LONG-TERM SILVICULTURAL EXPERIMENT ON METHODS OF CUTTING

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IN OLD-GROWTH forests, untouched by axe or saw, growth in terms of usable wood is offset by losses. By judicious selection of trees for cutting, stands are converted into productive units by removal of slow-growing trees, trees most susceptible to insect attack, and trees in which decay is progressing most rapidly. At the same time, consideration is given to economic factors such as quality of logs and the minimum volume per acre that can be harvested profitably. In working with all-aged trees, the ultimate aim is to manipulate stands by periodic cutting and promotion of growth and restocking so that successive crops of equal or increasing value can be harvested.

In order to test for and demonstrate the best method of cutting in ponderosa pine on the lava plateau of northeastern California, a methods-of-cutting experiment was initiated in 1938. The number of cutting treatments varied from four to six, arranged in randomized blocks. Ten replications were contemplated, one to be established each year. To date, eight of these replications have been established. Each plot, on which a single treatment is applied, is 20 acres in area exclusive of border strips. A block of four plots utilizes approximately 120 acres. Whether four, five, or six plots are established in a replication depends upon the size of area which is uniform in timber stand and subordinate vegetation.

Cutting treatments differ with respect to volume and character of trees removed and length of time between successive cuts. The lightest cut removes only the trees of poor risk, with particular reference to bark-beetle attack, the object being to harvest these trees prior to loss and while still usable for lumber. The minimum volume that can be harvested economically, together with the rate at which trees become "poor risks," determines the frequency of such cuts. At present this light cutting removes 15 per cent of stand volumes, averaging 18,000 board feet per acre, and intervals between cuts vary from 5 to 15 years. The other treatments remove approximately 25 per cent, 60 per cent, 80 per cent, and 100 per cent, with succeeding cuts made in 15, 30, 60, and 140 years, respectively. Also one plot is left without any cutting, so the range of treatments is from no cutting to complete cutting. Four of these treatments appear in each annual replication, with the lightest cut being added if five plots are possible and the clear cut if six plots are possible.

Prior to cutting treatment the number of trees above 11.5 inches in diameter averages 500 per plot. Each tree is mapped, numbered, measured, and described. Appropriate measurements are taken to determine the volume in

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board feet. Each tree is described with reference to characteristics likely to affect net growth, including current vigor of foliage; width, length, and density of crown; tree-thrift class; risk class; evidence of rot or disease; and damage to stem or crown. The logs are graded in the tree according to quality classes. Smaller trees, ranging from 3.6 to 11.5 inches in diameter, are tallied by 2-inch diameter classes and crown classes. Reproduction and area covered by subordinate vegetation is estimated by sampling within the plots.

During logging, records of logging costs are kept separately by treatments. After logging, all measurements and descriptions are repeated to determine changes due to logging. Five years after logging and at five year intervals thereafter, measurements and descriptions are repeated to determine changes over definite periods of time. Treatments may be compared with respect to growth in volume, growth in value, stand losses, changes in stand structure by diameter classes, degree of natural restocking, increase or decrease in shrub cover and smaller vegetation, logging cost, and net return over definite periods of time. Conclusions drawn from these comparisons will depend upon the objectives of management: whether the stand is to be managed for continuous production of sawlogs or managed for liquidation, that is, for the greatest monetary return within a few years' time.

To date, three replications have been remeasured five years after cutting. These few replications and the results obtained over such a short period of time are not likely to lead to any major conclusions. It is, however, desirable to analyze the growth data at the present time for the following reasons:

1. At the present rate of cutting in the remaining old-growth stands on some 2 million acres, it is important to put into practice promptly any improvements in cutting practice that may be indicated from the experiment.

2. Because of changes in personnel that are bound to occur several times during the course of the experiment, a progress report including the methods of analysis in detail should be prepared.

3. Estimates of standard errors are needed to determine whether the eight blocks so far established are enough to detect differences of practical importance, and if not, to determine the number of additional blocks needed.

Variance- and covariance-analysis methods as commonly used with the randomized block design should provide adequate comparisons of stand growth and growth relative to starting volume. This result would be sufficient if we were satisfied with the best one of the five methods of cutting tested. It is desired, however, to go farther, and predict the best possible cutting method. The range of cutting from no cutting to complete cutting of merchantable-size classes, together with the detailed measurements and descriptions of individual trees, was planned with this in mind. The timber marker is faced with making a decision on each tree—whether to cut or to leave. Performance on the plots will provide predictions of average growth, after different intensities of cutting, of trees of a given age and diameter class having crowns of a given size, shape, density, vigor class, and position in the crown canopy, that is, dominant, codominant, intermediate, or suppressed. Regression analysis of growth over diameter could be used to find which variables affected growth significantly as well as the differential response with degree of cutting. It would be expected that some variables could be eliminated and some regression coefficients pooled, so that in the end the trees could be grouped into classes that differed with respect to growth. These classes would have to be easily identifiable and few in number for practical use in marking timber. Knowledge of the relative importance of variables affecting growth would enable the timber marker to select the least desirable or the most desirable trees within classes, where additional volume was needed for harvest or for reserve. Likewise, adjustments for improvement in growth could be made in the treatments tested in which marking was based on existing tree classifications.

The advice of statisticians is needed on the most appropriate methods of analysis and in setting up orderly computational procedures. Should regression equations based on growth performances of individual trees be used as a basis for grouping into tree classes? Crown vigor and size are expressed in qualitative rather than quantitative terms, namely, vigorous, medium, poor; wide, medium, narrow; long, medium, short; and dense, medium, thin. How would these non-measurement data be used in multiple-regression analysis? With substantial data in the most important classes, would simple averages suffice for grouping? For example, growth percentage of trees with vigorous, wide, long, dense crowns minus growth percentage of trees with vigorous, wide, long, thin crowns should indicate the importance of the factor of crown density in trees having vigorous and large crowns. Wide, medium crowns might respond in the smae manner as narrow, long crowns and be grouped. Possibly such a procedure would lead to an adequate classification and might correspond closely to one of two existing classifications. Could growth by tree classes be compared and the interaction of tree classes and cutting treatment be estimated by considering the experiment as a split-plot design, correcting for unequal starting volumes of tree classes and plots by covariance analysis? If this should be feasible, would the tree-classification system giving the smallest error variance be the best system?

The ultimate objective is a growth-prediction equation, based on such variables as reserve volume by tree classes, site-quality index, and size of the average tree, which can be applied to inventory data not only after the best method of cutting but after any method of cutting. Similar procedures would be followed to derive equations for predicting growth of smaller trees growing into the merchantable-size classes, and for loss prediction.