REPORT ON THE CASPAR CREEK CUTTING TRIALS

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INTRODUCTION

During 1959-61 the California Department of Forestry established the Caspar Creek Cutting Trials to evaluate four different silvicultural systems in the second-growth coastal redwood/Douglas-fir stands of the Jackson Demonstration State Forest. Four objectives listed in the establishment report of the study were to compare cutting systems by: 1) assessing logging damage, 2) determining logging costs, 3) measuring individual tree response, and 4) monitoring regeneration. An important part of the study relates to the choice of a harvest treatment for these 80 to 100 year old stands. The biological and ecomonic results of the managerial choice will have implications for the future commercial management of these coastal forests. We will consider the differences of stand response between tree selection, group selection, and clear-cutting harvest; in addition we will see the consequences of doing nothing for another 25 years. These tree and group selection harvests may be viewed as a commercial thinning to improve growth and recover expected mortality, or as a step in establishing uneven-aged management in these stands.

At the time of the original study stand managers were just beginning to consider reliance on young-growth stands as the source of raw materials for the mills of the region. Economic, environmental, and political issues influenced managerial decisions, and most harvesting was done by some type of partial cutting. Until 1980 all harvests of young stands on the Jackson Demonstration State Forest (JDSF) except for this study and one clearcut in 1964 have been based on single tree selection. There was interest by JDSF (in 1962) in an attempt to convert these stands from even-aged to uneven-aged stands. Most other ownerships show the same pattern of few harvest clearcuts. There is a large acreage of young stands that were selectively logged, taking 30 to 50 percent of the volume. Partially cut stands have developed without understanding the biological or economic consequences of this harvest technique.

OBJECTIVES

The objective of this report is to show the growth and development of the residual stands and the regeneration 25 years after logging was completed. Other objectives of the original JDSF 1962 report 1/ are not discussed unless they influence the stand yield. In the proposal for the current

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1/ Malain, R.J. and Burns,D.M. 1962. Young growth redwood and Douglas-fir cutting trials, a preliminary report. Calif. Div. of For. Sacramento, Calif.

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study three objectives were set down to help understand the value of partial logging. These objectives are:

1. To determine if adequate regeneration occurred.
2. To describe the diameter distribution in terms of the Q-ratio, the diminution quotient of an uneven-aged stand structure.
3. To see if additional logging entries are justified to continue movement towards uneven-age management.

Four cutting treatments: group selection, light and heavy tree selection, and clearcut are evaluated in terms of number of trees, basal area, and volume.

THE ORIGINAL STUDY

The stand selected for the cutting trials was approximately 75 acres of young-growth mixed redwood/fir about four miles from the coast along the south side of Caspar Creek. This is a small short drainage about five miles south of Fort Bragg (Figure 1). Treated stand blocks are south of the creek and have an east to northeast aspect. Relief of the site is steep; elevations rise from 85 feet at the stream to 400 feet in about one-quarter of a mile. Slopes are generally 40 to 45 percent. Soils are Hugo on the lower slopes, changing to Caspar near the ridge tops. Site index for the stand for redwood averages about 155,2/, and for Douglas-fir 190,3/

2/ Lindquist, J.L. and Palley, M.N. 1961. Site curves for young-growth coastal redwood. Calif. Forestry and Forest Prodcts 29:1-4.

3/ Lindquist, J.L. 1982. Site index curves for natural stands of Douglas-fir in northwestern California. USFS Ms in files of author. (Unpublished material).

The JDSF establishment report (1962) summarized the pre- and post-cut per acre values of number of trees, basal area, and Spaulding volume for trees >11.0 inches DBH by species in each treatment block. We will give some of this stand data to show initial conditions and levels of harvest in each treatment block (Table 1). The original board-foot volumes have been changed to Scribner, to agree with the current study, which uses volume equations developed by Wensel and Krumland 4/

4/ Krumland,B. and Wensel,L. 1979. Volume and taper relationships for redwood, Douglas-fir, and other conifers in the North Coast of California. Co-op Rwd. Yield Res. Pro. Berkeley,Calif.

Board-foot volumes of Table 1 are found by using local volume table (LVT) equations, developed for redwood and Douglas-fir from 1960 diameter and height data, stand basal area, and number of trees per acre. The average board-foot volume of trees over 11.0 inchs DBH of the five blocks was 111.2M+/-12.3 M per acre. Basal area of the trees over 11.0 inchs DBH averaged 378.4+/-41.8 sq.ft. per acre. Basal area of redwood (Sequoia sempervirens (D.Don Endl.)) was 41 percent; Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), accounted for 46 percent; and the remaining 13 percent is mixture of grand fir (Abies grandis (Dougl.) Lindl.), hemlock (Tsuga heterophylla (Raf.) Sarg.), and Bishop pine (Pinus muricata D. Don). The clear-cut block was a heavier stocked stand than the other four blocks. Other blocks are quite similar in basal area, volume, and species composition. Overall, board-foot volumes were 32 percent redwood, and 68 percent other conifers.

A short description of the cutting test will help us evaluate the results in a context that relates to tree selection practices. The group selection block was on 21 acres and consisted of 14 small clear cut patches that averaged 0.38 acres each. In most cases, cutting centered on stand conditions, such as a clump of poor vigor trees, or an opening created when an old-growth residual was taken. In this block about 29.3 percent of the basal area and 32.0 percent of the volume was cut.

The light selection block was 20 acres, and the selection from below was to remove defective or low vigor stems; a stand of well distributed vigorous trees was desired. In creating this residual stand 41 percent of the basal area and 40 percent of the volume was harvested.

Heavy tree selection, on 13 acres, was also to leave the most vigorous well distributed trees. Cutting removed 53.7 percent of the basal area and 52.3 percent of the volume. The final block was a 13.5 acre clearcut, in which all trees were taken. In the partially cut blocks redwood was favored because its vigor gave better potential for growth. Note that redwood percentages of both basal area and volume increased as the result of the harvest. Average diameter also increased somewhat in the residual stands as a result of the selection in both the light and heavy blocks. The group selection average diameter remained essentially unchanged after cutting. The increase of the average diameters and percent of redwood indicates that selection was heaviest in the smaller, non-redwood conifers.

CURRENT GROWTH STUDY METHODS

In 1978 a plot approach to remeasurement of these cutting blocks was started. Rather than measure all the tagged trees in each block, only trees in the plots would have to be considered. This use of five samples in each block permits an evaluation of the variability within the

the cutting blocks. The 1984 remeasurments are a continuation of the growth study methods established on plots installed in the winter of 1978-79. Five random permanent 0.4 acre plots were installed in each of the group, light, heavy, and uncut control blocks. Each plot is defined by a set of tagged trees that have been remeasured periodically by the staff of the JDSF. All tree measurements are now restricted to only trees within the plot boundaries. This sample system now permits us to make an evaluation of the reliability of mean growth and yield because of the estimates of variation in the stand response. The design of the original experiment did not allow a full statistical comparision between treatments due to lack of randomness in assigning treatments to the blocks.

Random selection of plot locations was made on existing block maps. The plots are 132 feet square, and located so that there is no overlap, and remain within the area of tagged trees in the treatment block. Plot corners were installed with a transit, and each tree was mapped with an azimuth, slope distance, and slope angle from plot corners. Coordinates to describe the horizontal and vertical location of each tree are relative to the northwest corner of each plot, these coordinates were used to prepare stem maps following the 1979 measurements.The maps show all trees over 4.5 inches DBH and stumps whether old or young growth. These maps and field sheets for each of the 20 plots are basic information for further work in these partially logged stands.

The JDSF records of all the tree diameter measurements over the period, from installation of the study through 1979, were available for the growth analysis. To determine the per acre growth in each plot, it was only necessary to identify the tagged trees within each plot's boundaries. Recorded diameters from remeasurements in 1964, 1967, 1968, 1975, 1979, and 1984 of the trees are used to complete the record of stand growth in each of the plots. As a tree reached 11.0 inches a tag was attached and this tree was counted as ingrowth. Numbers of stems and basal area per acre, kept separate for redwood, Douglas-fir, and other conifers, were determined for each year by simple summation. The averages and standard deviations for the five plots in each block are shown for four stand values in each of the measurement years in Table 2. The species subtotals of number of trees per acre and basal area are used to compute stand cubic and board-foot values.

Part of the 1984 field measurement was to put in 10 random regeneration sub-plots in each of the 0.4 acre main plots. Each sample location was defined by a pair of X and Y coordinates between 6 and 126 feet, then samples would remain within the plot boundaries, these coordinates are relative to the northwest corner of the plot. At each sample location a circular 1/1000 acre (milacre) plot 3.72 feet in radius, and a 1/250 acre plot 7.47 feet in radius was established. On the milacre plot only trees smaller than 4.5 feet in height were recorded by six species and four size classes; less than 1.0', 1.0-1.99', 2.0-2.99', and 3.0-4.5'. On the 1/250 acre sub-plot trees from 4.5 feet tall to 4.5 inches DBH were recorded by species and diameter class; less than .5", .5-1.49", 1.5-2.49", 2.5--3.49", and 3.5-4.49" . These ~~50~~ samples in each ~~of the~~ treatment blocks are used to look at the ability of stands to regenerate following partial harvest.

VOLUME COMPUTATION

Stand volume computations are made with local volume lines (LVL) that express stem volume as a function of stem diameter at breast-height squared. Estimates of tree cubic and board foot volumes were made using equations of Wensel and Krumland (1978), these equation coefficients are shown in Table 3. The tree volumes were calculated only for the year of the intial measurement, 1979, and 1984 the years in which sufficient tree heights were measured. Separate LVLs were computed for redwood, Douglas-fir, and whitewood in each of the three treatment blocks and control block. The LVL is a restrained linear regression equation that expresses the best linear fit of the tree volumes to the square of the tree diameters. Restraint on the line fit of the data is made by forcing the regression to show a zero volume for a specified diameter. In this report the cubic--foot stem volume is zero for a 4 inch tree, and the zero board-foot volume is for a 10 inch tree. The slope coefficients of the forced regression line are calculated using the following equations:

$$b = \frac{(Dia \times Vol) - (K \times Vol)}{(No \times K) - (2 * K * Dia^{2}) + (Dia^{4})} \qquad (1)$$

where: b= regression slope.
Dia = DBH of the ith tree.
Vol = stem volume of the ith tree.
K = DBH where Vol=0;cuft=16,bdff=100
No = number of trees in sample

Intercepts for the slope line in are computed as follows:

$$a = K * (-b) \qquad (2)$$

where: a= line intercept coefficient
b= slope coefficient.
K= constant where volume is 0.

Computed coefficients for the three years when heights were measured in the blocks are shown in Table 4. An analysis of the trends in the coefficients indicate that for redwood and Douglas-fir there is little variation in the cubic or board-foot values between the four blocks in either the initial or terminal years. For 1979 so few trees were taken in two of the blocks that trees from all blocks were combined. A second trend is the gradual increase in the coefficients over time. This increase is to be expected. As trees grow in height there is a continual increase in stem volume as the result of the height growth as well as that increase caused by the diameter growth. It was felt that it would be possible to use an average value for each species in all the stand blocks. The averages, shown in Table 4, are the values used in the computational program for the plot data. Coefficients for the LVTs of the measurement years 1964,1966,1968,1975, and 1979 were determined indirectly. Average coefficients for each species for the initial and terminal years were plotted, then a straight line intropolation was made for those years when heights were not measured. Inconsistancies of trends for the coefficients of the whitewood species, as a result of too few trees in the sample, resulted in use of Douglas-fir for all whitewood volume computations. Values of the LVT coefficients used to compute volumes for the species groups are shown in Table 5.

RESULTS

There are a number of items to consider in understanding the effects of the stocking levels created by the partial logging techniques reported in this study. The most obvious related to growth and yield are shown in Table 2 and graphically in Figures 2,3,and 4. Growth trends of basal area and volumes have not changed much over the 25 year period, indicating little growth response to treatment. Determining the value of these cultural operations on stand yield one must deal with some rather subtle response differences. These data do not provide clear or obvious answers to some questions about the suitability of selection logging in this timber type.

MORTALITY AND INGROWTH

A total of 49 trees died on the 20 plots during the growth period; 43 were Douglas-fir, and one (1) redwood. Of this mortality 35 were in the unlogged control plots. A summary of the values describing this tree loss is shown in Table 6. The basal area reflects the final live tree diameter, and volumes are based on the 1984 LVT coefficients. In the uncut block the 35 dead trees averaged 15.4 inches DBH, and are not an important volume component. However, during the 1979-84 period one tree 32.2 inches DBH died, this tree alone accounted for nearly one-fifth of the periodic board-foot loss in the uncut plots. The Douglas-fir that died in the uncut stand were small, and logging just to capture their volume does not appear to be a valid reason to enter these older stands with a partial cut. In contrast fewer trees died in the treated blocks, but dead trees were much larger. Loss of trees in the treated plots was mostly by disease, but some blew down; no trees were lost by suppression.

A second source of stand change results from ingrowth of trees beyond the 11.0 inch diameter threshold. Since only stems larger than this diameter limit were measured and recorded in the initial inventory we have no information about smaller trees until they grew beyond this diameter. Per acre changes as the result of ingrowth is of no real influence in the uncut stand, only five trees are counted as ingrowth over the 24 year period. It appears that competition was too severe for the small suppressed trees to grow in diameter. Redwood accounted for 79 percent, Douglas-fir 5 percent, and whitewoods 16 percent of the 100 stems counted as ingrowth over the period. None of the ingrowth stems were established after logging, all exceeding the 11.0 inch diameter limit were left by the logging. Only in the group selection are there new redwood sprouts that are nearing this 11.0 inch DBH limit. A picture of the ingrowth situation is shown in Table 7.

If the diameter distributions of all the blocks were similar prior to logging it must be that logging released the residual trees less than 11.0 inches DBH. There are 2.5 trees per acre periodic ingrowth in the uncut block, but an average of 15.9 trees per acre in the cut blocks. Even with the reduced number of stems the logged blocks have ingrowth that is 6.3 times that of the uncut block.

Total periodic basal area increase attributed to ingrowth ranges from 2.9 percent in the uncut to an average of about 20.0 percent for the logged blocks. A sizeable portion of the basal area periodic increment in the treated blocks occurs as ingrowth. Although the average diameter of the uncut stand is not seriously affected by either ingrowth or mortality the large number of small ingrowth in the treated blocks does reduce their average diameters.

This trend of nearly all mortality being Douglas-fir and ingrowth as redwood should be pointed out as having an important influence on future managerial options on the specis composition development of uneven-aged stands

BASAL AREA GROWTH

As shown in Table 1 the logging reduced the stand basal area of the group,light, and heavy selection blocks to 71, 58, and 46 percent respectively of the precut stands. Averages of the five plots in each block for each year of measurement are shown in table 2. These averages are also shown in Figure 2. The trends of basal area yield indicate that all blocks track a nearly parallel course over the span of years. There is little evidence that logging has caused a sharp change in response over that of the uncut block. There is a slight drop in the 1979-84 period in the uncut stand, one plot has a heavy loss. Periodic basal area growth, shown in Table 8, was tested by analysis of variance (ANOVA) and the Student-Newman-Kuels (SNK) multiple range test (Zar,1974). Since the original treat-

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Zar,J.H 1974. Biostatistical Analysis. Prentice-Hall, Englewod Cliffs, New Jersey. 620 pgs.

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ments were not assigned in a random manner it is not suitable to put much reliance on statistical comparisions, however, these forms are discussed here as a means of showing some of the relations that occur in the data.

The ANOVA indicated no significant differences between the mean periodic basal area growth rates. This uniformity of growth occurred despite a statistically significant difference between the initial basal area stocking levels after the logging. The SNK test indicates that the initial basal areas of the light and heavy tree selection plots were not statistically different. From Table 2 we see that the average initial basal areas of the tree selection treatments were only 31 square feet different. This stand reaction, of uniform basal area growth over a wide range of stocking levels, is not unusual.

Basal area growth percentages shown in Table 8 express the average annual periodic increment as a percent of the stand basal area. Level of cutting has influenced growth percent in a positive manner. The uncut stand has thelowest, and the heavy selection the highest growth percent. None of the blocks are producing at even a 2 percent rate. The basal area increment at these ages is flat and the partial harvest did not result in a marked increase. The increase that is shown is mostly a function of the lowered initial basal area levels. There is an indication that the growth percent is still rising in the heavy selection while others fall over the long period.

To consider the effect of the initial diameter size on basal area growth as the result of treatment we can look at how trees have responded over the period. Average basal area for each initial diameter class is calculated for the five plots in each block. The basal area for the same set of trees, by initial diameter size, is then computed for the 1984 diameter measurements; the difference is the periodic basal area growth for the initial diameter class. For this calculation all ingrowth and mortality trees were excluded, here only survivor trees basal area growth is considered. Cumulative percent of survivor trees basal area growth by diameter class is shown in Table 9. Number of trees, by diameter class, at the initial inventory date are distributed in the blocks as shown in Table 10. In the uncut stand 54 percent of the trees, 20 inches and less, account for only 23 percent of the stand basal area growth. In the tree selection blocks there is a reduction of the percentage of number of trees in diameter classes less than 30 inches, at the 35 inch class the percentages of the blocks are all essentially the same. This pattern holds for the periodic basal area growth of these survivor trees. There is a shift towards a greater percentage of the basal area in the smaller trees of the tree selection blocks.

It is shown in Table 10 that only for the heavy selection is the distribution of the number of stems much different than that of the uncut block. Cutting in the group selection was not expected to disrupt the diameter distribution. In the light selection the trees taken covered the diameter range and left a residual stand with fewer trees but distributed much like the uncut block. Mortality and ingrowth do cause changes in the cumulative percentages, but in Table 10 there is a view of the importance of initial diameter to the distribution of basal area growth. Logging affects basal area growth distribution showing an average of 54.4 percent of growth in trees 25 inches or less; 41 percent of the uncut growth occurs in this segment of the stand.

Increased basal area growth of the small diameter classes in the tree selection blocks when compared with the response in the uncut blocks reveals an interesting condition. Reduction of competition has allowed residual small trees to respond with increased radial growth and show an average basal area periodic ingrowth of 16.4 square feet versus the 2.1 square feet of the uncut block. For the portion of the stand greater than than 20 inches, the reduction of stand did not result in an increase of growth. This shift towards the smaller trees has an impact on the production in the large valuable trees (the board-foot increment). Survivor growth of trees greater than 25 inch DBH in the uncut block was 41.9 square feet as opposed to an average of 30.3 in the logged blocks. This basal area growth took place on fewer trees in the cut blocks, but a look at the average diameters, from values in Table 2, indicates that the uncut block had the greatest periodic diameter increment 3.1 inches. This radial growth has been influenced by the mortality in the uncut block. Basal area and volume growth are strongly tied to tree size, and the large trees in the cut and uncut blocks seemed to grow at about the same rate. There is little evidence of change in total basal area growth as a result of cutting, but a shift toward a greater importance of the smaller diameter classes in the cut blocks.

VOLUME GROWTH

Average block board-foot volume yield shows no abrupt trend shift over the period; there is the appearance of nearly parallel trends (Figure 4). Logging has reduced the initial stand volumes in the treated stands to the levels shown in Table 2. Analysis of variance and the SNK multiple range test of the cubic and board-foot initial volumes showed that there are significant differences among blocks in both volume units. The SNK test shows that in both units only the initial volumes of the light and heavy selection were not different. Similar tests on the periodic growth rates revealed that there was a significant difference between the growth rates of the light selection and uncut blocks.

Periodic annual board-foot growth and growth percent of four periods are shown for the blocks in Table 11. The maximum board-foot periodic growth was in the uncut block. By contrast the periodic basal area growth of the uncut block was the smallest. Periodic growth percent of the the uncut block was consistently the lowest of the four blocks. While the growth percent of the board-foot volume is generally higher than of the basal area there are still only growth rates larger than 2 percent in the heavy cut block.

Distribution of the board-foot volumes by diameter class of the initial inventory is shown in Table 12. It shows that the cumulative trends of the uncut and group selection are similar, also the light and heavy tree selection seem similar. Logging has reduced the percentage of total volume in the smaller trees in the light and heavy selection when compared to the group and uncut blocks. The cumulative percentage of the board-foot growth ,Table 13, indicates that the percentage growth of a diameter class is somewhat larger than that of the initial volume. This increase is most evident in the small diameter classes of the tree selection blocks. For the small diameters of the uncut block volume growth is a smaller percentage than the initial volume of the class, in the uncut stand the small trees are fading. As in the case of basal area there is shift in the amount of growth toward smaller trees.

An objective of partial cutting in the tree selection being tested is the increase of stand yield by capturing the normal mortality and making the net yield approach the gross yield. Management attempts to recover volumes that might be lost. To consider this concept in this study we compare the gross yield of the uncut block with that of the treated stands. Gross yield of the uncut is the current yield plus the periodic mortality. Treated stands also need the volume harvested to determine gross yield. A comparsion of the initial stand values following treatment reported by the CDF and the five plot sample average indicates a relatively good agreement of the values of the initial stand values (values extracted from Tables 1 and 2).

Block	Stems per acre CDF	Stems per acre 5-Plt	Basal area per acre CDF	Basal area per acre 5-Plt
	(number)		(sq ft)	
Uncut	143.0	151.0	355.0	396.0
Group S.	98.0	109.5	250.0	280.5
Heavy S.	50.0	52.0	172.0	164.0
Light S.	72.0	72.0	210.0	195.3

To adjust net to gross yield the harvest volume,reported as the full block average,must be added to the five plot average initial volume of the current study. We cannot determine from the plots the volume cut, so the CDF values are the most reliable figrues available to determine gross yield. This comparsion of gross yield of the treated to the uncut blocks is perhaps the best way to consider the value of the selection procedures is shown in Table 14.

Results indicate how the selection logged blocks responded by a percentage comparision to the uncut control block. These percentages show the relative position of the yield prior to cutting, and then where these same stands are in terms of the gross yield after the growth period. In all cases the logged blocks are a smaller percentage of the uncut block volume after the growth period than they were initially. In this test the board-foot gross yield of the logged blocks do not exceed that of the uncut block.

DIAMETER DISTRIBUTION AND REGENERATION

Knowledge of the diameter structure of a stand as it moves through time is a valuable piece of information for the manager, and is critical to uneven-age management. The diameter distribution shows quickly and well the relative importance of the different parts of the stand. With some knowledge of radial growth these tree distributions can be used to project future structures that are likely to develop. It is of particular interest here to consider the diameter distributions after logging treatment, and how they have changed as a result of growth. The influence of treatment on regeneration of the desired species into the residual stands is another valuable use of the diameter distribution data. If the partial logging is to provide a means to establishment of an uneven-aged management regime these trends should be apparent in the data.

Two diameter distribution sets are examined in this report; the initial inventory (1959-60) and the 1984 measurements of the four blocks. The initial values,as reported by the CDF,were limited to trees over 11.0 inches DBH. For the 1984 measurement all trees over 4.5 inches DBH were tallied on the plots, and the terminal diameter distributions will reflect this lower limit. Regeneration of all conifers less than 4.5 inch DBH was tallied in 1984, and these figures are available to add further knowledge of the current stand structure. Table 15 and Figure 4 show conditions for the initial inventories of the blocks in 1959 for the group selection and 1960 for the other blocks. While there is no information about the stand smaller than 11.0 inches this component did exist and is seen as ingrowth that entered over the growth period.

The typical shape of the uneven-aged stand is often referred to as an inverse "J", with the maximum numbers at the extreme left of the curves shown in Figure 4. An example of the shape of the precut stand is the uncut block. In the uncut block the maximum number of trees are in the 15 to 20 inch range, and the curve drops off both to the left and right. This bell-shape is expected in stands as old as these 85 years. Suppression causes heavy losses in the small diameter trees and there are no new trees being established. Group selection does not select trees except by area, and does not change the distributions shape, only lowers it across the diameter range. This appears to have occured. Heavy tree selection also lowered the curve, and the shape is like that of the uncut curve with a maximum toward the middle of the diameter range. Only the light selection residual stand has a trend that looks like the inverse J. Information about the initial stands diameter distributions is limited because trees smaller than 11 inches were not recorded.

The 1984 diameter distribution data, Table 16 and Figure 5, provides better information on the small trees, and we can better judge whether trends toward an inverse J is developing. While measuring the plots in 1984 a distinction was made on new trees in the tally, whether they were old existing trees left after logging, or trees established during the growth period. Except in the group selection few new trees exceed the 4.5 inch diameter limit. Most of the regeneration conifers were tallied in the regeneration sub-plots. This new wave of younger trees is smaller than 4.5 inch DBH 24 years after logging.

A successful uneven-aged management regime requires that after each harvest entry the residual stand begin an immediate regeneration process that maintains a large number of small trees. Young redwood stumps should sprout and provide an immediate recovery. However, there has to be proper light conditions for these stems to grow. Experience with 75 percent basal area leave plots in thinning studies at Whisky Springs leads to the conclusion that crown cover this heavy does not let sprouts develop. The need to open the stand for satisfactory redwood and Douglas-fir growth is not compatible with the frequent light cuts used in uneven-aged management. Results of the sampling of regeneration, smaller than 4.5 inches DBH, are summarized in Table 17. This summary is shown by species and nine size classes in each of the blocks.

Results of the regeneration survey indicate that there was indeed a large number of new stems established after the logging. The almost complete absence of regeneration in the uncut block makes the case that logging has created conditions suitable for conifer regeneration. Most of the conifer regeneration taller than 4.5 feet in the light and heavy tree selection is either grand fir or hemlock. Redwood and Douglas-fir account for 4.7 percent in the light selection block, and 27.7 percent in the heavy selection block. Despite the large number of conifers, the low percentage of the desirable species, in the tree selection blocks, makes the long term prospect a shift toward grand fir and hemlock. Even after the relativly heavy cuts the more tolerant species have an advantage in the tree selection blocks. The most appropriate mixture of species is in the group selection; 37.2 percent redwood, and 22.1 percent Douglas-fir. Very little of this regeneration is in the uncut portions; this regeneration is established on aproximately one-third of the block area. Overall the group selection has a reasonable number stems of redwood and Douglas-fir that appears to be in a good condition to restock the cut patchs of the block.

A supplemental list of regeneration is shown in Table 18, which fills in the diameter distribution numbers for the diameter clases smaller than 6.0 inches in the 1984 inventory. This allows a better evaluatation of movement toward an inverse J diameter distribution.

Q-RATIO EVALUATION

Suitability of uneven-aged management for the mixed redwood/fir stands has been expressed for a number of years. The CDF suggested in its 1962 report that this should be considered as a part of the Cutting Trials. Conversion of an even-aged stand to an uneven-aged structure hinges on repeated entry into these stands. Further, that regeneration occur under the residuals after each logging. While it is not expected that a single cut in these stands will produce a good form of the inverse "J" diameter distribution, a tendency toward this should be apparent after nearly 25 years. Stem diameter distributions developed after growth of the residuals, ingrowth, and regeneration by the 1984 measurement do show some sense of this trend. There are only two age classes in these stands, yet the diameter distributions should begin to have the appearance of the uneven-aged stand.

The 1984 tree selection diameter distributions do not show a consistant trend that can be described by a Q-ratio with an inverse J-shape. This ratio relates the number of trees in a diameter class to the next higher and lower diameter class by a constant,i.e.,1.2 or 1.3. A range of ratios: 1.1,1.2,and 1.3 with an initial number of trees in the 50 inch class of .25,.50,.75, and 1.0 were computed and compared to the existing diameter distributions shown in Tables 14 and 15. Large numbers of grand fir and hemlock regeneration in the two tree selection blocks caused a sharp rise in numbers of the smaller diameter classes. However, Q-ratios tested did not create curves that were consistent with the existing diameter distributions.

In the group selection block, without a heavy influx of grand fir and hemlock regeneration, a Q of 1.20 with .6 trees in the 50 inch class created a curve that fits well across the range from the 50 through 4 inch classes. Differences in the 2 inch class are large, but not unreasonable. The predicted distribution is shown in Table 19; it is compared with the group selections actual 1984 diameter distribution from Table 16.

There is a tendency toward a bell-shaped curve in the uncut block. Only a few trees are found in the 1 to 4 inch classes; with a maximum in the 12 to 20 inch range. This peak will tend toward the right and down as the trees grow in diameter and small trees die. It is not useful to attempt a fit of the uneven-aged structure to this uncut block.

There are enough stems regenerated in the selection blocks to indicate movement toward an uneven-aged stand. However, only the group selection block now has a diameter distribution that can described by a Q ratio. Further logging is needed to see if new redwood or Douglas-fir can be established and thrive under two layer canopies. The next wave of regeneration would have to become established in the tree selection blocks under the dense shade cover of the established understory of grand fir, hemlock, and brush.

Clear-cut Block

During 1980-81 a pre-commercial thinning study was put in the stand that developed after the 1961 harvest of the 14 acre clear-cut block. Eighteen 0.4 acre plots in three replicated blocks of six plots were measured prior to thinning. Two replications were in the unburned portion of the block; the third in the portion where the logging slash was burned. The burned portion had a dense stand of blue blossom (Ceanothus thyrsiflorus Esch.). This brush caused two problems for Douglas-fir regeneration; a reduction in number due to competition, then damage to the established fir as the brush died and fell. In both the burned and unburned portion the redwood sprout clumps are the most important component of the developing stand. Douglas-fir has now been released and beginning to show rapid height growth, it will assume a increasing percentage of the stand basal area. The vital statistics of the stand in Table 17, are an example of the regenerative potential of second growth when clear cut.

Basal area of redwood more than 1.5 inches averages 92.8 percent and Douglas-fir 7.2 percent, but the number of redwood is 76.9 percent. The portion of the stand greater than 10.5" DBH is entirely redwood. The stand is growing well, and nearly 100 percent of the redwood is of sprout origin. Douglas-fir will soon match the redwood in height, and begin to be a greater percentage of the basal area. Thinning will accelerate radial growth, but it will be at least 5 years before any Douglas-fir surpass 10.5 inches.

DISCUSSION

Three major items relevant the choice of selection logging in management of the coastal redwood/Douglas-fir are addressed in this report. First; how do the stands respond in growth and yield, perhaps the most vital issue. Ecomonic production is still the single most important feature of any managerial activity on these productive commercial forest lands. Second, does the tree and group selection logging allow adequate regeneration that perpetuates the desired redwood/Douglas-fir type. Finally, what progress are the residual stands making toward a stable uneven-aged structure that will sustain repeated cutting on a suitable logging schedule.

Effects on yields.

Logging has had little obvious effect on the shape of the yield trends of either basal area or volume. Figures 2,3, and 4 show that all stands have followed parallel courses over the period. There are some flucuations over the period but the logged blocks have maintained nearly the same positions relative to the uncut block. Mean annual increment (MAI) derived from the volume yields of Table 2 indicates that all blocks are increasing, but the cut blocks at a somewhat greater rate than in the uncut block. During the 1979-84 period the uncut block's MAI has flattened, and perhaps culminated. This was the result of the continuing mortality of small residual Douglas-fir.

The periodic annual growth (PAG) of board-foot volume over the entire period shows an important feature of these stands ability to respond despite stocking reductions. Despite the removal of 29 percent of the original basal area the PAG of the group selection is 86 percent of the uncut block. For the light selection 41 percent of basal area removed with PAG=73.3 percent; heavy selection: 53.6 percent removed and PAG=77.1 percent. Periodic growth percents of Table 7 do not indicate that basal area reduction has a corresponding influence on volume growth. There is an increase in volume growth percent with increase in the cut. Even at its best there is less than a 1 percent increase between the uncut and heavy tree selection. Periodic board-foot growth remains high after logging, but the percent response in board-foot volume is still low.

Failure of the treated blocks to maintain a gross yield equal to that of the uncut block is an important part of this study. This failure perhaps hinges on the age of the stands when the logging was done. Selection logging to improve the growth response is too late when the stands are beyond 80 years. Mortality is heavier in the uncut block, but nearly all dead trees were small and of little ecomonic value. Logging to prevent their loss would be of marginal value. More serious ecomonic losses of large volume trees occurred in the treated blocks. These losses affect the gross stand yield, but it appears that losses of the treated blocks have more serious ecomonic impacts.

Regeneration

The heart of a silvicultural system related to logging has to deal with the response of desired species to renew the stand 5/. Most of the emphasis of selection logging

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5/ Chapman,H.H. 1950. Forest Management. The Hildreth Press. Bristol, Conn.

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systems relates to the release of residual trees after repeated cutting, and improvement of the growth percent in the stand. However, ecomonic factors related to not having enough of the desired species regenerate should not be ignored. There does not appear to be an adequate number of redwood or Douglas-fir established and growing well in the tree selection blocks. The 25 year period considered in this study is long enough to make judgements on the adequacy of the regeneration under the residual stands. Tables 16,17,and 18 show the diameter distributions of the stands by various species and size classes. Table 18 shows the small diameter classes of the tree selection blocks to be well stocked. But, of stems taller than 4.5 feet only 7.5 percent on the light selection are redwood or Douglas-fir; in the the heavy selection this is 23.4 percent. Unless the stand is opened sufficiently, as in the group selection, Douglas-fir is nearly excluded from the regeneration regime. The heavy selection block does have some Douglas-fir in the understory, but most Douglas-fir are not growing well and show poor vitality. A few redwood sprout clumps, grand fir, hemlock, and brush have occupied the space under the stands of the tree selection blocks.

A striking contrast is shown between the regeneration of the tree selection blocks and the clear-cut block. In 19 years the clear cut has 742 trees per acre over 1.5 inches, and 46 per acre over 10.5 inches. This greater radial growth occured in a stand that is nearly 100 percent redwood or Douglas-fir. Grand fir and hemlock is almost entirely absent in this new stand.

Diameter distributions.

Despite the long time period there is only limited movement toward a stand diameter structure that characterizes uneven-aged management. This system requires more than a single cut for this shape to become evident. The stand at 85 years was perhaps past the time when small suppressed residual trees have the vigor to release to create the typical inverse J-curve. In the tree selection plots few stems of the regeneration have grown past the 5 inch diameter class. The diameter distribution of the group selection plots is more typical of the shape desired in an uneven-age management system. This result is due to better diameter growth of regeneration in portions that were clear logged. Young redwood sprouts and Douglas-fir have radial growth rates more like that of the clear-cut block. Group cutting creates sufficient space for enough regeneration that grows at a rate to create the smooth inverse J-curve.

The tree marking process used in this study has had a long term influence on the stand diameter distribution and growth response of the residual stand. Cutting in the tree selection blocks was similar to a thining from below that cuts poor growing high risk trees. This removal of smaller trees is shown by an increased average diameter of the residual stand over that of the total stand. Logging did not remove those stems that accounted for the bulk of the growth. A typical uneven-aged logging would have concentrated the cut in the largest trees, removing those which are ecomonically mature. Until a number of cutting cycles have been completed one should not expect too much movement towards a well defined inverse J-curve of the diameter structure. A more significant factor is whether there is adequate regeneration of redwood and Douglas-fir. Among the treated blocks the group selection treatment shows both the best trend towards the inverse J, and a sufficient number of well-growing redwood and Douglas-fir.

RECOMMENDATIONS

It appears that tree selection has not functioned well in stands as old as these tested. I do not recommend that the State continue this form of partial logging to create uneven-aged stands for its commercial operations. If objections to clear cutting, made on environmental or political considerations, are important then the group selection seems a better alternative. The small group cuts permit proper regeneration and maintain good overstory growth under an uneven-aged regime.

Questions posed in the original study I feel should continue to be studied. These relate to the long term effects of repeated entry into the stands that have been partially cut. The original study called for the following schedule, assumming an 80 year rotation:

Group selection. Two more cuts, in a 27 year cycle, each taking approximately one-third of the original area of the block.

Light selection. A twenty year cut cycle with cuts in 1980, 2000, and 2020 to remove the original stand.

Heavy selection. Two cuts in a 27 year interval to completely remove the original stand.

These additional logging entries would allow the State to assess problems of damage to advance regeneration in the uneven-aged management scheme. The investment in time into this study warrants its continuation as it provides a pro-longed investigation of the problems of partial logging.

Table 1. Summary of the stand values prior to and after logging of the treatment blocks. Data are those reported by the JDSF at the establishment of the Cutting Trials in 1962. Values are per acre for trees >11.0 inches DBH, and board-foot volumes are for the Scribner Rule.

Value	Group S. Tot.	Group S. Lve.	Light S. Tot.	Light S. Lve.	Heavy S. Tot.	Heavy S. Lve.	Clear Tot.	Uncut Tot.
Trees	141	98	139	72	130	50	142	143
B area	354	250	359	210	372	172	452	355
Bd.ft.	98M	67M	105M	63M	111M	53M	131M	110M
Dia.	21.4	21.6	21.7	23.1	22.9	25.1	24.1	21.6
RBA%	49	55	27	28	37	42	51	30
RVL%	39	44	37	39	26	30	40	23

RBA% = percentage of redwood basal area
RVL% = percentage of redwood board-foot volume

There are Two Table 1's

Table 1. Average cumulative percentage of the Scribner volume of trees >11.0 inches DBH in 1984 measurement of the 20 plots of the Caspar Creek Cutting Trials (based on 5 plots per block).

Diameter	Heavy Sel.	Light Sel.	Group Sel.	Uncut
(inches)		(percent)		
10	0	0	0	0
15	2.5	4.0	3.5	2.2
20	9.5	11.8	15.2	12.6
25	16.6	26.2	32.3	29.8
30	39.5	41.0	50.5	53.1
35	68.8	69.6	79.9	80.9
40	90.4	83.0	93.8	89.9
45	100.0	98.2	94.9	95.8
50		100.0	100.0	100.0

Table 2. Average percentage of the Scribner volume of trees over 11.0 inches DBH in 1984 by three major species

Species	Heavy sel.	Light Sel.	Group Sel.	Uncut
		(percent)		
Redwood	40.6	33.4	36.9	31.7
Doug-fir	47.5	42.7	57.3	51.3
Whitewood	11.9	23.9	5.8	17.0
1984 Vol.	83325	90534	122315	159211

Two Table 2's?

Table 2. Per acre values of the Caspar Creek Cutting Trials sample plots in each measurement year. Inventory values are for trees over 11.0 inches DBH.

LIGHT SELECTION

	Measurement year						
Plot	1960	1964	1966	1968	1975	1979	1984
Number of trees per acre							
1	47.5	47.5	47.5	47.5	47.5	47.5	47.5
2	107.5	107.5	107.5	112.5	115.0	115.0	117.5
3	40.0	42.5	45.0	57.5	60.0	65.0	72.5
4	75.0	80.0	80.0	82.5	85.0	82.5	80.0
5	90.0	92.5	95.0	97.5	97.5	95.0	92.5
Ave	72.0	74.0	75.0	79.5	81.0	81.0	82.0
SD	28.4	28.3	28.0	27.1	27.4	26.1	25.8
Basal area per acre							
1	145.7	156.2	161.8	168.2	184.2	195.9	206.6
2	198.6	211.7	219.1	231.4	252.4	264.1	280.1
3	169.0	180.9	189.1	204.5	229.4	244.1	267.1
4	220.2	236.3	244.4	253.7	276.8	284.8	297.5
5	243.0	258.3	268.8	279.1	301.5	289.2	289.6
Ave	195.3	208.7	216.6	227.4	249.9	255.6	268.2
SD	38.9	41.1	42.6	43.0	45.1	37.9	36.2
MAI	2.3	2.3	2.3	2.4	2.5	2.5	2.5
Cubic-foot volume per acre							
1	7403	8057	8384	8761	9709	10486	11211
2	8911	9708	10127	10776	11889	12844	13882
3	7963	8692	9122	9830	11094	12144	13532
4	10313	11279	11754	12292	13510	14218	15125
5	11688	12606	13166	13725	14955	14484	14543
Ave	9256	10068	10511	11077	12232	12835	13659
SD	1750	1869	1949	1968	2051	1630	1499
MAI	108.9	111.9	114.2	117.8	122.3	123.4	125.3
Scribner volume per acre							
1	47000	52233	54836	57830	66009	71852	77943
2	49812	55812	58972	63043	72593	78706	86496
3	52262	57574	60588	64144	74896	81211	90737
4	63690	70471	74187	77890	88553	93476	101464
5	73188	80055	84037	88030	99071	94818	96030
Ave	57190	63229	66524	70187	80224	84818	90534
SD	10963	11656	12189	12429	13353	9877	9009
MAI	673	703	723	747	802	816	831

Table 2 (cont.)

HEAVY SELECTION

Plot	1960	1964	1966	1968	1975	1979	1984
			Measurement year				
Number of trees per acre							
1	47.5	47.5	47.5	45.0	45.0	45.0	50.0
2	52.5	60.0	60.0	62.5	65.0	65.0	72.5
3	55.0	67.5	67.5	67.5	70.0	70.0	77.5
4	57.5	62.5	62.5	62.5	62.5	75.0	82.5
5	47.5	50.0	50.0	50.0	50.0	47.5	52.5
Ave	52.0	57.5	57.5	57.5	58.5	60.5	67.0
SD	4.5	8.5	8.5	9.5	10.6	13.5	14.8
Basal area per acre							
1	178.0	190.7	197.5	192.7	213.7	226.6	245.1
2	162.1	174.8	180.6	186.3	204.0	214.5	234.7
3	194.4	222.2	234.4	241.5	273.0	293.9	323.6
4	112.1	125.3	131.6	130.6	153.0	175.2	195.0
5	173.4	190.3	197.7	202.4	223.1	217.7	239.2
Ave	164.0	180.7	188.4	190.7	213.4	225.6	247.5
SD	31.2	35.4	37.3	39.8	43.0	43.0	46.9
MAI	1.93	2.01	2.05	2.03	2.13	2.17	2.27
Cubic-foot volume per acre							
1	8559	9342	9446	9503	10631	11542	12668
2	7806	8498	8825	9134	10054	10823	11943
3	8855	10272	10910	11323	12925	14374	16139
4	5268	5966	6314	6354	7493	8707	9837
5	7676	8566	8970	9259	10266	10171	11363
Ave	7635	8529	8953	9115	10274	11123	12390
SD	1412	1603	1691	1780	1932	2096	2340
MAI	89.8	94.8	97.3	97.0	102.7	106.9	113.7
Scribner board-foot per acre							
1	55610	61843	65037	63793	73759	80122	88373
2	49849	54108	56659	58735	66534	71750	79466
3	56307	65355	70220	73449	87208	97051	109682
4	30152	34783	37436	37842	47207	53918	61632
5	49393	55862	58959	61235	70604	68937	77473
Ave	48262	54390	57662	59011	69062	74356	83325
SD	10612	11858	12489	13081	14472	15829	17606
MAI	568	604	627	628	691	715	764

TABLE 2. (CONT)

GROUP SELECTION

Plot	1959	1964	1966	1968	1975	1979	1984
			Measurement year				
Number of trees per acre							
1	135.5	137.5	137.5	140.0	140.0	140.0	140.0
2	77.5	80.0	85.0	85.0	85.0	85.0	95.0
3	107.5	107.5	112.5	112.5	115.0	115.0	115.0
4	95.0	107.5	107.5	107.5	112.5	117.5	127.5
5	135.0	135.0	137.5	137.5	140.0	137.5	145.0
Ave	109.5	113.5	116.0	116.5	118.5	119.0	124.3
SD	24.6	23.6	22.2	22.8	22.9	22.1	20.2
Basal area per acre							
1	250.9	273.4	281.3	291.0	310.5	322.3	333.6
2	230.7	245.1	254.1	260.7	274.6	290.2	306.7
3	258.5	273.1	283.9	291.4	312.8	323.8	338.1
4	291.5	320.6	331.4	340.3	369.0	386.4	409.6
5	371.1	388.8	401.4	411.4	441.7	446.9	474.8
Ave	280.5	300.2	310.4	318.9	341.7	353.9	372.6
SD	55.2	56.5	58.0	59.0	65.3	62.6	68.7
MAI	3.34	3.33	3.38	3.39	3.42	3.40	3.42
Cubic-foot volume per acre							
1	11082	12348	12820	13392	14475	15529	16325
2	10611	11488	11949	12356	13117	14244	15266
3	12352	13293	13888	14349	15539	16460	17415
4	14398	15919	16512	17031	18523	19757	21046
5	17394	18474	19080	19784	214001	22102	23848
Ave	13167	14304	14850	15383	16611	17618	18780
SD	2781	2863	2920	3012	3336	3232	3573
MAI	156.7	158.9	161.4	163.6	166.1	169.4	172.3
Scribner volume per acre							
1	61744	70595	74170	78025	88162	94662	101057
2	65714	72282	75187	78384	86028	93439	100025
3	73311	80758	84555	88199	98659	104846	112808
4	91966	101986	106605	110712	123356	131087	139875
5	107443	116113	121267	126011	140724	144937	157809
Ave	80036	88347	92357	96266	107386	113794	122315
SD	19225	19923	20768	21278	23814	23073	25531
MAI	953	982	1004	1024	1074	1094	1122

Table 2. (Cont)

UNCUT CONTROL

	Measurement year						
Plot	1960	1964	1966	1968	1975	1979	1984
Number of trees per acre							
1	142.5	142.5	140.0	140.0		137.5	130.0
2	127.5	125.0	125.0	125.0		120.0	120.0
3	177.5	172.5	167.5	162.5		162.5	152.5
4	140.0	137.5	137.5	137.5		135.0	112.5
5	167.5	167.5	165.0	165.0		167.5	167.5
Ave	151.0	149.0	147.0	146.0		144.5	136.5
SD	20.7	20.3	18.5	17.2		20.0	22.9
Basal area per acre							
1	379.3	396.2	400.4	408.8		442.8	445.3
2	377.2	390.4	397.4	404.7		430.3	447.6
3	408.1	421.0	423.9	426.6		464.9	475.7
4	390.9	405.6	415.4	423.5		457.2	433.3
5	425.7	447.2	451.8	463.0		509.4	534.7
Ave	396.2	412.1	417.8	425.3		460.9	467.3
SD	20.5	22.8	21.9	23.0		30.2	40.7
MAI	4.66	4.58	4.54	4.52		4.43	4.29
Cubic-foot volume per acre							
1	18644	19797	20135	20690		23110	23480
2	17197	18204	18663	19173		21203	22446
3	19286	20247	20455	20701		23385	24311
4	19748	20770	21383	21926		24263	23138
5	19196	20584	20930	21611		24626	26396
Ave	18814	19921	20313	20822		23318	23954
SD	985	1029	1037	1070		1335	1521
MAI	221.3	221.3	220.8	221.5		224.2	219.8
Scribner volume per acre							
1	113489	122861	126206	130707		151362	156651
2	105325	113981	117652	121786		139596	149823
3	112823	121550	124420	127545		149235	159105
4	121863	130848	135810	140285		160633	157280
5	115142	126094	129418	134797		158770	173195
Ave	113728	123067	126701	131024		151919	159211
SD	5910	6217	6665	7030		8403	8573
MAI	1338	1367	1377	1394		1461	1461

Table 3. Cubic and Scribner tree volume regression coefficients for the Caspar Creek Cutting Trials. (Krumland and Wensel,1979)

	Cubic (top DIB 5")			Scribner (top DIB 8")		
Specie	Intrcpt	LnDia.	LnHt.	Intrcpt	LnDia.	LnHt.
Redwood	-7.1431	1.792	1.282	-7.6623	2.026	1.597
Doug.fir	-7.1387	1.580	1.436	-6.841	1.793	1.609
W.wood	-7.4838	1.648	1.473	-9.151	1.754	2.113

Table 4. Local volume table coefficients computed from tree diameters and stem volumes in 1959-60,1979, and 1984 in the four blocks of the Caspar Creek Cutting Trials.

	1959-60		1979		1984	
Species	cu.ft.	bd.ft.	cu ft.	bd.ft.	cu.ft.	bd.ft.
Uncut						
Rwd.	.21010	1.5029	.24030	1.7979	.24966	1.8759
D.-fir	.29934	2.2727	.31096	2.3851	.33276	2.5388
W.wood	.30870	2.4792	.32788	2.6757	.32995	2.7272
GROUP S.						
Rwd.	.19482	1.3102	.24029	1.7979	.24188	1.8023
D.-fir	.30176	2.2890	.31096	2.3514	.30472	2.3465
W.wood	.23691	1.6958	.32788	2.6757	.30019	2.3217
HEAVY S.						
Rwd.	.21581	1.5359	.24023	1.7979	.23368	1.7014
D.-fir	.33000	2.5035	.31096	2.3851	.31580	2.5249
W.wood			.32788	2.6756	.33434	2.7591
LIGHT S.						
Rwd.	.20685	1.4924	.24023	1.7979	.23804	1.7455
D.-fir	.31032	2.3479	.31096	2.3851	.32879	2.6749
W.wood	.30405	2.3640	.32788	2.6757	.32326	2.6255
AVERAGES						
Rwd.	.20689	1.4606	.24029	1.7979	.24081	1.7813
D.-fir	.31035	2.3533	.31096	2.3851	.32047	2.5213
W.wood	.28322	2.1797	.32788	2.6757	.32193	2.6084

Table 5. Local volume table coefficients used in each of the measurement years for computation of stand volume by species.

	Measurement year						
Spec.	1960	1964	1966	1968	1975	1979	1984
Cubic volume							
Rwd.	.20699	.21398	.21678	.21961	.22045	.23374	.24080
D-fir	.31035	.31246	.31330	.31414	.31667	.31836	.32047
W-wd.	.31035	.31246	.31330	.31414	.31667	.31836	.32047
Scribner volume							
Rwd.	1.4603	1.5272	1.5539	1.5806	1.6609	1.7144	1.7813
D-fir	2.3533	2.3883	2.4023	2.4163	2.4583	2.4863	2.5213
W-wd.	2.3533	2.3883	2.4023	2.4163	2.4583	2.4863	2.5213

Table 6. Periodic average per acre stand mortality in the Caspar Creek Cutting Trials.

Block	No. Plots	No. of trees	Basal area	Average diameter	Vol.	Vol.
			(sqft)	(inch)	(cuft)	(bdft)
Uncut	5	17.5	22.7	15.4	1246	6099
L.Sel.	2	3.0	11.8	26.9	678	4700
H.Sel.	2	1.0	5.6	31.9	321	2318
G.Sel.	4	3.0	7.5	21.5	430	2749

Table 7. Average periodic per acre ingrowth of stems beyond the 11.0" DBH threshold on the Caspar Creek Cutting Trials.

Block	No.Plts.	No.Trs.	B.area	Ave.Dia.	Vol.	Vol.
			(sqft)	(inch)	(cuft)	(bdft)
Uncut	3	2.5	2.1	12.4	88	254
L.Select	4	13.5	14.6	14.1	658	2688
H.Select	5	16.0	16.8	13.9	729	2910
G.Select	5	18.0	17.9	13.5	754	2788

Table 8. Periodic basal area growth and periodic annual growth percent for three sub-periods and the total period from the initial to the terminal measurements.

Block	1960-68 9 years		1969-78 10 years		1978-83 5 years		1960-83 24 years	
	(sqft)	(%)	(sqft)	(%)	(sqft)	(%)	(sqft)	(%)
Lt.Sel.	32.1	1.69	28.2	1.17	12.6	.96	72.9	1.31
Hv.Sel.	26.7	1.67	34.9	1.68	21.9	1.85	83.5	1.69
Gp.Sel.*	38.4	1.28	34.9	1.04	18.6	1.03	92.0	1.13
Uncut	29.1	.79	35.6	.80	6.4	.38	71.1	.69

* group select was established in 1959

Table 9. Cumulative percentage of the survivor tree basal area growth by the initial inventory diameter classes.

Initial Dia.	Light select	Heavy select	Group select	Uncut
(inch)		(percent)		
10	0.0	0.0	0.0	0.0
15	14.1	9.2	13.4	5.3
20	26.8	22.0	32.2	22.8
25	56.1	48.6	58.5	41.0
30	74.9	74.9	80.3	71.0
35	92.4	96.0	94.4	92.2
40	96.2	98.8	96.9	97.3
45	100.0	100.0	99.3	98.9
50			100.0	98.9
55				100.0

Table 10. Cumulative percentage of the number of trees by diameter classes for the initial inventory of the Caspar Creek Cutting Trials.

Initial diameter	Light select	Heavy select	Group select	Uncut
(inchs)		(percent)		
10	0.0	0.0	0.0	0.0
15	30.5	20.2	29.7	25.5
20	49.3	37.5	54.3	54.0
25	73.6	60.5	77.6	76.8
30	86.1	83.6	90.4	89.7
35	98.8	97.1	97.3	97.0
40	97.9	99.0	98.6	99.0
45	100.0	100.0	99.5	99.7
50			100.0	99.7
55				100.0

Table 11. Board-foot periodic growth and periodic annual growth percent for trees >11.0 inches DBH.

Block	1960-68 9 years		1969-78 10 years		1979-83 5 years		1960-83 24 years	
	(bdft)	(%)	(bdft)	(%)	(bdft)	(%)	(bdft)	(%)
Lt.Sel.	1444	2.23	1382	1.89	1300	1.30	1388	1.88
Hv.Sel.	1194	2.27	1534	2.30	1794	2.27	1461	2.22
Gp.Sel.*	1623	1.59	1753	1.40	1704	1.44	1691	1.67
Uncut	1922	1.57	2089	1.48	1458	.94	1895	1.39

* group select was established in 1959

Table 12. Cumulative percentage of the initial board-foot volume by initial tree diameter class.

Initial Dia.	Light select	Heavy select	Group select	Uncut
(inch)		(percent)		
10	0	0	0	0
15	4.8	3.3	5.7	5.4
20	13.5	13.1	19.1	22.2
25	39.3	33.2	47.4	48.9
30	61.3	64.2	72.6	71.6
35	83.6	93.0	90.6	89.3
40	91.0	97.9	94.6	95.6
45	100.0	100.0	98.5	98.1
50			100.0	98.1
55				100.0

Table 13. Cumulative percentage of the periodic board-foot growth by the initial diameter classes.

Initial Dia.	Light select	Heavy select	Group select	Uncut
(inch)		(percent)		
10	0	0	0	0
15	12.2	8.1	11.1	3.6
20	23.5	22.0	28.2	18.4
25	52.1	47.1	53.9	50.1
30	71.8	73.6	76.7	74.2
35	90.2	95.3	92.2	90.1
40	95.0	98.5	94.6	95.9
45	100.0	100.0	98.4	97.9
50			100.0	97.9
55				100.0

Table 14. Scribner gross yield of the logged vs. the uncut blocks of the Caspar Creek Cutting Trials. Harvested volumes derived from the CDF 1962 report.

	Uncut	Group	Light	Heavy
Initial volume	113728	111536	99290	106462
Percent of uncut	100.0	98.1	87.3	93.6
Est. of cut vol.	0.0	31500	42100	58200
1960 post cut	113728	80036	57190	48262
1984 Vol.	159211	122315	90534	83325
Period mort. vol.	6099	2749	4700	2318
Gross yield	165310	156564	137334	143843
% of uncut gross	100.0	94.7	83.1	87.0

Table 15. Average number of conifer stems per acre larger than 11.0" DBH at the initial inventory date for the Caspar Creek Cutting Trials. Stand age approximatly 85 years.

DBH class	Light S.	Heavy S.	Group S.	Uncut
(inch)		(no. trees/acre)		
2				
4				
6				
8				
10				
12	10.5	3.0	14.0	13.0
14	8.0	5.5	10.5	19.5
16	6.5	4.5	13.5	15.5
18	5.0	4.5	14.0	19.0
20	5.5	2.0	7.5	14.5
22	9.0	3.5	10.5	13.0
24	6.5	7.5	9.0	16.5
26	4.5	5.0	9.5	10.0
28	5.0	4.0	5.5	6.5
30	1.5	4.0	5.0	8.0
32	4.0	2.0	5.0	7.5
34	1.5	4.0	1.0	3.0
36	1.5	1.0	2.0	1.0
38	1.0	1.0	.5	1.5
40	.5	.0	.5	1.0
42	1.0	.5	.5	.0
44	.5	.0	.0	.5
46			.5	.5
48			.5	.0
50				.0
+50				.5

Table 16. Average number of stems per acre (all conifers) over 4.5 inches DBH at the 1984 inventory of the Caspar Creek Cutting Trials.

Diameter	Light S.	Heavy S.	Group S.	Uncut
(inch)	(no. trees/acre)			
2				
4				
6	15.0	29.0	25.5	24.0
8	11.0	19.5	22.5	20.5
10	8.5	10.0	22.0	13.5
12	7.5	7.0	19.0	17.5
14	12.0	7.5	12.5	20.0
16	10.0	7.5	11.0	12.0
18	8.0	4.5	15.5	20.0
20	5.0	4.5	10.0	11.5
22	5.5	3.0	9.5	10.0
24	5.5	2.0	7.5	9.5
26	5.0	3.0	8.5	13.0
28	5.0	5.5	9.0	10.0
30	3.0	5.0	4.5	10.5
32	7.0	7.0	7.0	7.5
34	3.5	2.0	5.5	9.5
36	1.5	3.0	3.5	4.0
38	2.5	1.5	4.0	3.0
40	1.0	4.5	1.5	1.5
42	1.5	2.0	.0	2.0
44	1.5	.0	.0	.0
46	1.0	.5	1.0	1.0
48	.0	.0	.5	.5
50			.5	.0
+50				.5

Table 17. Number of regeneration stems per acre in the subplots of the 1984 measurement of the Caspar Creek Cutting Trials.

	Size class										
Light	1/1000 acre					1/250 acre					
	1	2	3	4	tot.	5	6	7	8	9	total
Rwd	0	0	0	0	0	35	25	0	5	0	65
D-fir	20	120	80	0	220	60	5	0	0	0	65
Gfir	1400	420	340	240	2400	755	465	115	20	0	1355
Hem.	1500	620	560	480	3160	190	40	0	5	0	235
Hwd.	60	0	60	40	160	60	90	60	5	0	215
Con.	2920	1160	980	720	5780	1040	535	115	30	0	1720
Heavy											
Rwd.	100	40	25	25	190	45	40	30	10	0	125
D-fir	0	0	0	0	0	40	80	55	20	10	205
G.fir	0	40	100	100	240	330	405	235	30	35	1035
Hem.	0	20	0	20	40	15	20	5	5	0	45
Hwd.	0	0	0	0	0	30	95	110	85	25	345
Con.	100	100	125	145	470	430	545	325	65	45	1410
Group											
Rwd.	0	0	20	0	20	75	65	35	20	15	210
D-fir	0	60	0	80	140	75	45	0	0	5	125
G.fir	40	80	60	0	180	35	10	0	0	0	45
Hem.	300	120	40	20	480	105	50	15	5	10	185
Hwd.	20	40	200	0	260	120	165	75	15	5	380
Con.	340	260	120	100	820	290	170	50	25	30	565
Uncut											
Rwd	0	0	0	0	0	30	30	15	15	0	90
D.fir	0	0	0	0	0	0	0	0	0	0	0
G.fir	60	40	20	0	120	0	5	0	0	0	0
Hem.	40	0	0	0	40	0	0	5	0	0	5
Hwd.	20	20	140	100	300	125	10	10	0	10	145
Con.	100	40	20	0	160	30	35	20	15	0	95

Class	Plot size	Size limits
1	1/1000	< 1 foot tall
2	"	1-2 feet "
3	"	2-3 feet "
4	"	3-4.5 feet "
5	1/250	< .5 inch DBH
6	"	.5-1.5 inch "
7	"	1.5-2.5 inch "
8	"	2.5-3.5 inch "
9	"	3.5-4.5 inch "

Table 18. Conifer regeneration per acre for stems <4.5 feet tall, and for the 1-4 inch diameter classes of the 1984 inventory's regeneration survey of the Caspar Creek Cutting Trials

Diameter	Light S.	Heavy S.	Group S.	Uncut
(inch)	(number trees/acre)			
<4.5'	5780	470	820	160
1	1575	975	460	65
2	115	325	50	20
3	30	65	25	15
4	0	45	30	0

Table 19. Predicted stand structure of an uneven-aged stand with a Q ratio of 1.20, and .6 trees per acre at 50 inch DBH

Diameter	Predicted	Actual
50	.6	.5
48	.72	.5
46	.86	1.0
44	1.04	.0
42	1.24	.0
40	1.49	1.5
38	1.79	4.0
36	2.15	3.5
34	2.58	5.5
32	3.10	7.0
30	3.71	4.5
28	4.46	9.0
26	5.35	8.5
24	6.42	7.5
22	7.70	9.5
20	9.24	10.0
18	11.10	15.5
16	13.31	11.0
14	15.97	12.5
12	19.17	19.0
10	23.00	22.0
8	27.60	22.5
6	33.12	25.5
4	39.75	55.0
2	47.70	510.0

Table 20. Average stand values for the six plots of each replication prior to treatment of the Caspar Creek Cutting Trial clear-cut block. Stand was 19 years old when thinned.

Block	Trees>1.5" DBH No.stms Ave	S.D.	B.area Ave.	S.D.	Dia.	Trees >10.5"DBH No.stms Ave.	S.D.	B.area Ave.	S.D.	Dia
			(sq.ft.)		(in.)			(sq.ft.)		(in.)
1	734	239	145	35	6.0	41	17	34	14	12.3
2	915	160	139	22	5.3	38	21	31	15	12.2
3	577	132	125	39	6.3	58	35	56	33	13.2

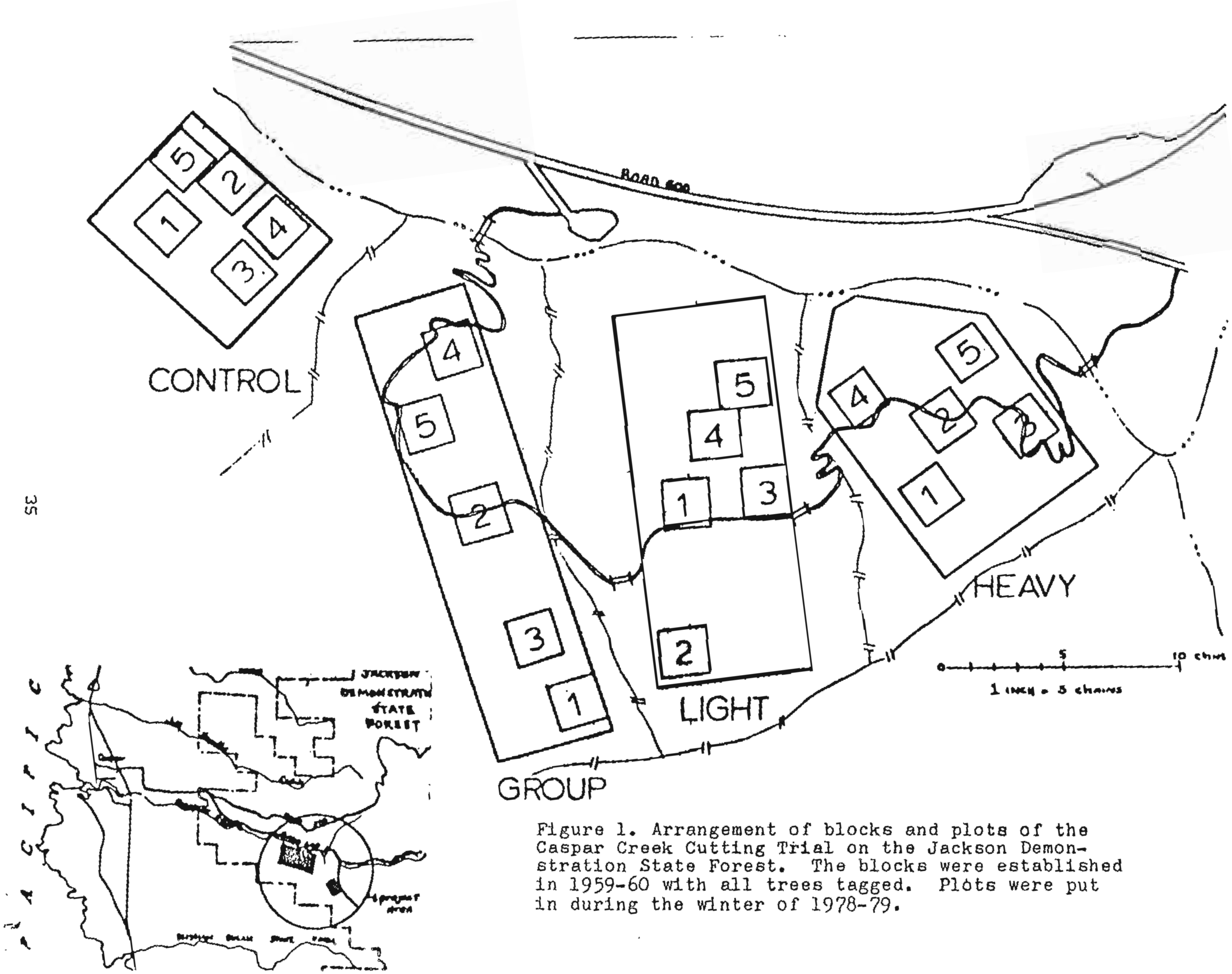


Figure 1. Arrangement of blocks and plots of the Caspar Creek Cutting Trial on the Jackson Demonstration State Forest. The blocks were established in 1959-60 with all trees tagged. Plots were put in during the winter of 1978-79.

Figure 2. Total stand basal area per acre of trees larger than 11.0 inches DBH.

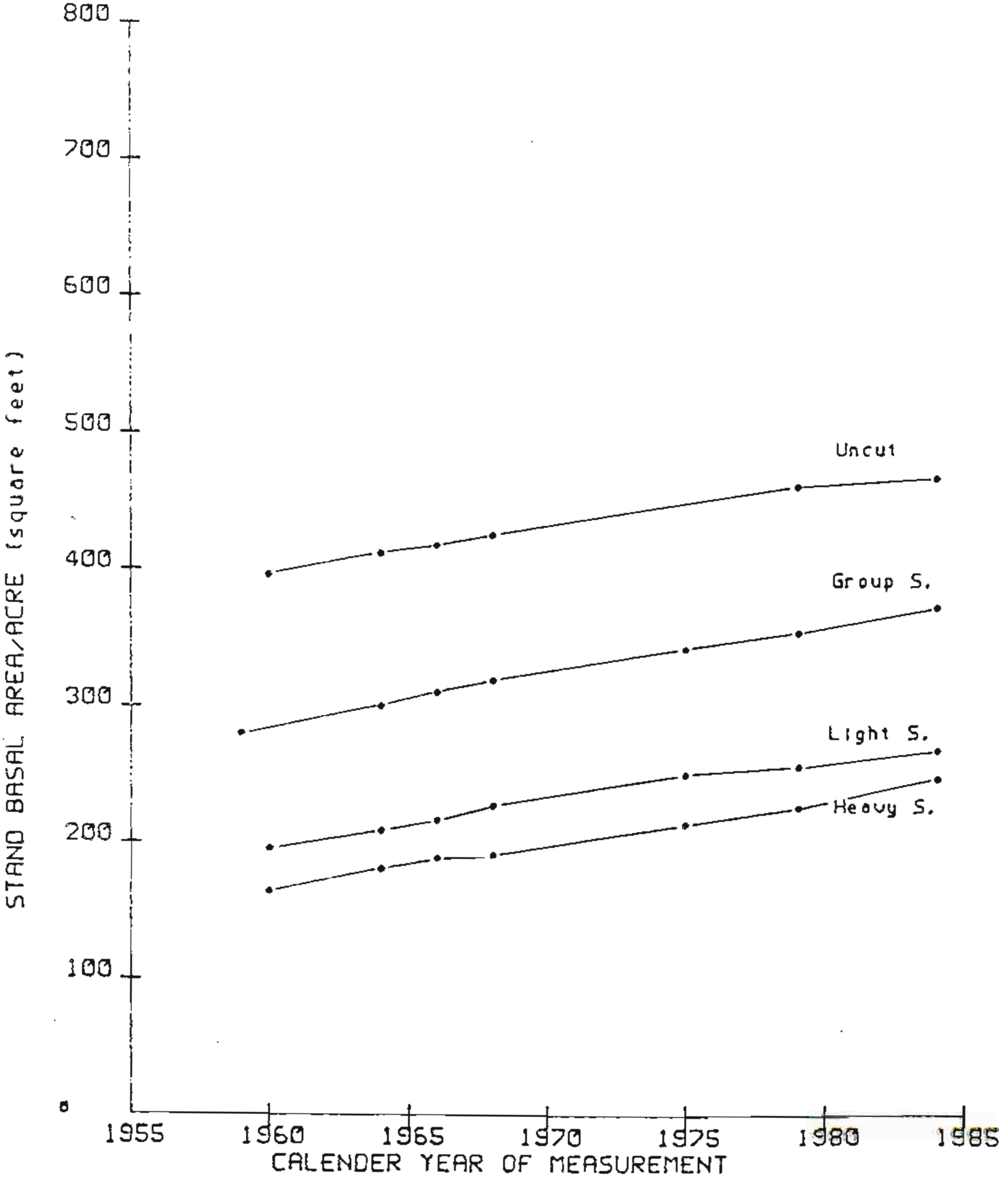


Figure 3. Stand cubic-foot volume per acre of trees larger than 11.0 inches DBH.

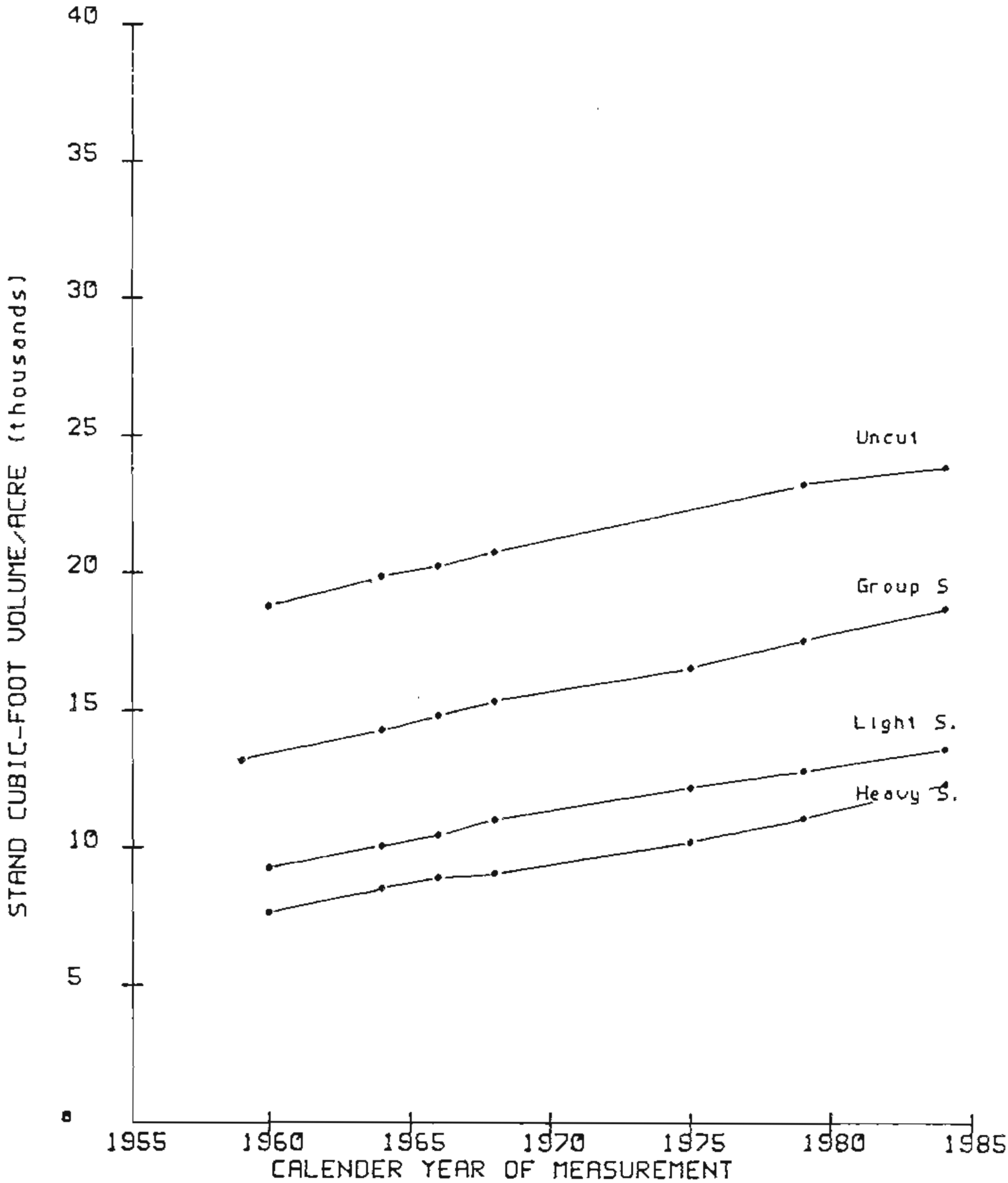


Figure 4. Scribner board-foot yield volumes per acre of trees larger than 11.0 inches DBH.

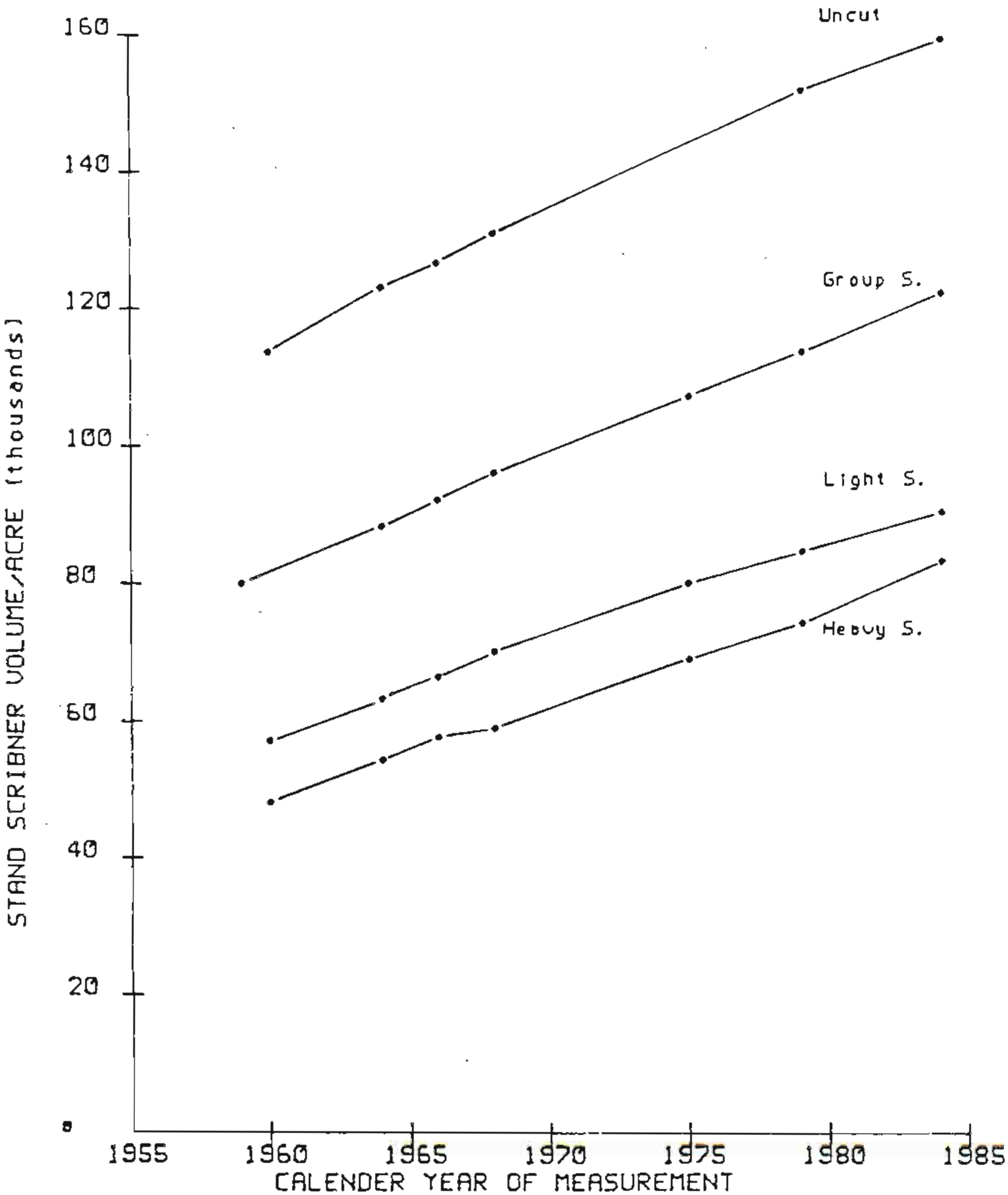
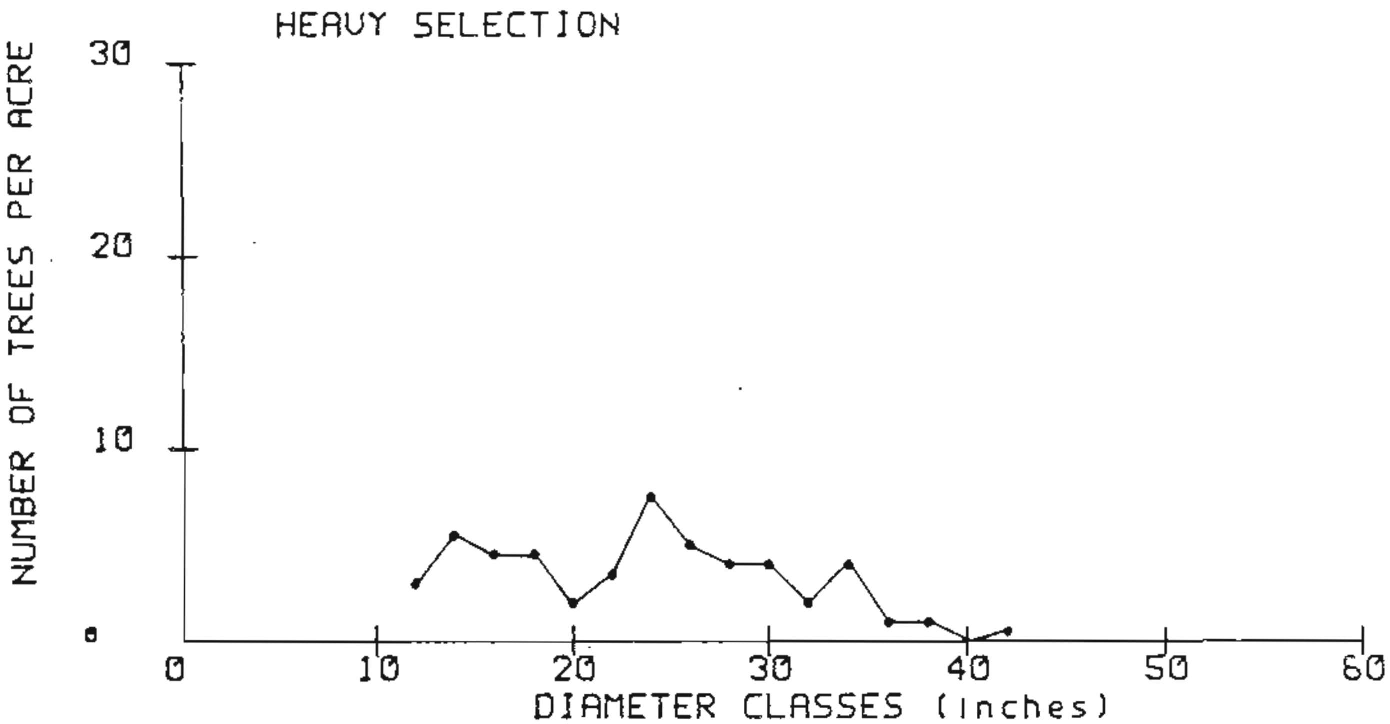


Figure **5**. Diameter distributions for the initial inventories, trees larger than 11 inches DBH.



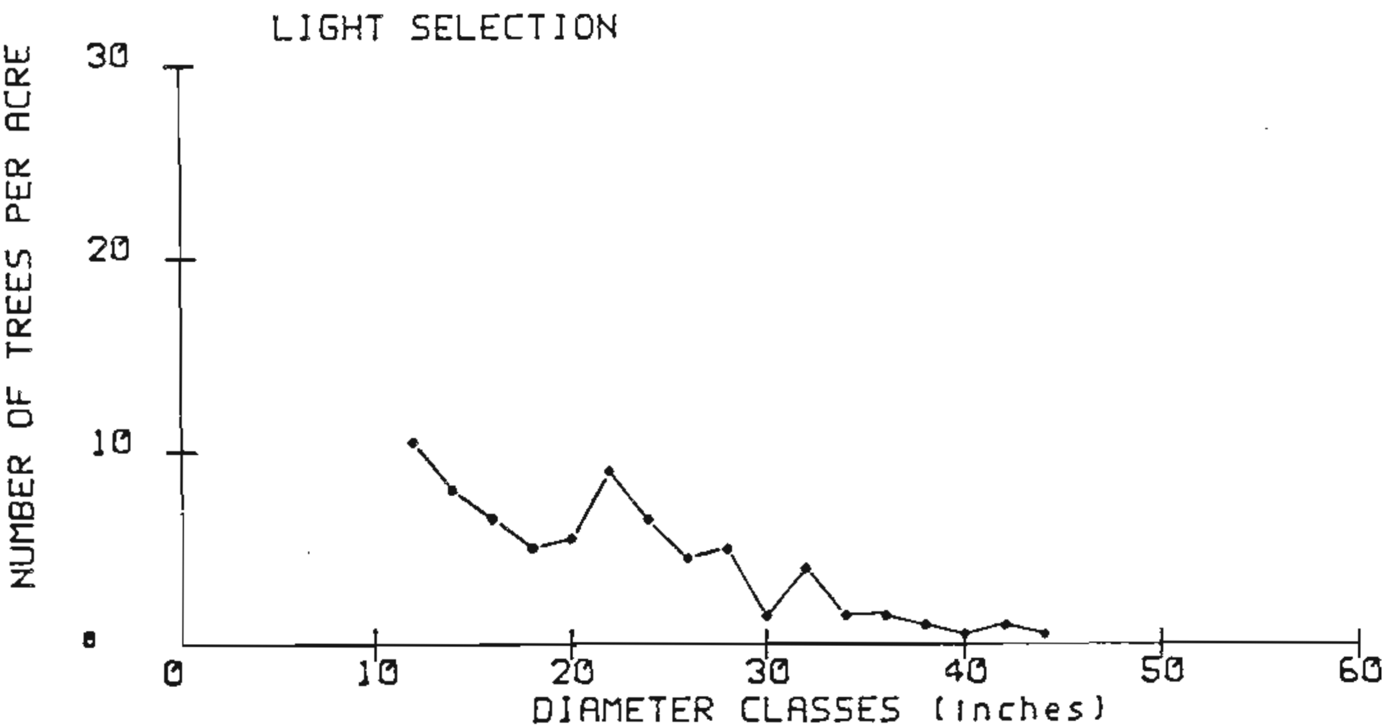
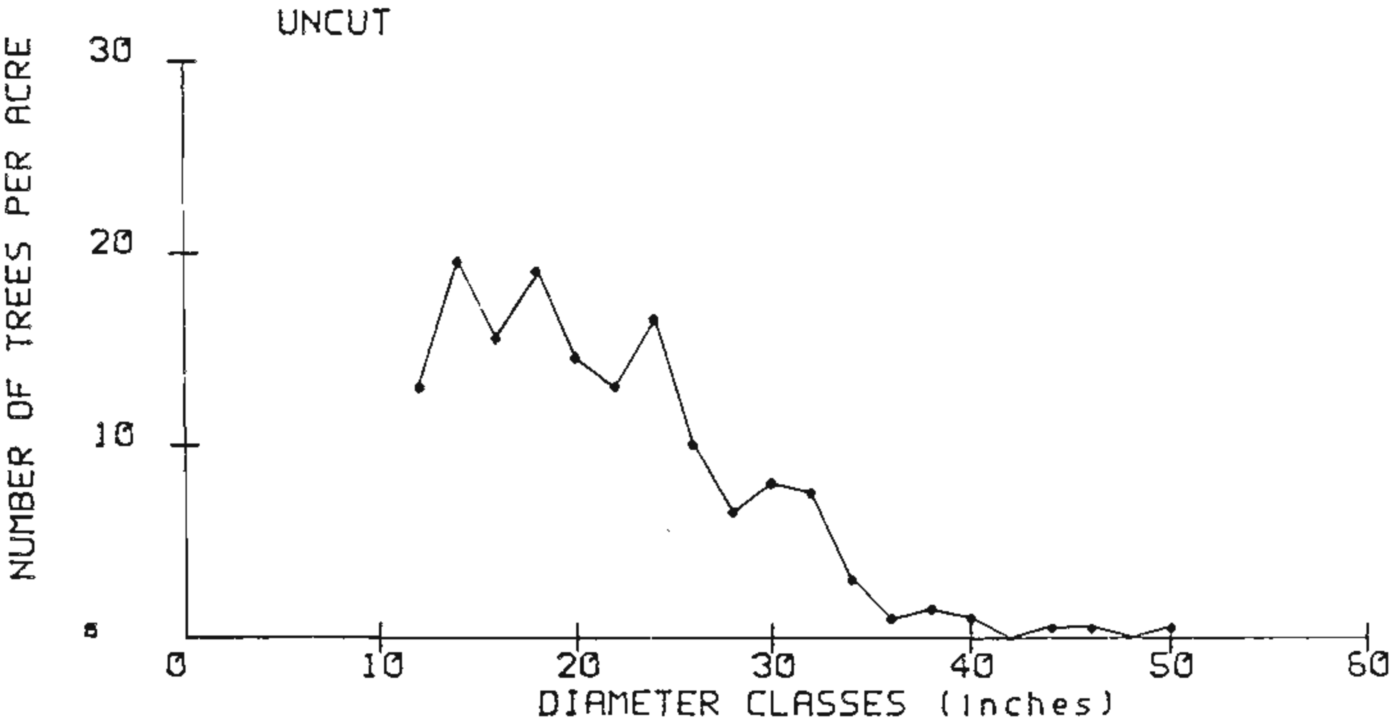


FIGURE 5. (CONT.)



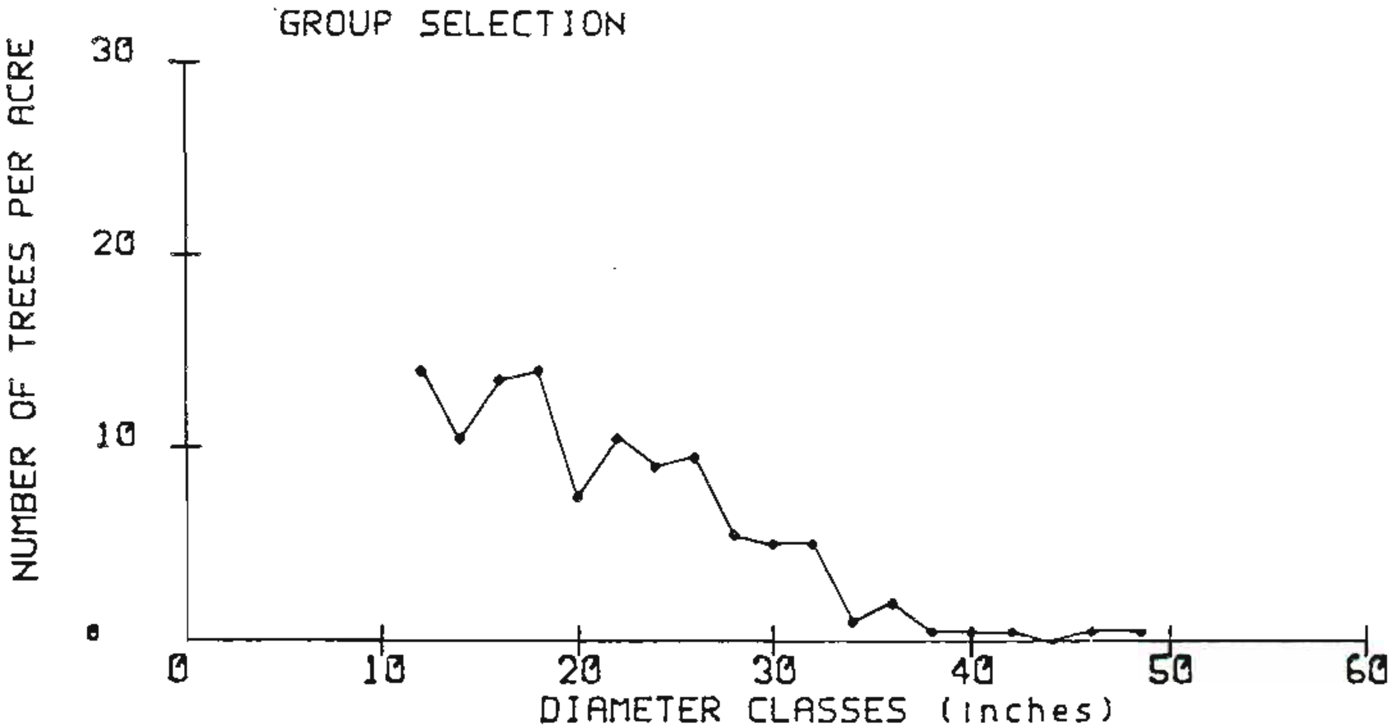


Figure 6. Diameter distributions for the 1984 inventories, trees larger than 4.5 inches DBH.

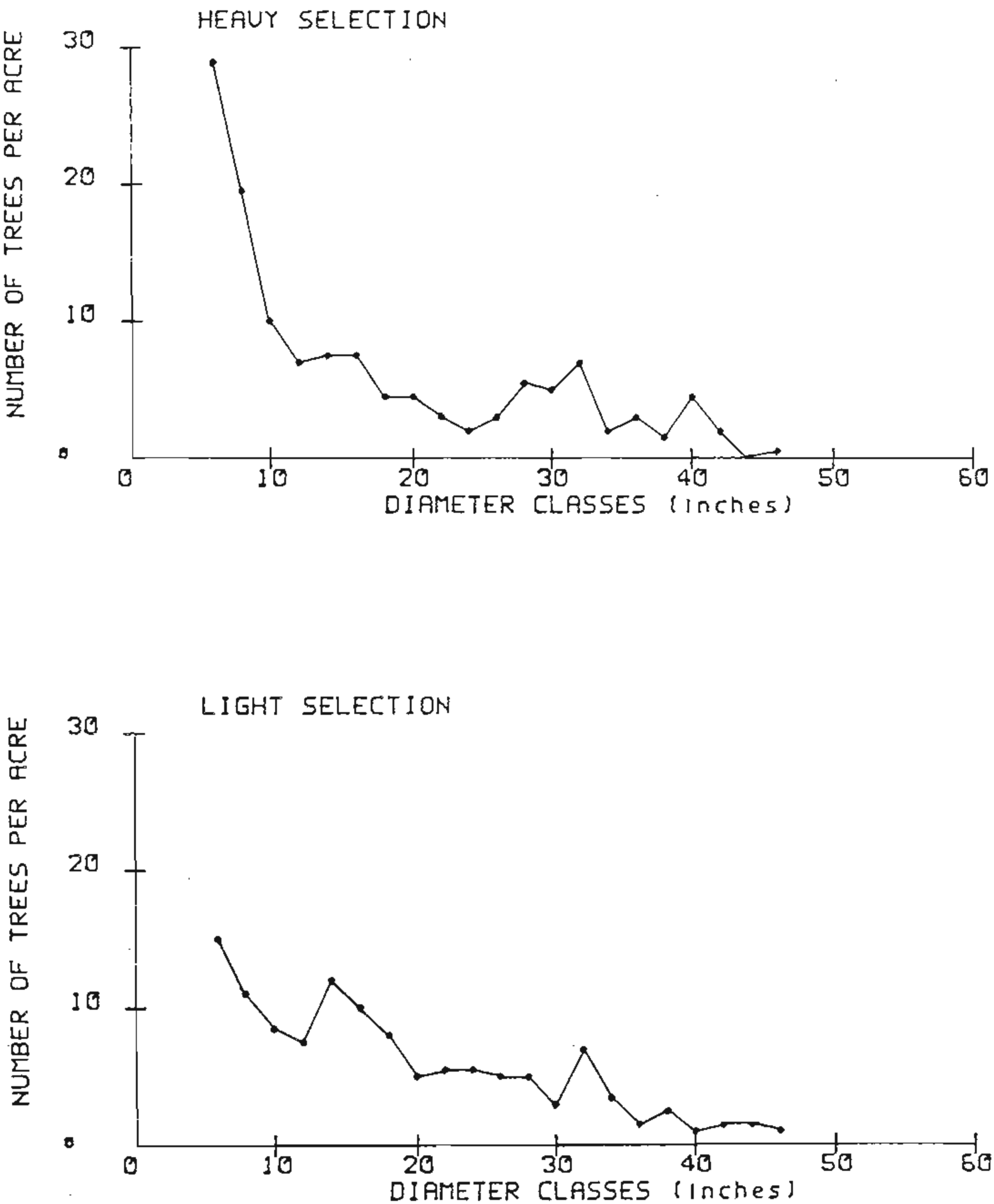


Figure 6. (CONT.)