 90-year classes.

TABLE 2

Distribution of Samples by Stand Age When Logged

Stand age class at logging	Number of samples
50	1
60	1
70	3
80	18
90	18
100	3
110	1
	45

When the original stands were reconstructed, one of the most noticeable features was the low density in number of trees. Ackerman (1), in constructing pine yield tables for the B19 region in Alberta, found that the average number of trees in the 80- and 90-year age classes were 1,030 and 925 respectively. The average number of trees prior to logging for the 45 samples in this study was 330 at an average age of 84 years. A complete comparison between Ackerman's yield table data and the average of the data collected for this project is presented in Table 3.

TABLE 3

Comparison Between Yield Table Data and Average of Data for Stands Prior to Logging

——	Yield table	Average for samples
Age	84	84
No. of trees	988	330
Basal area	159	95.2
Total vol. (cu. ft.)	4,271	2,805
Av. diam.	5.5	7.3

This comparison may not be entirely valid due to a difference in the site of the samples as compared to the average site for the yield tables. However, the important difference is the larger average diameter of the samples, and it is this factor which has made the stands attractive to the operator. From the yield tables, under average conditions, it would take 125 years to attain an average diameter of 7.3 inches. The inference is that the low stocking of the samples in number of trees has resulted in merchantable material being produced at a young age.

FIELD DATA

A total of 45 sample plots, each 0.4 acre in size, were established. Most of these were 2 chains square, but when conditions did not permit such a dimension, plots 1 x 4 chains were used.

Each plot was subdivided into four equally sized blocks and the diameters of the trees in each block recorded separately. The first tree tallied in each diameter class in each block was marked as an increment and height tree, with a minimum of 25 trees so marked on each plot.

A boring at breast height was made on each increment tree and the radii recorded at logging, for four 5-year periods prior to logging, and for each 5-year period subsequent to logging. The present radius and diameter were also recorded. The height of each tree was obtained by use of a topographic chain and Abney hand level.

The regeneration was tallied on 40 milacre quadrats grouped in two strips per plot. A brief description of the ground cover, moisture regime, and soil was also recorded for each plot.

An estimate was made of the mortality which had occurred since logging and the trees were recorded by diameter classes. This estimate was based on the position of down trees relative to that of the logging slash and also on a comparison of the degree of rot in the dead trees with that of the cut stumps.

RESULTS

Diameter Growth

One of the main purposes of this study was to discover if residual pine trees respond to release when a stand is partially cut. It was hoped that the rate of growth following cutting could be correlated with some density measure of the residual stand.

As these pine stands prior to logging were of a low density, most of the trees were growing at or near their maximum possible rate for a particular site. Notwithstanding, trees in the smaller diameter classes were subjected to moderate suppression, and it was expected that release in the form of accelerated diameter growth would occur when the stands were partially cut.

Table 4 shows the diameter of trees at various 5-year periods prior to and subsequent to logging, the data being sorted on the basis of diameter at logging.

TABLE 4

Diameter Prediction Table for Lodgepole Pine Residual Trees
(Basis: 1,091 trees)

Diameter in inches at logging	Diameter in inches at 5-year intervals before and after logging										
	−20	−15	−10	− 5	Logging	+ 5	+10	+15	+20	+25	+30
2	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5	2.7	2.9	3.0
3	2.1	2.3	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2
4	3.0	3.3	3.5	3.8	4.0	4.2	4.5	4.7	4.9	5.2	5.4
5	3.9	4.2	4.5	4.7	5.0	5.3	5.5	5.8	6.1	6.3	6.6
6	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8
7	5.7	6.0	6.4	6.7	7.0	7.3	7.6	8.0	8.3	8.6	8.9
8	6.6	7.0	7.3	7.7	8.0	8.3	8.7	9.0	9.4	9.7	10.1
9	7.5	7.9	8.3	8.7	9.0	9.4	9.7	10.1	10.5	10.8	11.2
10	8.3	8.8	9.2	9.6	10.0	10.4	10.8	11.2	11.6	12.0	12.3
11	9.2	9.7	10.2	10.6	11.0	11.4	11.8	12.2	12.5	12.9	13.3
12	10.1	10.7	11.2	11.6	12.0	12.4	12.8	13.2	13.6	14.0	14.4

It is evident from Table 4 that there is negligible increase in diameter growth following logging, the trees merely continuing to grow at the same constant rate they exhibited prior to logging. The fact of no release is surprising in view of the young age of the sampled stands. An attempt was made to construct separate growth tables for three broad residual volume classes but no correlation was found between diameter growth and this variable. Similar negative results were obtained when the data were grouped by residual stand density index classes.

To test the uniformity of diameter growth between individual trees, the standard error of estimate was calculated for the 7-inch class at 10, 20, and 30 years after logging. The results are given in Table 5.

TABLE 5

Standard Error of Estimate for Residual Trees of 7-Inch D.B.H. Projected for 10, 20, and 30 Years

No. of years after logging	Standard error of estimate
	(inches)
10	± .40
20	± .75
30	±1.32

The data from Table 5 serve to indicate that diameter at a future date from logging can be estimated fairly accurately, but that the chance of error naturally increases with time. The 7-inch class was tested because that is approximately the average diameter of the residual stands.

Volume Growth

A co-frequency diameter growth chart (8) was constructed for each plot and the diameter distribution of the present stand at date of logging was determined. The volumes of the present and projected stands were then computed, and subtracting one from the other, the gross increment was obtained for each plot. Dividing the gross increment figures by the number of years since logging gave the mean annual gross increment since logging.

The volume of the estimated mortality since logging was next computed for each plot and the mean annual mortality determined. Deducting this figure from the mean annual gross increment gave the mean annual net increment since logging.

Using the gross and net increment figures, several relationships were tested. First, the gross annual increment was plotted over the residual volume of the presently living trees (see Figure 1). A straight-line relationship was indicated and such a line was drawn, using a least-squares fit. Similarly, gross and net annual increments were plotted over residual volume (i.e. residual volume equals the residual volume of the present stand plus the mortality) and regression lines were drawn (see Figure 2).

The standard deviations, standard errors of estimate, and the correlation coefficients for the curves of Figures 1 and 2 are given in Table 6.

TABLE 6

Regression	Standard deviation (cu. ft.)	Standard error of estimate (cu. ft.)	Correlation coefficient
Gross ann. inc. on resid. vol. of presently living trees (Fig. 1)	±15.30	±12.17	.618
Gross ann. inc. on resid. vol. (Fig. 2)	±15.30	±13.49	.489
Net. ann. inc. on resid. vol. (Fig. 2)	±20.31	±20.22	.175

Table 6 shows that there is very poor correlation between net increment and residual volume, and passing a regression line through the data does not make the standard error of estimate any lower than the standard deviation. Gross increment plotted on residual volume has a significant correlation at the one-per-cent level, but the introduction of mortality to obtain net increment practically destroys this correlation.

The separation distance between the gross and net curves of Figure 2 represents the annual mortality for any particular residual volume. The accuracy of Figure 2 is open to question, however, as there is an inherent error in estimating mortality from a single examination. Also, in stands cut by different operators, mortality varies with the amount of logging damage and a true average figure is difficult to obtain. There is a definite tendency, however, for mortality to be greater in the stands with the largest residual volumes. It is of interest to note that on the areas sampled there was no evidence of excessive blowdown following logging.

Regeneration

Table 7 presents the percentage stocking by milacre quadrats for the various coniferous species, and for hardwoods and conifers in general. (Trees smaller than 0.6 inch at breast height were arbitrarily classed as regeneration although a few of the conifers were undoubtedly present prior to logging.) These are the average figures for all of the data and are based on 1,800 quadrats with an average elapsed time since logging of 22 years.

TABLE 7

Percentage Stocking by Milacre Quadrats for Various Species

Species	% stocking
Lodgepole pine	6.6
White spruce	7.6
Black spruce	2.0
All conifers	14.6
All hardwoods	28.8

Pine regeneration is totally inadequate and must be considered a failure (Table 7). The same is true even when all conifers are grouped together. The hardwood figure is very conservative as on many plots aspen, which had come in since logging, were now 1 or 2 inches in diameter and were not tallied as regeneration. The incidence of pine, which have come in since logging and are now present in a diameter class, is negligible.

DISCUSSION OF RESULTS

Partial cutting has resulted in little or no acceleration of diameter growth in the residual stand, and as the number of trees was reduced the annual volume increment is probably less than that produced by the original stand.

As there is little correlation between net annual increment and residual volume, all the data were combined. The average figures for the condition samples are shown in Table 8.

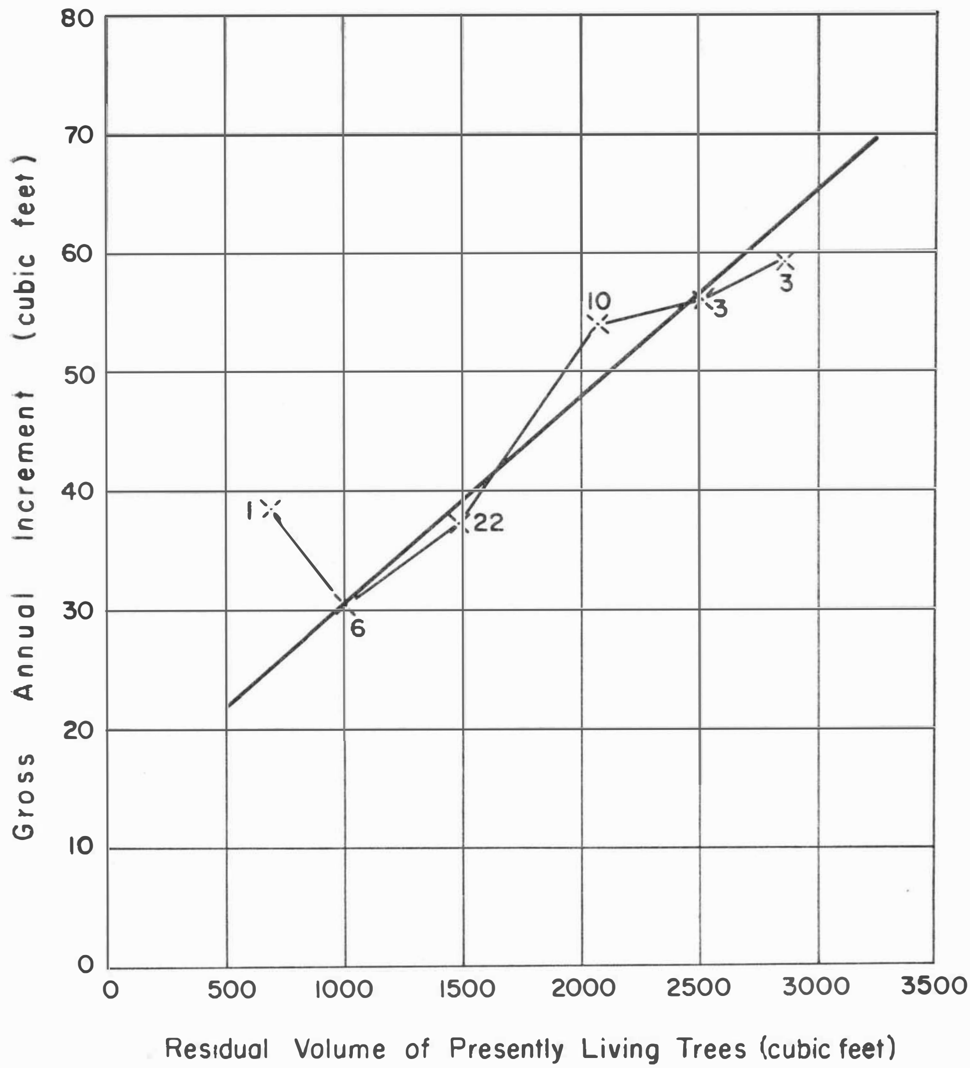

FIGURE 1. Gross annual increment plotted over residual volume of presently living trees. (Basis 45 plots)

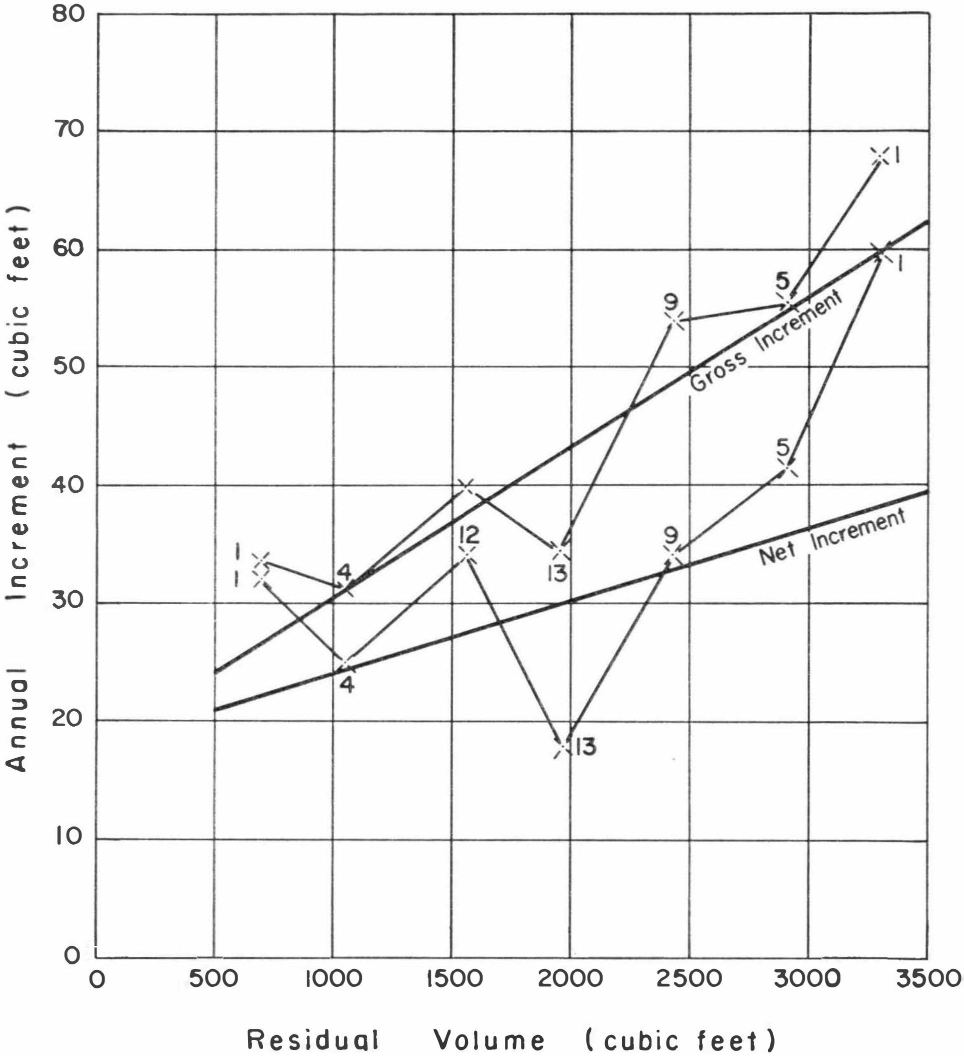

FIGURE 2. Gross and net annual increments plotted over residual volume. (Basis 45 plots)

TABLE 8

Average of all Samples, Per Acre Basis

	Original stand	Cut	Residual stand	Present stand
Stand age	84	84	84	106
No. trees	330	73	257	220
Basal area (sq. ft.)	95.2	26.8	68.4	84.9
Volume (cu. ft.)	2,805	832	1,973	2,658

At an age of 106 years, the net productivity of the stand portrayed in Table 8 is the sum of the cut volume plus the present volume or 832 + 2,658 = 3,490 cubic feet per acre. The question that arises is what volume would the original stand have produced at 106 years if not partially cut?

From Pressler's formula the growth percentage of the residual stand in

Table 8 is $\dfrac{(2{,}658 - 1{,}973)}{(2{,}658 + 1{,}973)} \; \dfrac{200}{22} = 1.345\%.$

Since there was no accelerated diameter growth in the residual stand, this growth percentage might be applied to the original stand without too much error to estimate its volume after the same period of 22 years. On this basis the original stand, if left undisturbed, would have a volume of 3,870 cubic feet at age 106. This estimate is probably quite conservative as the largest and fastest growing trees were removed by cutting, and the growth percentage used for prediction is based on the inferior portion of the original stand. On the basis of this calculation, partial cutting has resulted in an approximate net loss in volume of 3,780 — 3,490 = 290 cubic feet per acre over a period of 22 years.

All the results presented here are based on one partial cut, but with no pine regeneration entering the stand it should be obvious that second and third cuts will result in a drastic reduction of the growing stock. From a growth and regeneration point of view there seems to be little justification for partial cutting in pine. The final result of such a cutting policy is only too obvious in the Edson district where large areas have been practically denuded of pine by frequent cuttings and the stands have deteriorated to less desirable hardwood species.

SUMMARY

In order to assess the results of partial cutting in lodgepole pine, a study was made of cut-over stands in the Edson district of Alberta. Forty-five 0.4-acre plots were established in stands which were cut from 12 to 30 years ago and an analysis performed to determine the effect of cutting on diameter growth, volume growth, and regeneration. The main results obtained are as follows:

1. Partial cutting causes no perceptible increase in the diameter growth rate of the trees left to form the residual stand.

2. The net volume growth in residual stands is poor and indications are that it is less than what would occur if the stands were allowed to grow undisturbed.

3. Pine regeneration is very poor and totally inadequate to reproduce the stand. In certain stands after cutting there is a definite change in composition towards a hardwood forest as a result of poplar and birch regeneration.

4. Continued partial cutting results in a drastic lowering of pine growing stock and ultimately in the almost complete elimination of this species from the stands.

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