



*Response of Western Larch and Douglas-fir to Logging Release  
in Western Montana*

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ONE OF THE CHIEF REASONS for leaving reserve trees when cutting forests is to provide growing stock for further increment. When reserve trees are left for this purpose, they usually are expected to accelerate in growth rate. Without such acceleration, the question arises whether it might not be better silviculture to remove the old stand and start a new one which will occupy the site more effectively.

Western larch and Douglas-fir trees often are believed to respond poorly to release in western Montana. Inspection of increment cores from trees on the average cut-over larch-fir stand reveals that some trees respond better to release than others, and some show a reduction in growth rate. Obviously, then, it is highly desirable to reserve trees which are able to use fully the growing space provided through logging.

Observations on past cuttings in the larch-fir type in western Montana show that most selective cuttings have removed the more vigorous, larger sized trees, leaving the smaller trees of fair and poor vigor. Such reserve stands usually exhibit poor growth and frequently no noticeable acceleration following cutting.

The purpose of the study reported here was to analyze the factors which affect the growth responses of Western larch and Douglas-fir following logging. Data were gathered on 124 one-fifth-acre temporary sample plots located on 20 different cut-over areas throughout the larch-fir type in western Montana. From 5 to 50 years had elapsed since cutting on these areas. Increment cores from 659 Western larch and Douglas-fir reserve trees 10 in. diameter breast high and larger were examined and diameter increment recorded

by five-year periods. Each tree was classified into one of three vigor classes based upon various external characteristics. These classes were designated: A, good vigor; B, fair vigor; and C, poor vigor. (For more detailed discussion of the vigor classification, see "A preliminary classification of tree vigor for Western larch and Douglas-fir trees in western Montana," by Arthur L. Roe, Northern Rocky Mountain Forest and Range Experiment Station, Research Note No. 66, 6 pp., illus.) Measurements of mortality and stumps were also recorded to permit reconstruction of reserve stand volume on each plot.

#### FACTORS AFFECTING GROWTH

A NUMBER OF FACTORS affect the growth and response of individual trees. The more important of these can be classified into two groups, as follows: (a) *Environmental factors*.—(1) site quality, (2) competition with neighboring trees, (3) climatic factors, such as climatic fluctuations, (4) biotic factors, such as insect and disease injuries. (b) *Individual tree factors*.—(1) species, (2) age, (3) vigor.

It was not possible, within the scope of this study, to treat all of the factors. Competition with neighboring trees, expressed as reserve stand volume in trees 10 in. d.b.h. and larger, species, and vigor were given specific attention. Other factors were considered only in a general way, as follows:

*Site quality*.—The plots sampled almost the entire range of site conditions found in the larch-fir type in western Montana. The data were interpreted, therefore, as representing typical conditions. Further studies will be needed before the effect of site quality will be fully understood.

*Climatic factors*.—Intervals since release of sample plots varied from 5 to 50 years prior to 1947, the date when the trees were measured. Hence, it is believed that the influence of climatic fluctuations, such as drought periods and periods of abundant precipitation, have been neutralized in the data upon which this analysis is based.

*Biotic factors*.—Insect and disease injuries are probably reflected in reduced vigor. This is especially true of dwarf mistletoe. Injury caused by some insects and diseases is of relatively short duration, and the trees either recover or die. Injury by animals, such as porcupine girdling, results in permanent injury and consequent reduction in growth.

*Age*.—Age was not treated specifically as a separate factor. It is, however, closely associated with vigor. It is given weight in the classification through

characteristics such as texture and color of bark, which are indicative of age to a considerable degree. In general, it is believed that the growth and response to release of Western larch is best up to about 150 years of age. In the case of Douglas-fir, the situation is less clear cut, and no conclusion has been reached. Age of the trees used in the study ranged from about 100 to 400 years. It is not known how the vigor classification which has been developed will apply to trees less than 100 years old.

#### ANALYSIS OF THE DATA

DIAMETER GROWTH WAS FOUND to be significantly correlated with vigor and reserve stand volume. D.b.h. growth rates for 10 years before logging were compared to d.b.h. growth rates for a similar period after logging. To avoid the necessity of a segregation by diameter classes, the ratio of pre-logging to post-logging growth was used, rather than the absolute difference in diameter growth. It was assumed that the ratios would not vary as much with the size of the tree as absolute growth under similar conditions.

The relationship between d.b.h. growth before and after logging is expressed in the following formula:

$$G.A. = (a + b \log x) G.B.$$

where

- $G.A.$  = d.b.h. growth in inches 10 years after logging  
 $a$  = constant  
 $b$  = regression coefficient  
 $\log x$  = logarithm of reserve stand volume in trees  
 10 in. d.b.h. and larger  
 $G.B.$  = d.b.h. growth before logging.

Table 1.—Constants and regression coefficients for Western larch and Douglas-fir

Vigor class	Constant $a$	Regression coefficient $b$
Western larch		
A	3.2550	-0.4753
B	1.8274	-0.1846
C	1.7740	-0.2209
Douglas-fir		
A	1.7077	-0.1471
B	1.6539	-0.1561
C	2.3751	-0.3718

Constants and regression coefficients for each species by vigor classes are given in Table 1. When the data were finally prepared for presentation, they were converted from the ratios back to diameter growth in inches.

### RESULTS

*Response of trees in relation to vigor.*—Growth response of individual trees varied by vigor classes (Fig. 1). The A-vigor trees responded best. B-vigor trees also showed growth acceleration, but in lesser amounts. The C-vigor trees made positive response only in reserve stands less than 3000 board feet per acre. In heavier reserve stands, their growth, in all but one instance, was less than before logging.

*Response of trees in relation to competition.*—Trees in the most lightly stocked stands in all vigor classes had the greatest acceleration of diameter growth rates. However, the rate of acceleration decreased rapidly up to about the 5000 board foot reserve stand class. From that point upward the rate tended to level off. Trees in the C-vigor class were an exception to the above in one respect. They showed negative response in reserve stands heavier than 3000 board feet. In general, however, the trend, though negative, tended to parallel that described for A and B trees. Thus, the same relationship to competition may be said to exist for trees in this vigor class as in the others.

*Comparison of growth rates and response between species.*—Western larch made better response, relatively, to logging release than Douglas-fir in nearly all reserve stand and vigor conditions. This seems at first to contradict our experience in which we have learned to regard Douglas-fir as showing better d.b.h. growth than Western larch. Despite better relative response by larch trees, Douglas-fir made faster diameter growth, both before and after logging.

Douglas-fir, due perhaps to greater tolerance, grows better under competition than Western larch. This is demonstrated by the fact that Douglas-fir had been making better diameter growth before logging. Further support is found in the fact that the rate of acceleration of Douglas-fir diameter growth after logging did not decrease as rapidly under increasing reserve stand volume. This may be a partial explanation as to why larch responds relatively better than Douglas-fir.

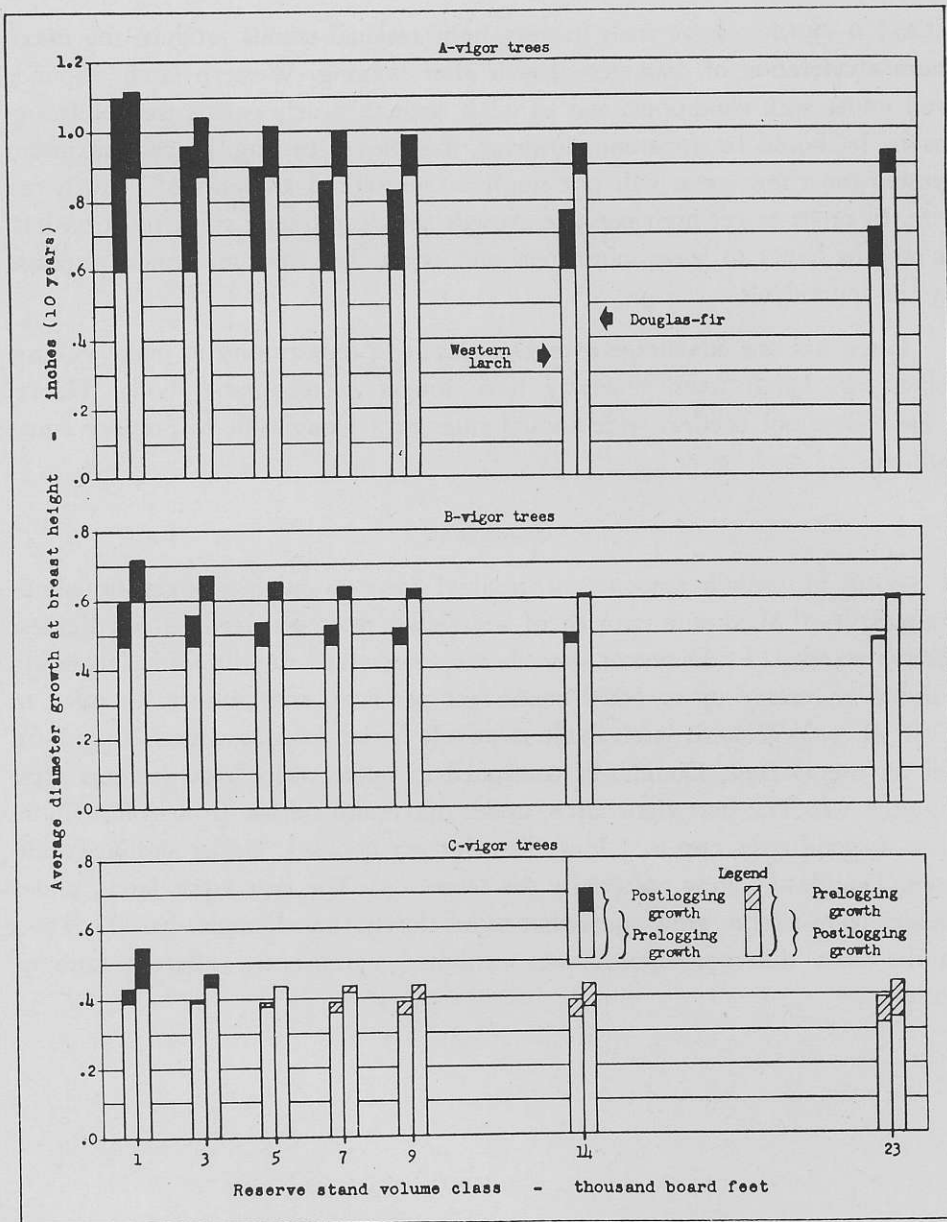


Fig. 1.—Growth response of Western larch and Douglas-fir by vigor class in relation to reserve stand volume.

## DISCUSSION

CLASS A-VIGOR reserve trees in very light residual stands produce the maximum acceleration of diameter growth after logging. Western larch responds well under such conditions, and its d.b.h. growth nearly equals that of Douglas-fir. It should be apparent, however, that heavy cutting, to get maximum growth on a few trees, will not result in substantial amounts of growth per acre. In order to get high per-acre growth, ample growing stock must be left. It may be better to leave more trees and expect less than maximum response by the individuals.

Larch has one advantage over Douglas-fir in opportunity to make volume increment. Larch trees generally have longer merchantable boles. Hence, a larch does not need as wide annual rings as a Douglas-fir to produce equal volume.

## SUMMARY

A STUDY of growth response of residual trees in larch-Douglas-fir stands showed: (a) Maximum growth of individual trees occurred in the lightest reserve stands. (b) Diameter growth rates decreased rapidly with increasing volume of reserve up to 5000 board feet per acre, after which it tended to level off. (c) Western larch made relatively better response than Douglas-fir, but on the average, Douglas-fir continued to make wider growth rings after logging. (d) The best vigor larch, under maximum release from competition, grew at good rates (up to 1.1 in. diameter per decade). Under similar conditions, Douglas-fir grew practically the same. (e) The best vigor larch, under greater competition, grew somewhat more slowly than Douglas-fir. (f) Trees in the three different vigor classes exhibited significantly different rates of growth.