California FORESTRY Note

State of California
The Resources Agency
Department of Forestry

1416 Ninth Street Sacramento, CA 95814 Phone 916-445-5571

NO. 99 JUNE, 1988

# THE CASPAR CUTTING TRIALS

## A CASE STUDY REPORT 25 YEARS AFTER HARVEST

JAMES L. LINDQUIST [1]

FIGURE ABOVE SHOWS HEAVY SELECTION DONE IN 1960. FIGURE TO RIGHT SHOWS CLEARCUT LOGGED IN 1961. NOTE THE NUMEROUS REDWOOD SPROUTS.

---

1 Consulting research forester. This study was conducted under contract with the California Department of Forestry and Fire Protection, Jackson State Forest, Fort Bragg, California.

State of California

George Deukmejian, Governor

The Resources Agency
Gordon K. Van Vleck
Secretary for Resources

Department of Forestry
and Fire Protection
Jerry Partain
Director

ACKNOWLEDGEMENT

Acknowledgement is made to Robert J. Malain and David M. Burns who initiated the original study in 1959 and all other JDSF personnel who have maintained and remeasured the growth plots since that time.

## ABSTRACT

Management of redwood/fir stands with partial logging has been tested in an 85 year old stand on the Jackson Demonstration State Forest. Five test blocks were established during 1959-1961. They are: clearcut, single tree light selection, single tree heavy selection, group selection and uncut control. After 24 years evaluation, an analysis of the results are made in this report. The three major subject areas reported on are: (1) growth and yield of basal area and volume; (2) periodic changes in diameter distributions; and (3) regeneration success under the residual canopies.

Gross stand volume growth of the logged blocks has not kept pace with that of the uncut block. Diameter distributions following logging have not clearly moved towards a distribution desired in uneven-aged management. Finally, regeneration of redwood and Douglas-fir will not maintain a well stocked stand of these species. Under the tree selection canopies brush, grand fir and hemlock take the space; sprouts in these blocks are not a significant part of the understory. Redwood stumps do not have an aggressive sprout population like that of the group selection and clear cut blocks.

Keywords: partial logging, redwood, growth and yield, diameter distributions, regeneration, tree selection, group selection

## TABLE OF CONTENTS

## 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 economic 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 and see the consequences of doing nothing for another 25 years. The 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, forest resource 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 had been based on single tree selection. The objective was to convert these stands from even-aged to uneven-aged stands.

Most other ownerships show the same pattern of few harvest clearcuts resulting in a large acreage of young stands that have been selectively logged, taking 30 to 50 percent of the volume. These 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 regeneration 25 years after logging. Other objectives of the original JDSF 1962 report (Malain and Burns, 1962) are not discussed unless they influence the stand yield. Three objectives in the proposal for this study are to help understand the value of partial logging. These objectives are:

1. To determine if adequate regeneration occurred.
2. To describe the diameter distribution by a 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-aged management.

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

## THE ORIGINAL STUDY

The stand selected for the cutting trials is approximately 75 acres of young-growth mixed coastal redwood/Douglas-fir about four miles from the coast along the south side of Caspar Creek. This 5,000-acre drainage is about five miles south of Fort Bragg (Fig. 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 average 40 to 45 percent. Soils are Dehaven, Hotel Series on the lower slopes, changing to Tramway, Irmulco Series near the ridge tops. Site index for the stand for redwood averages about 155 (Lindquist and Palley, 1961), and for Douglas-fir 190 (Lindquist, 1982).

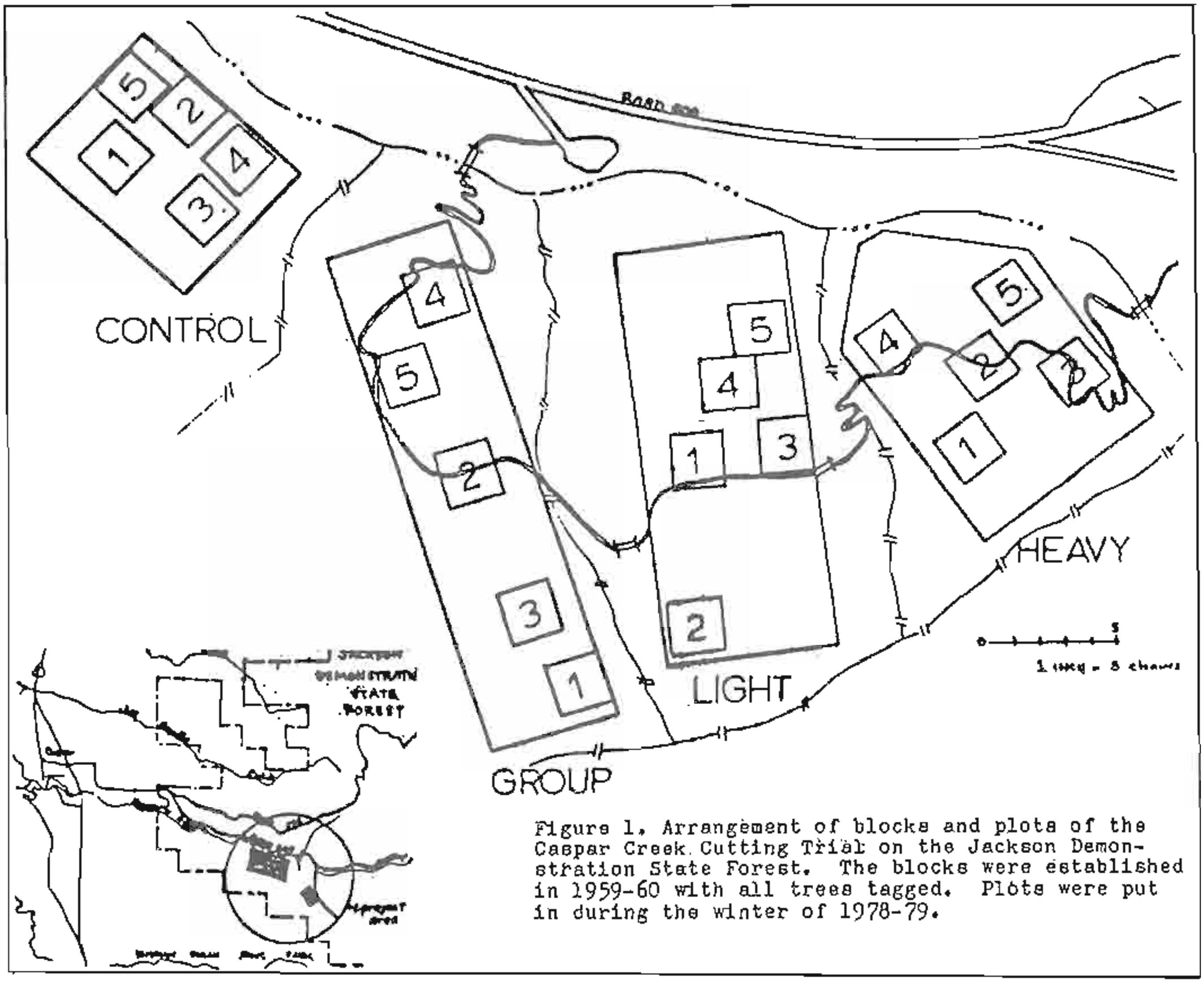



Figure 1. Arrangement of blocks and plots of the Caspar Creek Cutting Trial on the Jackson Demonstration State Forest. The blocks were established in 1959-60 with all trees tagged. Plots were put in during the winter of 1978-79.

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 diameter breast height (DBH) by species in each treatment block. Some of this stand data is shown to illustrate 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 (1979). 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 inches DBH of the five blocks was 111.2M+/-12.3 thousand per acre. Basal area of trees over 11.0 inches DBH averaged 378.4+/- 41.8 square feet 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 a mixture of grand fir (Abies grandis (Dougl.) Lindl.), hemlock (Tsuga heterophylla (Raf.) Sarg.), and Bishop pine (Pinus muricata (D. Don)).

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

The clearcut block was stocked heavier than the other four blocks. Other blocks are similar in basal area, volume, and species composition with board foot volumes 32 percent redwood and 68 percent whitewoods.

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 clearcut patches that averaged 0.38 acres each. Usually, group cuts were centered around clumps of poor vigor trees, or when openings were 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.

The heavy tree selection, on 13 acres, was also designed 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 changed little 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 cutting blocks. The 1984 remeasurements are a continuation of the growth study methods established on plots installed in the winter of 1978-79. Five permanent randomly located 0.4 acre plots were installed in each treated block and the uncut control block. Each plot is defined by a set of tagged trees that have been remeasured periodically by the staff of the JDSF. Now tree measurements are restricted to 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 estimates of variation in the stand response. Design of the original experiment did not allow a statistical comparison between treatments.

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

The JDSF records of the periodic tree diameter measurements, from 1960 through 1979, were available for the growth analysis. To determine the per acre values of each plot, it was necessary to identify the tagged trees within each plot's boundaries. Recorded tree diameters from remeasurements in 1964, 1967, 1968, 1975, 1979 and 1984 are used to complete the record of stand development in each plot. When a tree reached 11.0 inches a tag was attached; this tree was then counted as ingrowth. Numbers of stems and basal area per acre, kept separate by species were determined in each measurement year. The averages and standard deviations for five plots in each block are shown for stand values in each measurement year, (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 measure ten random regeneration sub-plots in each 0.4 acre main plot. Each sample location was defined by a pair of X and Y coordinates between 6 and 126 feet; samples remain within the plot boundaries. These coordinates are all 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". The 50 sample plots of each treatment block are used to evaluate the ability of stands to regenerate after logging.

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**

| 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 | 28.1 | 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 | 10466 | 11211 |
| 2 | 8911 | 9708 | 10127 | 10776 | 11889 | 12844 | 13882 |
| 3 | 7963 | 8692 | 9122 | 9830 | 11094 | 12144 | 13532 |
| 4 | 10313 | 11279 | 11754 | 12292 | 13518 | 14218 | 15125 |
| 5 | 11688 | 12606 | 13186 | 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 | 55613 | 58972 | 62043 | 72593 | 78706 | 86496 |
| 3 | 52262 | 57574 | 60588 | 64144 | 74896 | 82211 | 90737 |
| 4 | 63690 | 70471 | 74187 | 77690 | 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 |

**HEAVY SELECTION**

| Plot | 1960 | 1964 | 1966 | 1968 | 1979 | 1979 | 1984 |
|---|---|---|---|---|---|---|---|
| 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 | 10172 | 10910 | 11323 | 12925 | 14374 | 16139 |
| 4 | 5268 | 5966 | 6314 | 6354 | 7493 | 8707 | 9837 |
| 5 | 7676 | 8566 | 8970 | 9259 | 10268 | 10171 | 11363 |
| Ave | 7635 | 8529 | 8893 | 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 | 73750 | 80122 | 88373 |
| 2 | 49849 | 54108 | 56659 | 58735 | 66534 | 71750 | 79466 |
| 3 | 56307 | 65355 | 70220 | 73449 | 87208 | 97061 | 109682 |
| 4 | 30152 | 34783 | 37436 | 39842 | 47207 | 53918 | 61632 |
| 5 | 49393 | 55862 | 58959 | 61235 | 70604 | 68937 | 77473 |
| Ave | 48262 | 54390 | 57662 | 59011 | 69062 | 74356 | 83325 |
| SD | 10612 | 11854 | 12489 | 13081 | 14472 | 15929 | 17608 |
| MAI | 568 | 604 | 627 | 626 | 691 | 715 | 764 |

**GROUP SELECTION**

| Plot | 1959 | 1964 | 1966 | 1968 | 1975 | 1979 | 1984 |
|---|---|---|---|---|---|---|---|
| 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 | 298.2 | 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 | 366.4 | 409.6 |
| 5 | 371.1 | 368.8 | 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 | 16465 | 17416 |
| 4 | 14398 | 15919 | 16512 | 17031 | 18523 | 19757 | 21046 |
| 5 | 17394 | 18474 | 19080 | 19784 | 21002 | 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 | 21270 | 23814 | 23073 | 25531 |
| MAI | 953 | 982 | 1004 | 1024 | 1074 | 1094 | 1122 |

**UNCUT CONTROL**

| 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 | 379.2 | 396.2 | 400.4 | 408.8 | | 442.8 | 445.3 |
| 2 | 377.2 | 390.4 | 397.4 | 406.7 | | 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 | 425.2 | | 460.9 | 467.3 |
| SD | 20.5 | 22.6 | 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 | 19285 | 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 | 122067 | 126701 | 131024 | | 151919 | 159311 |
| SD | 5910 | 6217 | 6665 | 7030 | | 8403 | 8573 |
| MAI | 1338 | 1367 | 1377 | 1394 | | 1461 | 1461 |

## VOLUME COMPUTATION

Stand volume computations are done with local volume lines (LVL) that express stem volume as a function of stem DBH squared. Computations of tree cubic and board foot volumes were made using Wensel and Krumland equations (1978); coefficients are shown in Table 3. The tree volumes were calculated for the year of the initial measurement, 1979 and 1984- the years when tree heights were measured. Species LVL's were computed for each treatment block and control block. The LVL is a restrained linear regression equation that expresses the best linear fit of the tree volume to the square of the tree diameter. Restraint on the line 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.

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 |

LVT coefficients for the three years when heights were measured are shown in Table 4. An analysis of the trends of the coefficients indicate for redwood and Douglas-fir, little variation in the coefficients of the blocks for either the initial or terminal years. So few trees were taken in two blocks in 1979 that trees of all blocks were combined. Another trend is the gradual increase of coefficients over time. This increase is expected, as there is an increase in stem volume resulting from height growth as well as that caused by the diameter growth. An average value for each species was used for all the stand blocks. Averages, shown in Table 5, are the values used in the computational program for the plot data. Coefficients for the LVT's of 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 interpolation was made for those years when heights were not measured. Inconsistencies of trends for the coefficients of the white wood species, resulted in use of Douglas-fir for all white-wood volume computations.

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 |

## RESULTS

There are several items to consider in understanding the effects of the stocking levels created by the partial logging reported in this study. The most obvious effects are related to growth and yield shown in Table 2 and graphically in Figures 2, 3 and 4. Growth trends of basal area and volumes do not show abrupt changes over the 25-year period indicating little growth response to treatment.

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

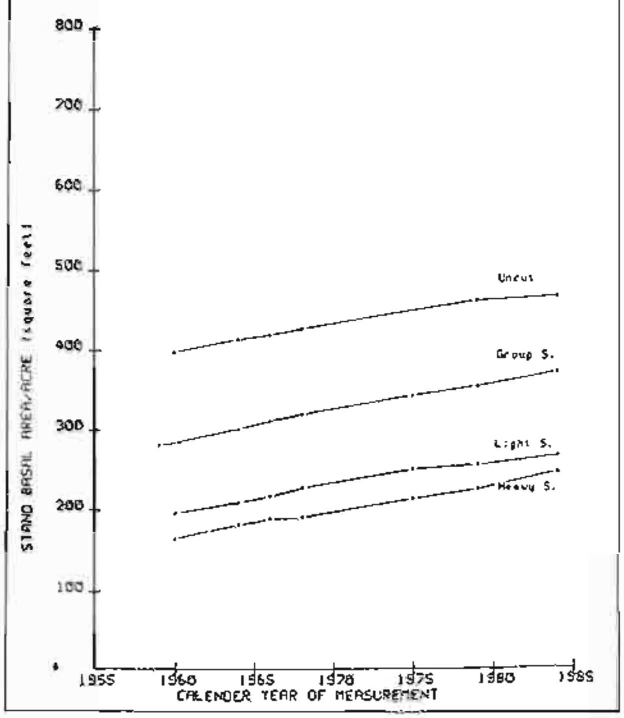



Figure 3. Stand cubic-foot volume per acre of trees larger than 11.0 inches DBH.

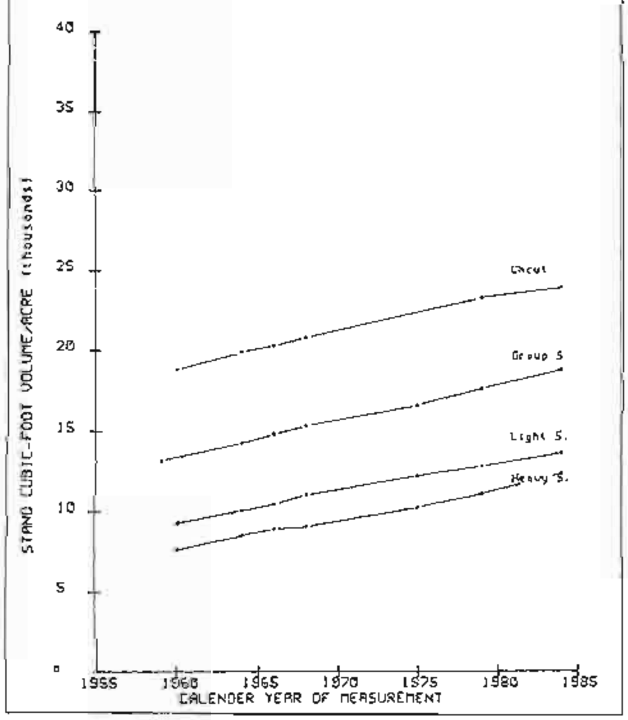
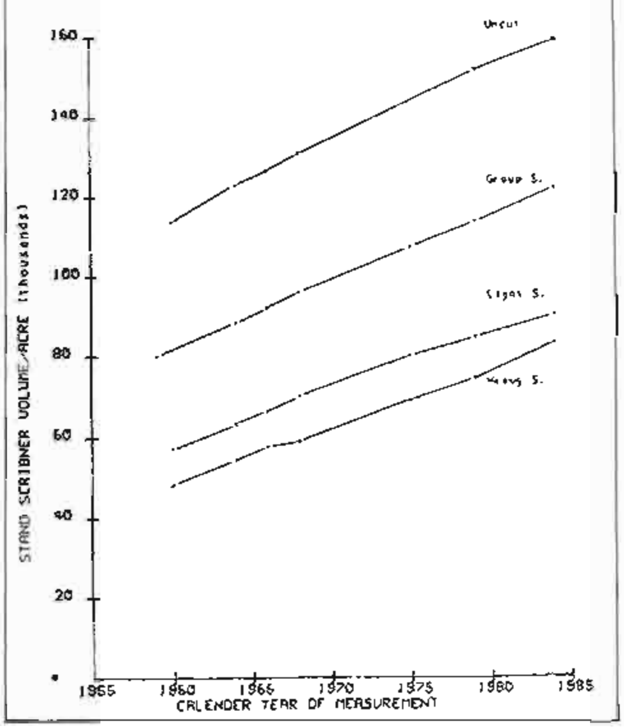



Figure 4. Scribner board-foot yield volumes per acre of trees larger than 11.0 inches DBH.



In determining the value of the cultural operations on stand yield, one must deal with some very subtle responses. These results do not provide obvious answers about the suitability of selection logging in this timber type.

## Mortality and Ingrowth

A total of 49 trees over 11.0 inches DBH died on the 20 plots during the growth period; 43 Douglas-fir and one (1) redwood. Of this mortality, 35 were in the unlogged control plots. A summary 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 individually are not an important volume component. However, during the 1979-84 period one tree 32.2 inches DBH died and 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 is not sufficient 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.

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

| Block | No.of plots | No.of trees | Basal area (sqft) | Average diameter (inch) | Vol. (cuft) | Vol. (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 |

A second source of stand change results from ingrowth of trees beyond the 11.0 " 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 in the uncut stand 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 in all treatments ingrowth over the period. None of the ingrowth stems were established after the 1959-60 logging. All stems exceeding the 11.0" DBH limit were left by the logging. Only in the group selection have new redwood sprouts approached this 11.0" DBH limit. A summary of the ingrowth situation is shown in Table 7.

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 (sqft) | Ave.Dia. (inch) | Vol. (cuft) | Vol. (bdft) |
|---|---|---|---|---|---|---|
| Uncut | 3 | 2.5 | 2.1 | 12.4 | 88 | 254 |
| L.Select | 4 | 13.5 | 14.6 | 14.1 | 658 | 2686 |
| H.Select | 5 | 16.0 | 16.8 | 13.9 | 729 | 2910 |
| G.Select | 5 | 18.0 | 17.9 | 13.5 | 754 | 2788 |

If the diameter distributions of the blocks were similar prior to logging it seems apparent from table 7 that logging released residual trees less than 11.0 inches DBH. There are only 2.5 trees per acre ingrowth in the uncut block, but an average of 15.9 trees per acre in the cut blocks. Even with the reduced number of residual 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 sizable portion of the periodic basal area increment in the treated blocks is ingrowth. Although the average diameter of the uncut stand is not seriously affected by either ingrowth or mortality, the large number of small ingrowth trees in the treated blocks does reduce the average diameters in those blocks.

The trend that nearly all mortality is Douglas-fir and ingrowth is redwood will have an important influence on future managerial options on the species 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 growth over that of the uncut block. There was a slight drop in the 1979-84 period in the uncut stand as a result of one plot with a heavy loss. Periodic basal area growth (Table 8) was tested by analysis of variance (ANOVA) and the Student-Newman-Kuels (SNK) multiple range test (Zar, 1974). Since the original treatments were not assigned in a random manner it is not suitable to put much reliance on statistical comparisons, however, these tests are shown and discussed here to highlight some of the relationships that are shown in the data.

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

The ANOVA indicated no significant differences between the mean periodic basal area growth rates of treatments. This uniformity of growth occurred despite a statistically significant difference between the initial basal area stocking levels after logging. The SNK test indicates that only the initial basal areas of the light and heavy tree selection plots are not statistically different. Average initial basal areas of the tree selection treatments were only 31 square feet different (table 2). Uniform basal area growth over a wide range of stocking levels is not unexpected.

Basal area growth percentages (Table 8) express the average annual periodic increment as a percent of the stand basal area. Level of cutting has influenced growth percent; the uncut stand has the lowest and the heavy selection the highest growth percent. No block is producing even a two percent growth rate. The basal area increment at these ages is flat and the partial harvest did not result in a marked change. The increased growth percent is primarily 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 the other three treatment rates have peaked and are falling.

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 |
|---|---|---|---|---|
| (inches) | | (percent) | | |
| 10 | 5.8 | 5.0 | 0.6 | 0.0 |
| 15 | 19.1 | 9.2 | 13.6 | 5.3 |
| 20 | 36.8 | 33.0 | 32.2 | 22.8 |
| 25 | 56.1 | 48.6 | 58.5 | 41.0 |
| 30 | 74.9 | 74.9 | 80.3 | 71.0 |
| 35 | 91.4 | 96.0 | 94.4 | 92.2 |
| 40 | 96.2 | 98.6 | 98.8 | 97.3 |
| 45 | 100.0 | 100.0 | 99.3 | 98.9 |
| 50 | | | 100.0 | 99.8 |
| 55 | | | | 100.0 |

To see the effect of initial tree diameter size on basal area growth resulting from treatment, we look at how tree diameter classes have responded over the period. Average basal area of each initial diameter class is calculated for the five plots in each block. The 1984 basal area for the same set of trees 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; only survivor trees basal area growth is considered. Cumulative percent of survivor trees basal area growth by diameter class is shown in Table 9. Similar distribution of number of trees in the initial inventory data are 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 was reduction of the percentage of number of trees in diameter classes less than 30 inches; at the 35-inch class the percentages of all blocks are essentially the same. The pattern for periodic basal area growth of tree selection blocks is a shift towards a greater percentage of tha basal area growth in the smaller trees.

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

| Initial diameter | Light select | Heavy select | Group select | Uncut |
|---|---|---|---|---|
| (inches) | | (percent) | | |
| 10 | 6.8 | 0.6 | 0.8 | 8.0 |
| 15 | 30.5 | 20.2 | 29.7 | 25.5 |
| 20 | 49.3 | 37.5 | 54.3 | 54.1 |
| 25 | 73.6 | 60.5 | 77.4 | 76.6 |
| 30 | 88.1 | 81.6 | 90.4 | 89.7 |
| 35 | 96.6 | 97.1 | 97.3 | 97.0 |
| 40 | 97.9 | 99.0 | 98.9 | 98.0 |
| 45 | 100.0 | 100.0 | 99.5 | 99.7 |
| 50 | | | 100.0 | 99.7 |
| 55 | | | | 100.0 |

Table 10 shows that only heavy selection has a stem distribution much different than that of the uncut block. Cutting by group selection did not disrupt the diameter distribution. In the light selection, the trees taken covered the diameter range; this left a residual stand with fewer trees but distributed much like the uncut block.

Mortality and ingrowth can affect the distribution of growth and Table 10 shows the importance of initial diameter to the distribution of basal area growth. Basal area growth in the treated units now shows an average of 54.4 percent of growth in trees 25 inches or less while 41 percent of the uncut growth occurs in this segment of the stand.

The small diameter classes in the tree selection blocks show increased growth as compared to the uncut blocks. Reduced competition allowed residual small trees to respond with increased radial growth. There is an average basal area periodic ingrowth of 16.4 square feet versus the 2.1 square feet of the uncut block. For the greater than 20 inches stand strata, the basal area reduction 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 inches 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. The average diameter, computed from values in Table 2, shows 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 highly correlated to tree size, and the large trees in the cut and uncut blocks seem to grow at similar rates. 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 logged blocks.

## Volume Growth

Average board-foot volume yields show no abrupt trend shift over the 24-year period; there are nearly parallel trends (Figure 4). Logging reduced the stand volumes in the treated stands to the levels shown in Table 2. Analysis of variance and the SNK multiple range test of both cubic and board-foot initial volumes showed significant differences among blocks in both volume units. The SNK tests show that for both units the initial volumes of the light and heavy selection were not different. A similar test on the periodic growth rates revealed that there was a significant difference between the growth 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; in contrast this block also had the lowest percent growth rate. Board foot volume growth rate percent is generally higher than the basal area growth rate percent. Only the heavy selection block has a volume growth rate exceeding two percent.

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

Distribution of the board-foot volumes by diameter class of the initial inventory is shown in Table 12. The cumulative trends of the uncut and group selection are similar and the light and heavy tree selection are alike. Logging reduced the total volume percentage of smaller trees in the light and heavy selection when compared to the group and uncut blocks. Table 13 shows however, that the small diameter classes have responded in the selection areas as their cumulative growth percentage is larger than their cumulative initial volume. This trend is reversed in the uncut stand and indicates that the small trees are fading. As in the case of basal area, the harvesting has shifted volume growth toward smaller trees.

An objective of tree selection logging is to increase net yield by capturing mortality; making the net yield approach the gross yield. To consider this idea, the gross yield of the uncut block is compared with that of the treated stands. The uncut gross yield is the current yield plus the periodic mortality. Treated stands require mortality and harvest volumes to determine gross yield. Comparison of the initial stand values following treatment as reported by CDF and the five plot sample average indicates a close agreement of the two estimates (Table 14a). To adjust net to gross yield, the harvest volumes, reported as the full block average, must be added to the current study's five-plot average initial volume. We cannot determine the volume cut from the plots so the CDF values are the most reliable estimates available to determine gross yield. Comparing treated and uncut block gross yields in this way allows one to consider the value of the selection procedures (Table 14b).

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 14a. Number of trees per acre and basal area per acre reported by CDF compared to five sample plot values within each treatment unit.

| Block | Stems per acre CDF | Stems per acre 5-Plot | Basal area per acre CDF | Basal area per acre 5-Plot |
|---|---|---|---|---|
| | (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 |

Table 14b 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 |

Results indicate how the selection logged blocks responded as a percentage of the uncut control block. These percentages show the relative position of the yield prior to cutting, and then as the gross yield after logging and for the growth period. In all cases, the logged blocks now are a smaller percentage of the uncut uncut block volume after the growth period. In this test the board-foot gross yield of logged blocks does 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-aged management. The diameter distribution clearly shows the relative status of the different parts of the stand. With knowledge of radial growth, the tree distributions can be used to project future stand structures. It is of particular interest to consider the diameter distributions after logging and how they have changed as a result of growth. Treatment influence on regeneration of the desired species in the residual stands is another valuable use of the diameter distribution data. If partial logging provides a means to establishment of an uneven-aged stand structure, these trends should be apparent in the data.

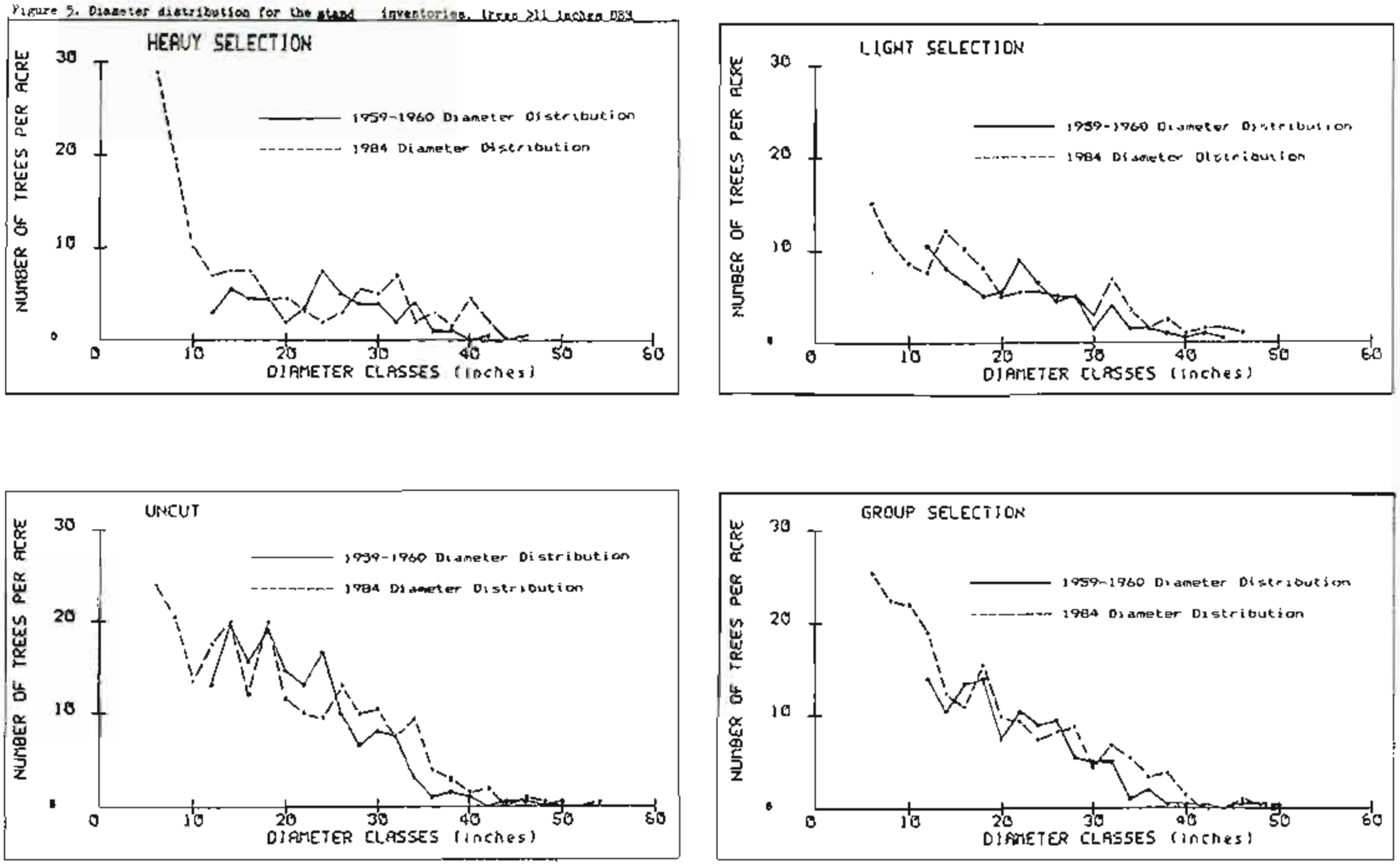
Two diameter distribution sets are examined in this report; the initial inventory of 1959-60 and the 1984 measurements. The initial CDF data were limited to trees over 11.0 inches DBH. For the 1984 measurement, all trees over 4.5 inches DBH were tallied, and terminal diameter distributions reflect this lower limit. Regeneration of conifers less than 4.5 inch DBH was sampled in 1984. These regeneration figures add further knowledge of the current stand structure. Distribution of the initial inventories of the 1959 group selection and 1960 remaining treatment blocks are shown in Table 15 and Figure 5. There was no information about the stand smaller than 11.0 inches and consequently this component is shown as ingrowth that entered over the growth period.

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 |

The typical shape of uneven-aged stands is referred to as an inverse "J", with the maximum numbers at the extreme left of the type curves shown in Figure 5. An example of the shape of the precut stand diameter distribution is the uncut block. Maximum number of trees of the uncut block are in the 15 to 20-inch range and the curve drops off to the left and right. This bell-shape is expected in stands as old as these 85-year-old stands. Suppression causes heavy losses in the small diameter trees, and few new trees are established. Group selection methods pick trees by area which does not change the distribution's shape but lowers it across the diameter range. Heavy tree selection also lowered the curve with the shape being similar to 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.

Figure 5. Diameter distribution for the stand inventories. Trees >11 inches DBH




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 are developing. Plot work done in 1984 made a distinction on new trees as to whether they were trees left after logging or newly established trees. Except in the group selection, few new trees exceed the 4.5-inch diameter limit. Most of the conifer regeneration was tallied by the regeneration sampling. These younger trees are smaller than 4.5 inches DBH 24 years after logging.

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 |

Successful uneven-aged management requires that each harvest entry begins an immediate regeneration process that maintain many small trees. Most young redwood stumps will sprout and provide an immediate recovery, but there has to be good light conditions for the stems to grow. Experience with 75 percent basal area leave plots in thinning studies at Whiskey Springs indicates that crown cover this heavy does not let sprouts develop. Open stands for satisfactory redwood and Douglas-fir growth are not compatible with the frequent light single tree cuts used in uneven-aged management. Results of the sampling of regeneration, smaller than 4.5 inches DBH, are summarized in Table 17.

Regeneration survey results indicate that there were many new stems established after logging. The almost complete absence of regeneration in the uncut block makes the case that logging has improved conditions for conifer regeneration. However, most 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. There are large number of conifers, but the low percentages of the desirable species in the tree selection blocks shifts the species mix to more grand fir and hemlock. After heavy tree selection, the most tolerant species still have an advantage. The most desirable 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 approximately one-third of the block area. Overall the group selection has a reasonable number of stems of redwood and Douglas-fir that appears to be in condition to restock the cut patches of the block.

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 | 120 | 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 " |

Better evaluation of movement toward an inverse J diameter distribution includes the list of regeneration shown in Table 18. This fills in the diameter distribution for the diameter classes smaller than 6.0 inches.

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 |

## Q-Ratio Evaluation

Interest in uneven-aged management for the mixed coastal redwood/fir stands has been held for a number of years. The CDF's 1962 report suggested that this should be investigated in the Cutting Trials. Conversion from even-aged to an uneven-aged stand structure requires repeated entry with regeneration occurring under the residual stand after each logging. It is not expected that a single cut will produce a good form of the inverse "J" diameter distribution, but this tendency should be apparent after 25 years. Diameter distributions developed after growth of the residuals, ingrowth, and regeneration show some sense of this trend. There are only two age classes in the stands, but the diameter distributions begin to have the appearance of an uneven-aged stand.

The 1984 tree selection diameter distributions do not have a consistent trend that can be described by a Q-ratio. 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 selection blocks caused a sharp rise in the smaller diameter classes. The Q-ratios tested did not create curves consistent with existing diameter distributions.

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 | 13.5 |
| 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 |

The group selection block, did not have a heavy influx of grand fir and hemlock regeneration. A Q-ratio of 1.20 with 0.6 trees in the 50-inch class created a curve that fitted 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 compared with the group selection's actual 1984 diameter distribution (Table 19).

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 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 be described by a Q ratio. Further entries are needed to see if additional redwood or Douglas-fir can be established in the tree selection blocks under the cover of the established understory of grand fir, hemlock and brush.

## Clearcut Block

During 1980-81 pre-commercial thinning was done in the new stand of the 14-acre clearcut block. Eighteen 0.4-acre plots in three replicated blocks of six plots were measured prior to thinning. Two replications were in the unburned part of the block and the third replication was in the portion where the logging slash was burned. The burned portion developed 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 and then damage to the young fir as the brush died and fell. In both the burned and unburned blocks, the redwood sprout clumps are the most important component of the developing stand. Douglas-fir has now been released and is beginning to show rapid height growth. It will assume an increasing percentage of the stand basal area. The vital statistics of the stand in Table 20 are an example of the regenerative potential of clearcut second growth.

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 | No.stms S.D. | B.area Ave. (sq.ft.) | B.area S.D. | Dia. (in.) | Trees >10.5"DBH No.stms Ave. | No.stms S.D. | B.area Ave. (sq.ft.) | B.area S.D. | Dia (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 |

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 inches 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 questions relevant to 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? Economic 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 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 follow parallel courses over the period. There are fluctuations over the period but the logged blocks have maintained nearly the same positions relative to the uncut block. Mean annual increment (MAI) from the yields of Table 2 indicates that all blocks are increasing, but the cut blocks at a greater rate than the uncut block. During 1979-84 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. The removal of 29 percent of the original basal area still allows the PAG of the group selection to be 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 percentages of Table 7 do not indicate that basal area reduction has a corresponding influence on volume growth. There is an increase in percent volume growth with increase in the cut but at best there is less than a 1 percent increase in growth percentage between the uncut and heavy tree selection. Periodic board-foot growth remains high after logging, but the percent growth 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 important. This failure may hinge on the age of the stands when the logged. Selection logging to improve the growth response is too late when the stands are beyond 80 years. Mortality is heavy in the uncut block, but nearly all dead trees were small and of little economic value. Logging solely to capture their volume would be of marginal value. More serious economic losses of large trees occurred in the treated blocks. Losses affect the gross stand yield and it appears that losses in the treated blocks have more serious economic impacts.

## Regeneration

The heart of a silvicultural system related to logging has to deal with the response of desired species to renew the stand (Chapman, 1950). Emphasis in selection logging systems relates to the release of residual trees after cutting and improvement of the stand growth percent. The lack of the desired species regeneration cannot be ignored however. 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 judgments on the adequacy of the regeneration under the residual stands. Tables 16, 17 and 18 show the diameter distributions by various species and size. Table 18 shows the small diameters of the tree selection blocks to be well stocked. Redwood or Douglas-fir regeneration taller than 4.5 feet are only 7.5 percent in the light selection; in 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 are not growing well. Some redwood sprout clumps, grand fir, hemlock and brush have taken the space in the tree selection blocks.

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

## Diameter Distributions

Despite the 25 year growth period there is only limited movement toward an uneven-aged stand diameter structure. This system requires more than a single cut for this shape to become evident. Stands 85 years old are perhaps past the time when small suppressed residual trees have the vigor to release to create the typical inverse J-curve. In the single tree selection plots, few stems of the regeneration exceeded the 5-inch diameter class. Diameter distribution of the group selection plots is more typical of the shape desired in an uneven-aged management system. This may result from better regeneration growth in parts that were clearcut. Young redwood sprouts and Douglas-fir have radial growth rates more like that of the clearcut block. Group cutting creates sufficient space for regeneration that grows at a rate to create the smooth inverse J-curve.

Tree marking used in this study has 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 thinning from below, taking poor growth, high risk trees. Removal of small trees is shown by an increased average diameter of the residual stand over that of the precut stand. Logging did not remove stems that accounted for the bulk of the volume growth. A typical uneven-aged selection mark would concentrate the cut in the largest trees, removing those which are economically mature. Until another entry is done, one should not expect 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 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 those tested. I cannot recommend that the State continue this form of partial logging to create uneven-aged stands for its commercial operations. When objections to clear cutting made on environmental or political considerations are important, then the small group selection system seems a better alternative. The small groups permit better regeneration rates and maintain good overstory growth, while still fostering an uneven-aged regime.

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

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

Light selection: A 20-year cycle with cuts in 1980, 2000 and 2020 to remove the original stand.

Heavy selection: Two additional entries in a 27-year cycle that completely removes the original stand.

These additional entries would allow the State to look at problems of logging damage to advance regeneration in uneven-aged management. The investment of time and effort into this study warrants its continuation as it provides a prolonged investigation of the problems of partial logging.

## LITERATURE CITED


Chapman, H. H. 1950. Forest management. The Hildreth Press. Bristol, Conn.

Krumland, B. and L. Wensel. 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, CA

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

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

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

Zar, J. H. 1974. Biostatistical analysis. Prentice-Hall, Englewood Cliffs, New Jersey. 620 pp.

CALIFORNIA DEPARTMENT OF FORESTRY
AND FIRE PROTECTION
1416 NINTH STREET
P. O. BOX 944246
SACRAMENTO, CA 94244-2460

TO: