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Levels-of-Growing-Stock Cooperative Study in Douglas-Fir: Report No 13--The Francis Study: 1963-90

Gerald E. Hoyer, Norman A. Andersen, and David Marshall

Levels-of-growing-stock study treatment schedule, showing percent of gross basal area increment of control plot retained in growing stock. All trees were retained on the western hemlock (WH) supplemental control plots.

	Basic LOGS treatments									Supplemental treatment (late thinning)				WH
	Fixed				Increasing/decreasing									
	1	3	5	7	2	4	6	8	C	L1	L3	L5	L7	WHC
	Percent													
First	10	30	50	70	10	30	50	70	100	—	—	—	—	—
Second	10	30	50	70	20	40	40	60	100	—	—	—		—
Third	10	30	50	70	30	50	30	50	100	10	30	50	70	All
Fourth	10	30	50	70	40	60	20	40	100	10	30	50	70	All
Fifth	10	30	50	70	50	70	10	30	100	10	30	50	70	All

Background

Public and private agencies are cooperating in a study of eight thinning regimes in young Douglas-fir stands. Regimes differ in the amount of basal area allowed to accrue in growing stock at each successive thinning. All regimes start with a common level of growing stock established by an initial calibration thinning.

Thinning interval is controlled by height growth of crop trees, and a single type of thinning is prescribed.

Nine study areas, each involving three completely random replications of each thinning regime and an unthinned control, have been established in western Oregon and Washington, U.S.A., and Vancouver Island, British Columbia, Canada. Site quality of these areas varies from I through IV.

This is a progress report on this cooperative study.

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Levels-of-Growing-Stock Cooperative Study in Douglas-Fir:

Report No. 13—The Francis Study: 1963-90

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Abstract

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Results of the Francis installation of the levels-of-growing-stock study in Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco), begun at stand age 15, are summarized together with results from additional first-thinning treatments started at age 25. To age 42 (5 years beyond the last planned thinning), total cubic-foot volume growth on this mid-site II Douglas-fir plantation has been strongly related to level of growing stock. Growth of lower levels of growing stock exceeded that of the control for only a brief period at age 30. Selection of a “best” treatment would depend on the unit of measure used: yield in total cubic-foot volume, merchantable cubic-foot volume, board-foot volume or dollar value. Close dollar values among several alternatives suggest that diverse stand structure objectives can be attained at age 42 with little difference in wood product-value per acre. General silvicultural prescriptions could be written to achieve the results of any of the treatments on similar sites.

Keywords: Thinning, growing stock, growth and yield, stand density, Douglas-fir, *Pseudotsuga menziesii*, series—Douglas-fir LOGS.

Summary

The levels-of-growing-stock studies in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), were designed to test the influence of treatment regimes by using a wide range of retained growing stock on the development of forest growth, yield, and stand structure. Results of the Francis installation located in the headwaters of the Willapa River in Pacific County, Washington, are summarized from calibration at age 15 through age 42 (completion of 60 feet of height growth from calibration, and the planned course of the experimental thinnings plus 5 years). In addition to the eight basic treatments and control common to the other eight study installations in the region, five additional treatments were added at Francis; four late first thinnings (at age 25), which matched the level of growing stock of four standard fixed treatments, and an unthinned western hemlock (*Tsuga heterophylla* (Raf.) Sarg.). Estimated Douglas-fir site index (50-year base) of this plantation is 124, a mid-site II.

Contrary to expectations when the study was started, cubic-foot volume growth was strongly related to level of growing stock for both the early and late thinning treatments. Basal area growth of thinned treatments was directly related to level of growing stock; however, basal area growth of the control was often less than that of treatments. Basal area growth culminated before age 25.

Different growing stock levels produced marked differences in tree size distributions and crown dimensions. Early relatively heavy thinning followed by successive thinnings at increasing levels of growing stock produced the most trees 16 inches in diameter and larger. It is possible to write general silvicultural prescriptions that would grow the relative diameter class distributions of any of the study treatments.

Periodic annual growth in cubic feet at age 42 is up to two times mean annual increment; the stand is far from culmination of volume increment. Results of the basic treatments generally are comparable to those reported from other installations in the study that are on comparable sites.

There is a substantial tradeoff among increased individual tree size, value, and total cubic-foot volume production. The cumulative net cubic-foot yield of the unthinned control at age 42 was greater than the total yield of any of the thinning treatments. The live volume of the unthinned western hemlock at age 42 exceeded the cumulative net yield of the Douglas-fir control by 11 percent.

Cumulative net yield in terms of board feet, a common merchandising unit of measure, was higher for several treatments than for the unthinned control. Increased board-foot volume and relatively higher value for larger log sizes translate directly into greater dollar value at age 42 for some thinned treatments. A middle level of stocking for late first-thinning treatments had the highest dollar value because they retained enough growing stock for reasonable volume growth while producing increased diameters and a substantial early dollar return.

Growth of late first-thinning treatments was about 10 percent less in cubic-foot and 17 percent less in board-foot volume than growth of matched early thinnings growing at the same level of basal area growing stock.

Early thinning treatments produced accelerated growth compared to control between ages 29 and 33 years. At 60 to 70 percent of basal area growing stock of control, basal area growth increased to 116 percent of control growth: cubic-foot volume growth increased to 109 percent of control.

The 12 treatments and 2 controls in the Francis study portray a wide range of stand development alternatives. Some of the treatments have stem distributions and understory attributes desirable for wildlife needs. The closely similar estimated dollar values across many of the alternatives suggest that carefully applied silvicultural prescriptions might meet some wildlife needs at little or no loss of wood product value per acre to the forest owner.

The final answer about ultimate worth of the study treatment alternatives in terms of stand structure, wood products, or dollar value is not yet clear. Growth is still high. There has not yet been a major wave of mortality in the controls. Trees on treatments with lower levels of growing stock are now beginning to grow into log sizes that produce major increases in product value. There is still much to be learned from continuing this study into older stand ages.

Other LOGS (Levels-of-Growing-Stock) Reports

Williamson, Richard L.; Staebler, George R. 1965. A cooperative level-of-growing-stock study in Douglas-fir. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

Describes purpose and scope of a cooperative study investigating the relative merits of eight different thinning regimes. Main features of six study areas installed since 1961 in young stands also are summarized.

Williamson, Richard L.; Staebler, George R. 1971. Levels-of-growing-stock cooperative study on Douglas-fir: report no. 1—description of study and existing study areas. Res. Pap. PNW-111. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 12 p.

Thinning regimes in young Douglas-fir stands are described. Some characteristics of individual study areas established by cooperating public and private agencies are discussed.

Bell, John F.; Berg, Alan B. 1972. Levels-of-growing stock cooperative study on Douglas-fir: report no. 2—the Hoskins study, 1963-70. Res. Pap. PNW-130. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 19 p.

A calibration thinning and the first treatment thinning in a 20-year-old Douglas-fir stand at Hoskins, Oregon, are described. Growth for the first 7 years after thinning was greater than expected.

Diggle, P.K. 1972. The levels-of-growing-stock cooperative study in Douglas-fir in British Columbia (report no. 3, cooperative L.O.G.S. study series). Inf. Rep. BC-X-66. Victoria, BC: Canadian Forestry Service, Pacific Forest Research Centre. 46 p.

Describes the establishment and installation of the two LOGS studies established on Vancouver Island at Shawnigan Lake and Sayward Forest.

Williamson, Richard L. 1976. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 4—Rocky Brook, Stampede Creek, and Iron Creek. Res. Pap. PNW-210. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 39 p.

The USDA Forest Service maintains three of nine installations in a regional, cooperative study of influences of levels of growing stock (LOGS) on stand growth. The effects of calibration thinnings are described for the three areas. Results of first treatment thinning are described for one area.

Berg, Alan B.; Bell, John F. 1979. Levels-of-growing-stock cooperative study on Douglas-fir: report no. 5—the Hoskins study, 1963-75. Res. Pap. PNW-257. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 29 p.

Growth data are presented for the first 12 years of management of young Douglas-fir growing at eight levels of growing stock. The second and third treatment periods are described.

Young Douglas-fir stands transfer growth from many to few trees. Some of the treatments have the potential to equal the gross cubic-foot volume of the controls during the next treatment periods.

Arnott, J.T.; Beddows, D. 1981. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 6—Sayward Forest, Shawnigan Lake, Inf. Rep. BC-X-223. Victoria, BC: Canadian Forestry Service, Pacific Forest Research Centre. 54 p.

Data are presented for the first 8 and 6 years at Sayward Forest and Shawnigan Lake, respectively. The effects of the calibration thinnings are described for these two installations on Vancouver Island, British Columbia. Results of the first treatment thinning at Sayward Forest for a 4-year response period also are included.

Williamson, Richard L.; Curtis, Robert O. 1984. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 7—Preliminary results; Stampede Creek, and some comparisons with Iron Creek and Hoskins. Res. Pap. PNW-323. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 42 p.

Results of the Stampede Creek LOGS study in southwest Oregon are summarized through the first treatment period, and results are compared with two more advanced LOGS studies and are generally similar.

Curtis, Robert O.; Marshall, David D. 1986. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 8—the LOGS study: twenty-year results, Res. Pap. PNW-356. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 113 p.

Reviews history and status of LOGS study and provides new analyses of data, primarily from the site II installations. Growth is strongly related to growing stock. Thinning treatments have produced marked differences in volume distribution by tree size. At the fourth treatment period, current annual increment is still about double mean annual increment. Differences among treatments are increasing rapidly. There are considerable differences in productivity among installations, beyond those accounted for by site differences. The LOGS study design is evaluated.

Curtis, Robert O. 1987. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 9—some comparisons of DFSIM estimates with growth in the levels-of-growing-stock study. Res. Pap. PNW-RP-376. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 34 p.

Initial stand statistics for the Logs study installations were projected by the DFSIM simulation program over the available periods of observation. Estimates were compared with observed volume and basal area growth, diameter change, and mortality. Overall agreement was reasonably good, although results indicate some biases and a need for revisions in the DFSIM program.

Marshall, David D.; Bell, John F.; Tappeiner, John C. 1992. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 10—the Hoskins study, 1963-83. Res. Pap. PNW-RP-448. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 65 p.

Results of the Hoskins study are summarized through the fifth and final planned treatment period. To age 40, thinnings in this low site I stand resulted in large increases in diameter growth with reductions in basal area and cubic volume growth and yield. Growth was strongly related to level of growing stock. All treatments are still far from culmination of mean annual increment in cubic feet.

Curtis, Robert O. 1992. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 11—Stampede Creek: a 20-year progress report. Res. Pap. PNW-RP-442. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 47 p.

Results of the first 20 years of the Stampede Creek study in southwest Oregon are summarized. To age 53, growth in this site III Douglas-fir stand has been strongly related to level of growing stock. Marked differences in volume distribution by tree sizes are developing as a result of thinning. Periodic annual increment is about twice mean annual increment in all treatments, indicating that the stand is still far from culmination.

Curtis, Robert O. 1994. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 12—the Iron Creek study: 1966-89. Res. Pap. PNW-475. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 67 p.

Results of the Iron Creek study in the Gifford Pinchot National Forest, southern Washington, are summarized through age 42 (completion of the 60 feet of height growth comprising the planned course of the experiment). Volume growth of this mid-site II plantation has been strongly related to growing stock; basal area growth much less so. Different growing-stock levels have produced marked differences in the size distribution and in crown dimension. Periodic annual volume increment at age 42 is two to three times mean annual increment in all treatments.

Contents

Introduction

The Francis levels-of-growing-stock (LOGS) installation is one of nine installations in a regional thinning study established in young even-aged Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands according to a common work plan (Williamson and Staebler 1971). Figure 1 shows the location of the nine installations. The LOGS study is a cooperative effort involving Canadian Forest Service, Natural Resources Canada, Oregon State University, USDA Forest Service, Washington State Department of Natural Resources, and Weyerhaueser Company. The overall objective of the studies is to compare the growth to growing-stock relation, cumulative wood production, and tree-size development under eight different thinning regimes begun before the onset of severe competition.

Detailed progress reports on individual installations are contained in the series of LOGS publications listed at the beginning of this report. Curtis and Marshall (1986) summarize results for the first 20 years. Since then, several of the higher site installations, of which Francis is one, have completed the full course of the experiment as originally planned.

The LOGS cooperative studies evolved from work in the late 1950s by George Staebler. Staebler (1959, 1960) argued that by thinning to reduce the amount of growing stock, increment could be transferred to the remaining faster growing trees while largely eliminating mortality losses. He also recognized that the implied assumption of near-constant gross increment over a wide range of stocking had not been tested for young Douglas-fir. The objectives of the LOGS studies, as stated in the 1962 plan, were "to determine how the amount of growing stock, including fixed,

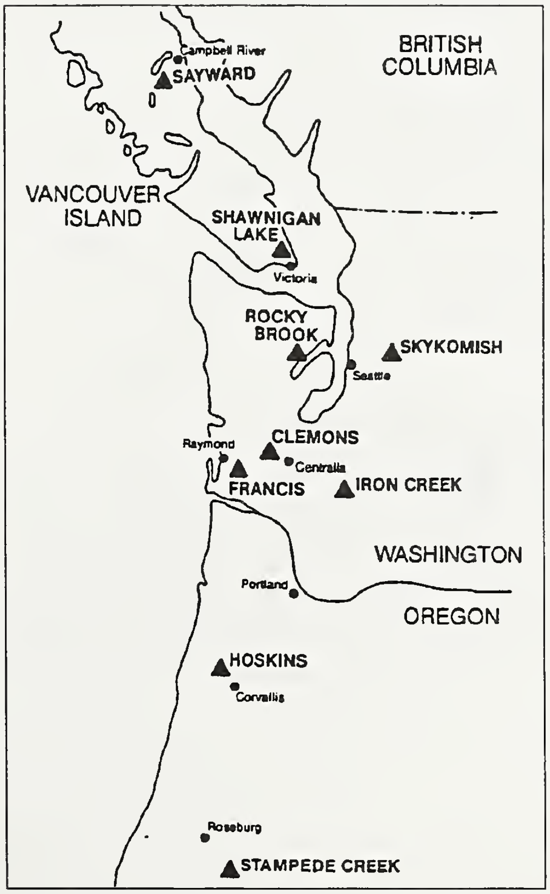


Figure 1a—Location of levels-of-growing-stock study installations.

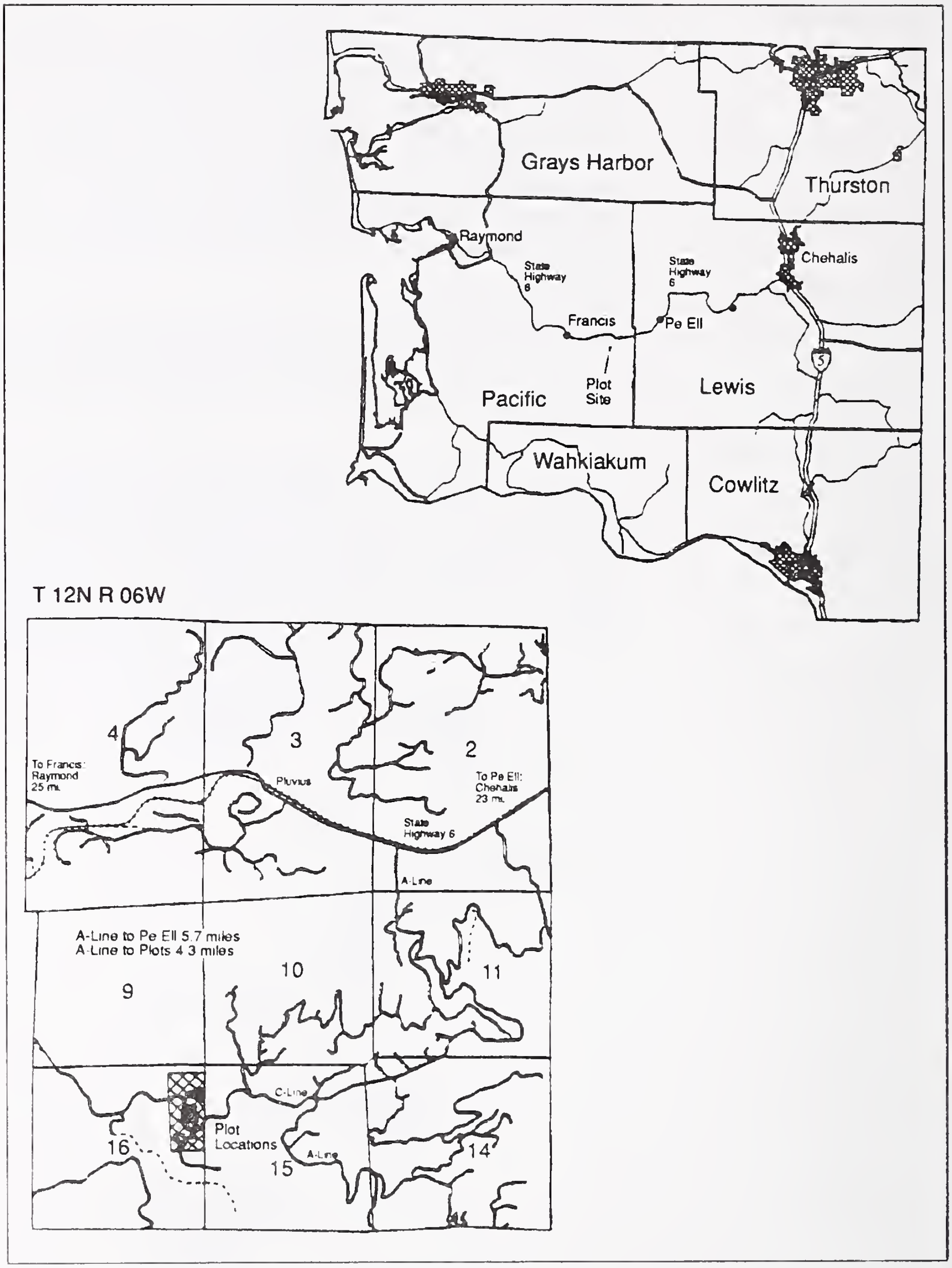


Figure 1b—Vicinity maps of the Francis Study.

increasing, and decreasing levels, retained in repeatedly thinned stands of Douglas-fir affects cumulative wood production, tree size, and growth-growing stock ratios." Treatments were designed to include a wide range of growing stock including fixed, increasing, and decreasing levels so that the results would show "how to produce any combination of factors deemed optimum from a management standpoint." The study was not designed as a test of specific operational thinning regimes but was intended to quantify growth and growing stock relations for a closely controlled initial stand condition and kind of thinning.

First control of growing stock began as "early" thinnings at about the time of initial crown closure. Supplemental treatments unique to the Francis installation add to the original study initial "late" thinnings at age 25 (after stand competition was well underway). The growing stock levels of four late-thinning treatments were the same as the four fixed-level "early" thinning treatments.

The purposes of this report are to (1) provide complete background details of the Francis installation, (2) document the quantitative results obtained through the fifth treatment thinning at total stand age of 33 years and the subsequent growth period to age 42, and (3) present and discuss the implications of results.

Methods

Description of Study Area

The Francis study was installed in fall 1963. The study area is on the westerly slope of the Willapa Hills at an elevation of about 1,300 feet in the western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) coastal forest zone. The plots are on a north through westerly aspect. Slope ranges from level to 20 percent. A systematic examination of the understory vegetation on the study plots in 1992 defined the plant association as Tshe/Pomu/Oxor as characterized by Henderson and others (1989). The study plots averaged site index 124 (King 1966) as of 1981 and averaged about 900 stems per acre before calibration treatment.

The soil on the study area is a deep, well-drained silt loam (Boistfort series) found on nearly level to moderately steep terraces of the elevated uplands of the coastal range of western Washington. It has formed on basalt and developed in a mild, wet coastal climate. A representative profile of the soil has 2.0 inches organic layer of litter and duff. The soil surface layer is 0 to 12 inches, dark reddish brown silt loam; weak medium granular structure; friable when moist, slightly sticky and plastic when wet; and very strongly acid. The subsoil, 12 to 44 inches, is a dark-brown silt loam with moderately fine subangular blocky structure; friable when moist, sticky and plastic when wet; and strongly acid.

The forest was planted to about 600 trees per acre in fall 1947 with 2-0 planting stock from a known local seed source. The larger trees used as site index samples averaged 8 years at breast height when the study was installed after the 1963 growing season. Based on the planting date, the stand was 18 years total age at study installation. Applying the conventional conversion value of 7 years to grow to breast height on site II, however, gives a total age of 15 years, comparable to the age estimates used in other installations. The latter method of counting age was used in the data summaries in this report. Adjacent natural western hemlock stands are 1 year younger than the plantation Douglas-fir.

Experimental Design

The experiment is a completely randomized design having three replications of eight thinning treatments, plus control. The 27 plots are one-fifth acre in area. Plot shape varies from a square to a 66- by 132-foot rectangle. Two are trapezoids. We used the various plot shapes to fit the 27 plots into a limited area of uniform initial stocking. There was no buffer on interior plots, but there were 30-foot isolation strips around the outer margins of the experimental area. Ground arrangement of the plots is shown in figure 2.

Stand Treatments

Treatments were rigidly controlled to provide compatibility among installations on different sites.

Crop trees were selected at the rate of 16 per plot (80 per acre), distributed to provide 4 well-spaced crop trees in each quarter of a plot. Crop trees were identified with bands of white paint.

An initial calibration thinning was made on the 24 plots assigned to thinning treatments, designed to reduce all to as nearly comparable a condition as possible. All trees less than one-half the initial stand quadratic mean diameter (QMD) were cut. Additional noncrop trees were cut as needed to meet the study plan specifications, which called for the stand to be thinned to 405 trees per acre. Control plots ranged from 685 to 1,110 trees per acre, averaging 888. Of the total, 610 were planted Douglas-fir: 278 were natural western hemlock fill-in to the plantation.

The target number of trees for thinned plots was derived from the equation,

$$S = 0.6167 * QMD + 8 ,$$

where

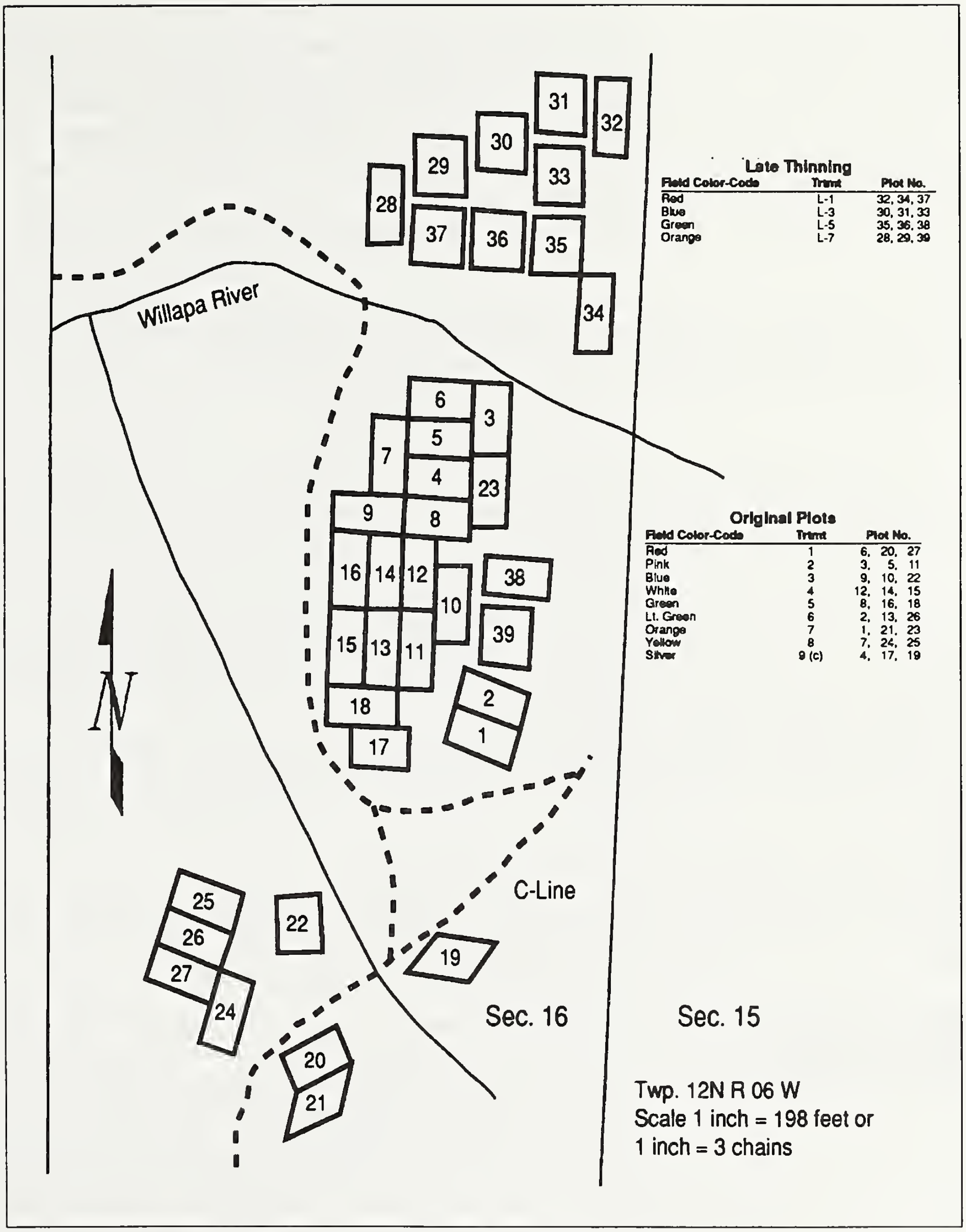
S = average spacing in feet, and

QMD = quadratic mean diameter of the leave trees.

Number of trees per acre was calculated by assuming average square spacing. Trial plots with number of trees per acre deviating more than 15 percent from the average of all (untreated) plots were not used. After the calibration thinning, the number of trees on the treatment plots was identical. Level of basal area varied somewhat between 21 and 36 square feet on the treated plots and between 38 and 65 square feet on controls. This range of basal area was somewhat wider than that specified on some of the other installations in the LOGS study where trees were larger at establishment. In those installations, controlling criteria were specified in terms of similar levels of basal area by plot, and number of trees was allowed to vary. The impact of this variation in beginning basal area at Francis was evident through the first treatment period where five plots in treatments seven and eight remained unthinned because their basal area levels were less than the specified target levels. This also affected the ratio of tree sizes cut during first thinnings on some plots.

All leave trees on thinned plots were identified with permanent numbered tags. Trees 1.6 inches in diameter at breast height (d.b.h.) and larger were tagged on the control plots. All trees were pruned to about 6 feet aboveground (or in the case of small trees, no higher than one-half of live crown) to facilitate the measurement process.

After the calibration thinning in 1963, treatment thinnings were made in 1966, 1969, 1973, 1977, and 1981 (ages 18, 21, 25, 29, and 33, respectively), which corresponded to approximate 10-foot increments in crop tree heights.



Late Thinning

Field Color-Code	Trtmt	Plot No.
Red	L-1	32, 34, 37
Blue	L-3	30, 31, 33
Green	L-5	35, 36, 38
Orange	L-7	28, 29, 39

Original Plots

Field Color-Code	Trtmt	Plot No.
Red	1	6, 20, 27
Pink	2	3, 5, 11
Blue	3	9, 10, 22
White	4	12, 14, 15
Green	5	8, 16, 18
Lt. Green	6	2, 13, 26
Orange	7	1, 21, 23
Yellow	8	7, 24, 25
Silver	9 (c)	4, 17, 19

Figure 2—Arrangement of plots in the Francis levels-of-growing-stock installation.

Thinning treatments were defined in terms of the percentage of periodic basal area growth retained as growing stock relative to the average gross periodic basal area growth on the unthinned control plots. See inside front cover; also appendix 1. Three general patterns were included: fixed levels of growing stock retained over time, increasing levels, and decreasing levels. (Treatment 1 at fixed level 10 retained 10 percent of the gross periodic basal area growth; treatment 3 at level 30 retained 30 percent, and so forth).

Kind of thinning was further specified by the requirements that:

1. No crop trees were to be cut until all noncrop trees had been removed.

2. Average quadratic mean diameter of trees removed in thinning should approximate the average diameter of trees available for thinning (that is, noncrop trees) until all noncrop trees have been removed.

3. Trees removed in thinning were to be distributed across the range of diameters of the trees available for thinning.

In conventional practice, mean diameter of trees removed in thinning (d) are compared with the mean diameter of all trees before thinning (D) by using the ratio d/D. The d/D ratios were calculated for each treatment at the five periodic thinnings. The d/D ratios ranged from 0.91 to 1.01 in 18 of 20 thinnings applied to the four fixed-treatment levels. The two earliest thinnings in treatment 1 were at d/D of 0.31 and 0.63, both a direct result of the need to allow the basal area of the plots to reach the threshold level defined by control. The pattern was similar in the increasing and decreasing treatments with 2 thinnings out of 20 at d/D 0.31 and 0.62, and for the same reason.

Jorgensen (1957) interprets the meaning of the d/D ratio as follows, based on a background of European experience:

d/D = 0.65 and under: Improvement cutting or "cleaning."

= 0.65 - 0.75: Low thinning.

= 0.75 - 0.90: Severe low thinning to light crown thinning.

= 0.90 - 1.00: Severe crown thinning.

= over 1.00: Selection thinning.

Study Supplement, Late First Thinning, and Western Hemlock

The basic LOGS study examined stand development after thinning at a relatively early age, 15 years total age in 1963. A common alternative practice begins thinning at a later age. We supplemented the basic study in 1973 by installing 12 one-fifth acre plots in the adjacent untreated plantation when the stand was 25 years old. We refer to this as "late" first thinnings. Except for one item noted below, all criteria used to treat the late thinning were identical with the ongoing treatments applied to the treatments in the basic study. The 12 plots had basal area per acre within the range of the average basal area that the three control plots of the basic study had attained by age 25. We randomly assigned three plots per each of four treatments and thinned to the four levels of basal area equal to the averages of treatments 1, 3, 5, and 7 of the basic study as of age 25. Supplemental (late) treatment L1 retained the same amount of basal area as treatment 1, L3 as treatment 3, L5 as treatment 5, and L7 as treatment 7. At each subsequent treatment of the basic study, the amount of basal area retained on each late thinning was the same, within specific tolerance limits, as its matched fixed treatment thinning in the basic study.

Special limitations defined trees to be left after the first late thinning. To keep tree size consistent between plots, we specified that the average plot d.b.h. after thinning would be 7.0 inches, the same as the average crop tree diameter on the three basic control plots. With basal area held the same between matched treatments of the two studies and with d.b.h. specified, the number of stems per acre varied. These requirements ensured consistency for the subsequent comparison but are contrary to usual thinning selection. Routine thinning would retain fewer trees with larger diameters. Selected crop trees on the newly established plots averaged 8.4 inches in diameter. The d/D ratio for the late thinnings ranged between 0.77 and 0.95.

In 1973 we also installed six one-tenth acre plots in the western hemlock stand located outside the clearly defined edge of the original Douglas-fir plantation. The western hemlock plots provide a comparison of the productivity of naturally regenerated western hemlock with the planted Douglas-fir. The unthinned western hemlock control plots (WHC) are compared to the study plots.

The presence of unthinned western hemlock control plots or treatments (WHC) together with the original Douglas-fir control plots (treatment 9) might lead to some descriptive confusion in the text. To avoid this possibility, the expression "Douglas-fir control" is used. This full expression is abbreviated in figures as T-9C (treatment 9, control) and should be understood to apply to the Douglas-fir control treatment.

Data Collection and Summarization

Immediately after the calibration thinning, and at all subsequent measurement dates, diameters of all tagged trees were measured to the nearest 0.1 inch. Ingrowth was tagged and measured on the control plots only. Heights were measured on a sample of the subject trees; sample size varied but was not less than eight Douglas-fir trees per plot distributed across the range of diameters. Of this sample, four to six of the largest diameter Douglas-fir trees had breast-height age determined. These trees provided a period-by-period field estimate of site index (King 1966) and height of the 40 largest trees per acre.

There was a component of western hemlock trees on the Francis study plots. Six (6) to twenty-five (25) percent of the basal area of the plots was hemlock at the start of the study. When other criteria permitted, we removed hemlock in thinning. Height and age were measured on a token number of hemlock trees on plots where hemlock was common. Site index for western hemlock uses Wiley (1978).

Constrained height-diameter curves were fitted to each measurement on each plot using an adaptation[1] of the procedure of Hyink and others (1988). Smoothed heights assigned from the curves were the basis for defining the missing tree heights and also for an alternative estimate of height-40 by plot and treatment. Tree volumes in total cubic feet inside bark (CVTS) were calculated for Douglas-fir by the Bruce and DeMars (1974) equation, using actual measured heights when available and heights predicted by the Clendenen equations for trees not having measured heights.

A parallel procedure using an equation by Wiley and others (1978) produced volumes for the unthinned western hemlock plots.

[1] Developed by Gary W. Clendenen and David D. Marshall.

With CVTS estimated for each tree, merchantable cubic-foot and board-foot volumes were estimated, using equations given by Brackett (1973). The board-foot unit is used in the Pacific Northwest for marketing logs and is a convenient basis for estimating tree value. The Scribner log rule formula version is used to determine board feet in terms of nominal 16-foot log lengths to a 6-inch top diameter, (Brackett 1973) and scale-book version is used for board feet in terms of 32-foot-long logs to a 4-inch top diameter (Northwest Log Rules Advisory Group 1982).

Relative Density

Relative density measures are useful in describing thinning regimes, as guides for density control, as values interpretable as measures of competition, and as predictors of growth.

The measure of relative density (RD) used here is defined as follows (Curtis 1982),

$$RD = (\text{basal area}) / \text{square root } (\text{quadratic mean diameter}),$$

which is very nearly proportional to Reineke's (1933) stand density index.

All ingrowth trees that began life after thinning in the main stand canopy were removed from the thinned plots. There are therefore no understory tree components to add numbers of small trees and influence mean diameter and RD. Some ingrowth trees were added on control plots when existing small trees finally exceeded the minimum diameter threshold.

Tree and Log Diameter

Usefulness of trees for commodity and other purposes and the relative values assigned depend on tree d.b.h. Diameter is the basis for an estimate of tree value. The following are tree diameter classifications appropriate to standard local log product sizes, a basis for later evaluations:

Trees less than 5.6 inches (2-5-inch classes)—seedlings and saplings, often with no wood value; frequently of value as understory for wildlife.

Trees 5.6 to 9.5 inches (6-9-inch classes)—often referred to as "pulp grade," even though sawn products are often produced.

Trees 9.6 to 15.5 inches (10-15-inch classes)—small saw logs.

Trees 15.6 to 21.5 inches (16-21-inch classes)—large saw logs.

Trees 21.6 inches and larger (22-inch and larger classes)—peelable sizes.

Trees 20 inches and larger meet the minimum requirements for wildlife needs as a source of a continuing supply of dead snags and large woody debris.

Dollar Value Estimates of Treatment Results

The dollar value of treatment results (final net value of all costs and returns, with interest, plus value of current stands at age 42) was estimated to provide a basis for interpreting the practical worth of treatments. Differences in final net value between treatments were expected to be great enough that graphic comparisons would aid evaluation of treatment results to date.

A first step for estimating value was to subdivide total tree volume into volumes by logs. This requires knowing the form or taper of each tree bole. Log diameters of the upper tree stems were estimated from the known tree d.b.h. and CVTS of each tree. An iterative process using a form factor equation assigned upper stem diameters at nominal log lengths so that the sum of the cubic-foot volume of the logs with assigned diameters was equal to the known total tree cubic-foot volume (Turnbull 1970). With log volumes and diameters known, standard log grades were assigned (Northwest Log Rules Advisory Group 1982). Standard log grades consider number of rings per inch, knot size, and log diameter. Log diameter was the most meaningful characteristic in this application.

Tree dollar value was assessed at two steps of commodity production: as logs before removal (stumpage) and the same logs as cut, removed, and delivered to market. (Both stumpage and delivered value—on a per acre basis—were examined as final net values to determine if the assumed costs that were assigned had any effect on the value of different treatments.) Stumpage prices for each log grade differ from delivered prices according to assumed logging costs. Some logging costs such as hauling distance were estimated per thousand board feet. Others were assessed per thousand board feet and on a log-size basis. More board feet per log gave a value advantage to larger logs. The assigned costs were part of routine thinning cost assessment procedures used for timber sales preparation (Chambers and Smego 1983).

Dollar value for each grade was assigned based on long-term moving average log selling prices for western Washington collected and used by State Department of Natural Resources economists (Chambers and Smego 1983, and updated through 1990).

Net dollar value of thinnings both as stumpage and delivered logs was carried at compound interest from age of thinning and added to the value at age 42, and the sum of values for treatments were compared. The effect of a range of interest rates from 4 to 7 percent was examined.

Costs of planting and planting stock also were included in the analysis. The thinning cost and wood value from the calibration thinning were not included in analysis for reasons discussed later. All costs and values used were current as of 1992. Using 1992 dollars for all years removes the considerable influence of inflating dollars as a factor when interpreting the relative worth of treatments carried out over an extended number of years.

Crown Measurements

At plot establishment, all trees were pruned to breast height to facilitate tagging and measurement. By age 25, tree crowns had lifted above breast height, and height to the base of the live crown and crown width were measured on the 9 or 10 trees of selected diameter representing the volume distribution of the trees on the late-thinned treatments. Similar measurements were made on trees in the fixed treatments at age 27. The height to the base of live crown was defined as the height aboveground where at least two live limbs occurred on a whorl at right angles to each other. Crown width was the average of two measurements taken at right angles on the ground beneath the vertically projected edge of crown. In 1992 (stand age 44), we measured crowns on the four largest diameter trees in each plot of the main LOGS treatments and determined base to live crown and crown width.

Analysis

The original study plan specified analysis of variance as the method of analysis. Many aspects of the experiment, however, are more meaningfully presented and interpreted through simple graphic comparisons of means. Analysis of variance follows the procedure used in previous LOGS reports (Curtis and Marshal 1986, Marshall and others 1992) and applies only to plots in the original ("early thinning") portion of the Francis study. This is a repeated-measures experiment computationally similar to a split-plot design (Snedecor and Cochran 1967), in which the periodic remeasurements correspond to subplots. Computations were done with the GLM procedure of SAS (SAS Institute, Inc. 1985) by using as successive response variables periodic annual gross increment in cubic volume and corresponding growth percentage; periodic annual gross increment in basal area and corresponding growth percentage; and periodic annual net increment in quadratic mean diameter.

Results

The Francis plots and others in the cooperative study provide a unique pool of treated stand-growth data for Douglas-fir in the Pacific Northwest. Since the beginning of the study, the plots have contributed along with other studies and permanent sample plots to estimates of Douglas-fir growth and yield (Curtis and others 1981, Hoyer 1975).

Analysis of Variance

The analysis of variance is presented in tables 1 and 2 and applies only to plots in the original study design. Differences among treatments were significant, as expected. The seven degrees of freedom were broken into seven orthogonal contrasts, which test differences among overall means through the fifth treatment period. The linear relation to the four equally spaced treatments was significant, as was the difference between increasing and decreasing treatments for all variables. Those among-increasing and among-decreasing treatments were significant or nearly so.

The first test in the periods portion of the analysis of variance was for differences among periods and was expected to be significant. The other contrasts tested for differences among individual period responses within the overall average response tested in the main-plot portion of the analysis. The interactions period × (linear) and period × (increasing treatments vs. decreasing treatments) were significant in most cases, others were not. These significant interactions disallow a simple interpretation of differences among treatments. Graphic modeling of treatment responses allows us to see responses over time.

Species Mix

By age 33, after the final treatment thinning, up to 21 percent of the basal area in some treatments remained in western hemlock. Table 3 shows the changes in percentage of western hemlock basal area as hemlock was removed by cutting.

Tree Crown Measurements

Average height to base of live crown, crown width, and crown-to-bole ratio were calculated at age 25 for fixed treatments, control, and late thinnings (table 4). Height to base of live crown at 10 feet was about double the pruning height on treatment 1. Crown base was progressively higher, to 22 feet, on the control as the level of growing stock increased. Height to base of live crown on the late thinning plot supplement was about 5 feet lower than the control plot average. By age 44, height to crown base ranged from 31 feet on treatment 1 to 62 feet on control.

Crown width (of largest diameter trees) on the fixed treatments increased as levels of growing stock were reduced. Crown width of the largest diameter trees on the late-thinned supplement was about the same as crown width of the largest trees on the control plot trees.

Site Index

Average site index estimated from field samples is given in table 5 and average height-40 is given in table 6 (international units are given in table 25). The field procedure for site-index estimation used the height and breast-height age of each of four to six sample trees per plot. The trees were from the current diameter range of the height-40 trees but were not the 8 per plot that precisely defines the 40 largest per acre. (Height-40 trees were close to, but not identical with, the “10 largest diameters from a group of 50 contiguous trees” the criteria used by King [1966]. Field samples of trees from both definitions provided nearly identical estimates of site index.). Average value of site index from the nine treatments was 131 at age 15, 126 at age 25, and 124 at age 33. Average value of site index on the late thinning treatment was 133 at age 25 and 128 at age 33.

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Table 1—Analysis of variance

Source of variation	Degree of freedom (5 treatment periods)
Treatments:	(7)
A. Fixed vs. variable percentage treatments	1
B. Among levels of fixed percentage treatments—	
Linear effects	1
Quadratic effects	1
Cubic effects	1
C. Increasing percentage treatments	1
D. Between levels of increasing percentage treatments	1
E. Between levels of decreasing percentage treatments	1
Error a for testing treatments	15
P periods	4
Treatments x period interactions:	
P X A	4
P X B linear effects	4
P X B quadratic effects	4
P X B cubic effects	4
P X C	4
P X D	4
P X E	4
Error b for testing treatments	4
	60
Total	115

Table 2—Analysis of variance results for periodic annual gross growth and gross growth percentage in volume (CVTS) and basal area, and net periodic annual growth in quadratic mean diameter[a]

	P-value[b] and mean square errors				
	Volume		Basal area		Diameter
Source of variation	PAI	Growth percent	PAI	Growth percent	PAI
Treatments:	.00**	.0*	.00**	.00*	0
A. Fixed vs. var	.13	.26	.77	.32	
B. Fixed (linear)	.00**	.00**	.00**	.00**	
B. Fixed (quad)	.40	.03	.90	.03	
B. Fixed (cubic)	.20	.73	.90	.48	
C. Increasing vs decreasing	.00**	.04*	.00**	.00**	
D. Among increasing	.00**	.80	.00**	.53	
E. Among decreasing	.00**	.01	.23	.00**	
Error a mean square	484.80	1.05	.79	.77	.00574
P periods:	.00**	.00**	.00**	.00**	.00**
P x A	.11	.16	.15	.15	.08
P x B (linear)	.00**	.00**	.21	.00**	.00**
P x B (quad)	.07	.00**	.02*	.21	.00**
P x B (cubic)	.03*	.22	.09	.01*	.19
P x C	.00**	.00**	.00**	.00**	.00**
P x D	.00**	.00**	.02*	.01**	.03*
P x E	.00**	.16	.52	.23	.00**
Error b mean square	171.21	.19	.16	.11	.00044

[a] Significance level: * is $0.01 < P \leq 0.05$; and ** is $p \leq 0.01$.

[b] P-value is the probability of a larger F, given that the null hypothesis of no difference among means is true.

Table 3—Western hemlock basal area as a percentage of total basal area on Francis LOGS plots, by treatment and period

	Year										
	1963	1969		1973		1977		1981		1985	
Treatment	A[a]	B[b]	A	B	A	B	A	B	A	B	A
	Percent										
Fixed:											
1	21	22	17	16	3	3	0	0	0	0	0
3	18	18	17	18	8	8	5	5	4	4	4
5	6	6	6	6	5	5	4	4	3	3	4
7	19	19	19	19	19	19	17	17	16	16	16
Increasing:											
2	11	10	4	5	1	0	0	0	0	0	0
4	17	17	17	17	16	16	14	14	11	11	12
Decreasing:											
6	21	21	21	21	17	18	10	10	8	8	9
8	25	25	25	26	26	27	20	20	17	17	18
Unthinned Control:											
	21	21	21	21	21	21	21	21	21	21	19
Average	18								10	9	9

[a] A = after cut.
[b] B = before cut.

Table 4 — Tree crown relations by treatment at ages 25[a] and 44[b]

Treatment	Crown width		Height to base		Crown bole ratio	
	Age 25	Age 44	Age 25	Age 44	Age 25	Age 44
	Feet				Percent	
1	16.1	34.3	10.3	31	82	70
3	13.6	29.5	12.6	50	79	54
5	11.7	23.5	14.8	60	75	48
7	11.4	22.4	19.0	64	68	43
9 (C)	9.0	15.8	21.6	62	63	33
L1	10.0	—	13.9	—	74	—
L3	8.7	—	15.7	—	71	—
L5	9.5	—	16.0	—	71	—
L7	8.9	—	15.5	—	70	—
WHC[c]	—	15.4	—	58	—	40

— = missing data.

[a] From measurements of 8 - 9 volume-sample trees on late thinned plots in 1973 and early thinned plots in 1975.

[b] Special remeasurement in 1992, at age 44, of 4 selected trees per plot that represented the diameter range of the 40 largest trees per acre.

[c] WHC = western hemlock control plots.

Table 5 — Trends of mean site index[a], in feet, at breast-height age 50 by treatment and year

Treatment	Year and age			
	1963 (15)	1973 (25)	1981 (33)	1990 (42)
	Feet			
Fixed:				
1	134	126	122	125
3	127	123	118	—
5	129	127	135	130
7	119	122	120	—
Increasing:				
2	134	129	128	—
4	138	130	129	—
Decreasing:				
6	135	125	120	—
8	136	127	124	—
Control	127	120	124	126
Average	131	126	124	—
Late thinning:				
L1	—	131	124	122
L3	—	134	130	125
L5	—	134	132	126
L7	—	133	128	123
Average		133	128	124
WHC[b]			117	115

— = missing data.

[a] Site index is according to King (1966) for Douglas-fir, Wiley (1978) for western hemlock.

[b] WHC = western hemlock control plots.

The alternative procedure of determining site index by using the average height of the height-40 trees based on smoothed heights from height-diameter curves and stand breast-height age produced higher site index estimates in the early years than did the direct field sampling process; site index averaged 9 feet higher at age 15 and 3 feet higher at age 25.

The relative productivity of the site, as reflected by the site index of western hemlock (115) to Douglas-fir (124), conformed closely to the relations defined as the "wet western hemlock sub zone" by Handley (1976) and for the Boistfort silt loam (Pringle 1986).

Height-40

Height-40 is the average height of the eight largest diameter trees on each plot. Heights of height-40 trees reported here were averages from four to six field samples that represented the diameter range of the 40 largest trees. At age 42, the height-40 of the early thinned fixed treatments (98.3 feet) was 4.3 feet taller than height-40 of the four equivalent late-thinning treatments (94.0 feet). Each early thinned treatment was consistently taller than its respective late-thinned treatment (table 6). At age 25, however, the height-40 for the same two groups was nearly the same. Table 7 gives mean diameter of the height-40 trees.

Live Stand and Accumulated Yield, All Trees

The trends of growing stock, expressed as relative density, are given for treatments by age in figure 3. The unthinned western hemlock plots are included. By age 40, the hemlock stand was at about 115 units of relative density, the Douglas-fir control (T-9C) was at 100 units, and the range of basic treatments span relative densities from 20 to 70 units. Relative density, an expression of the level of growing stock, is the product of the applied treatment. Figure 4 shows that expressing growing stock level in terms of relative density is not the same as expressing in terms of basal area, the criteria used to control study treatments. Each of the late-thinning treatments was reduced to the identical basal area levels of its matched treatment, but in terms of relative density, the late thinning had a fairly consistent 9-percent-greater level of growing stock than the presumed matching treatments.

Standing yield of live trees in terms of numbers, mean diameter, basal area, cubic-foot volume and board-foot volume in 16-foot logs is given by plot and treatment in tables 8 through 12. Similar information in international units is given in tables 27 through 36.

The 405 trees per acre at age 15 on treated plots were reduced to as few as 40 by the time of the final treatment thinning at age 33 (figs. 5 and 6). Average diameter at age 15 was 3.6 inches. By age 33, average diameter ranged from 10 to over 15 inches on the thinned plots and was 6.9 on the control. By age 42, QMD ranged from 12.6 to 19.5 inches on the thinning treatments and was 8.8 on the control (T-9C) (figs. 7 and 8).

Initial basal area after cutting at age 15 ranged from nearly 26 square feet to over 33 on the treatments and was nearly 52 square feet on the control plots. By age 33, before the last cut, treatments ranged from 67 to 146 square feet and averaged 260 on the control. By age 42, control (T-9C) basal area reached 304 square feet per acre (figs. 9 and 10).

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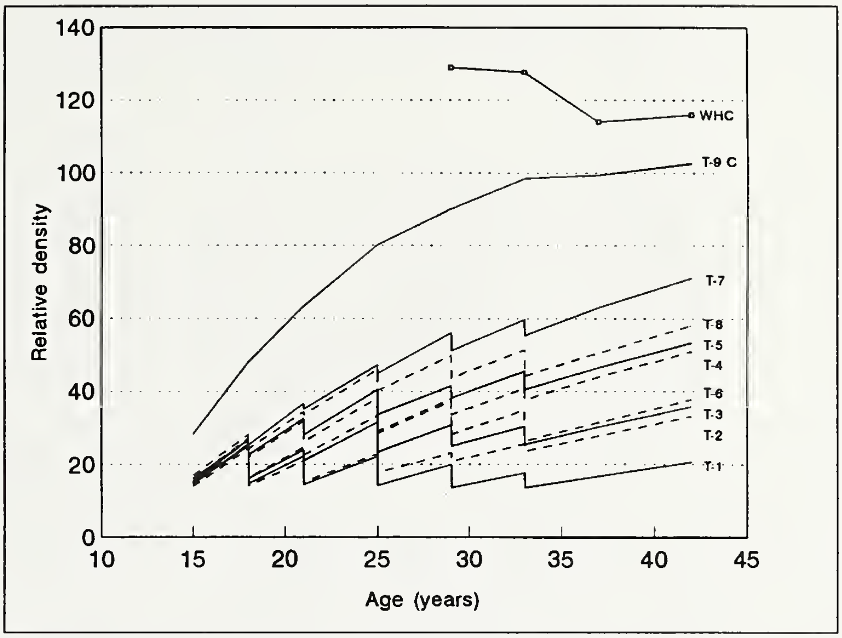

Figure 3—Growing-stock trends expressed as relative density and age for basic study treatment, control, and unthinned western hemlock.

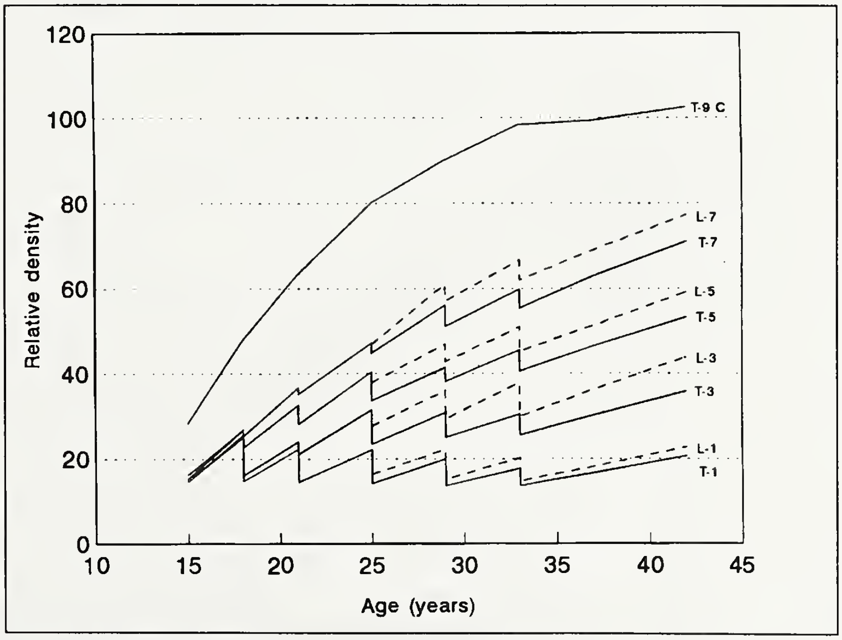

Figure 4—Relative density trends by age for fixed early (T) and late (L) thinning treatments.

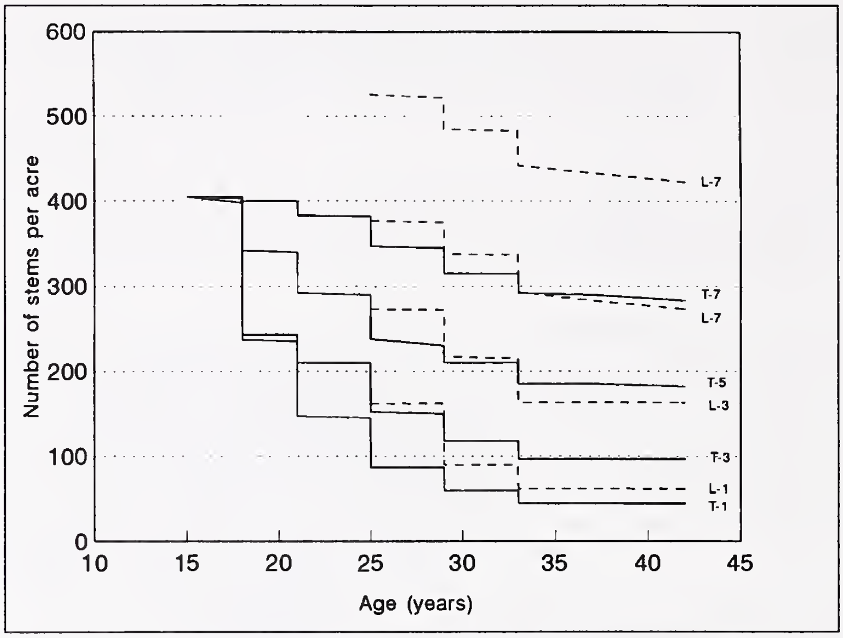

Figure 5—Number of trees by age for fixed (T) and late (L) thinning treatments.

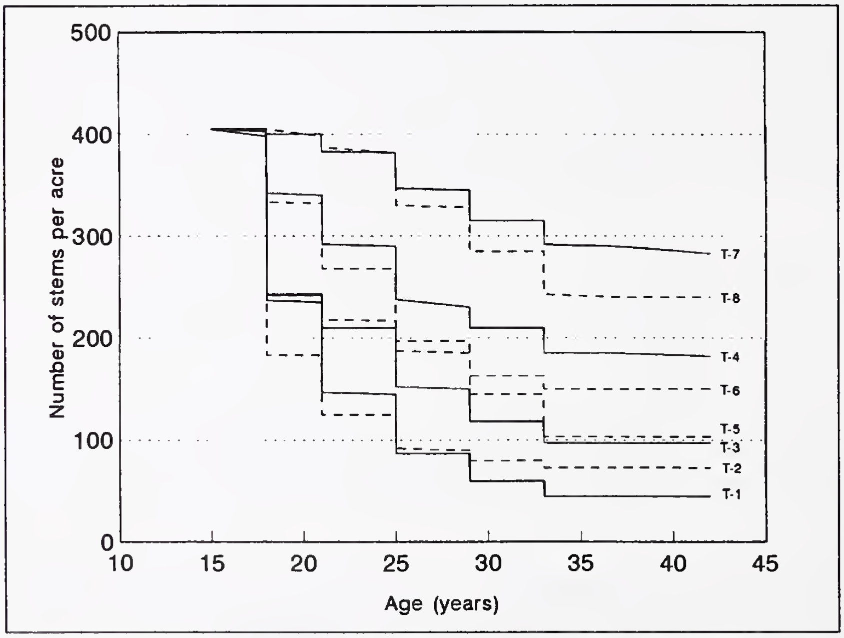

Figure 6—Number of trees by age for increasing and decreasing treatments.

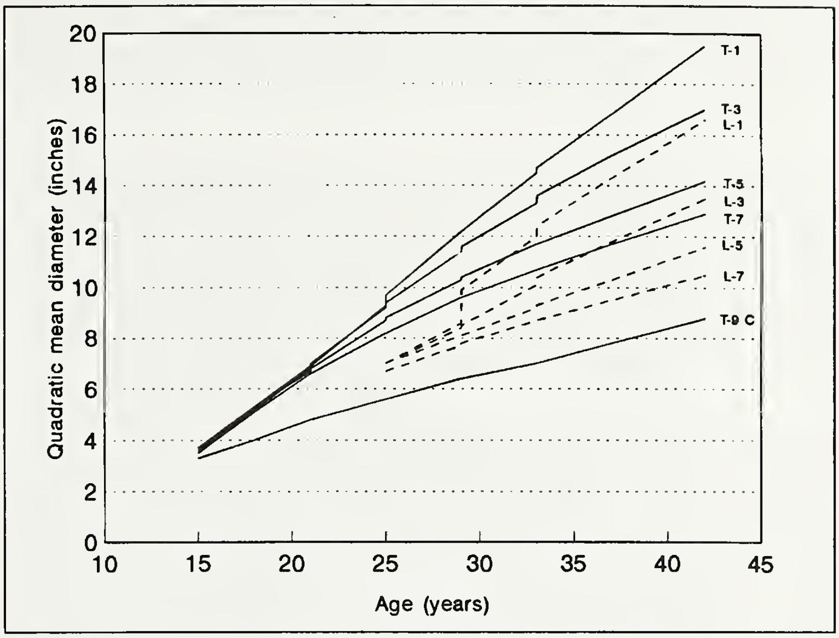

Figure 7—Quadratic mean diameter by age for fixed early (T) and late (L) treatments.

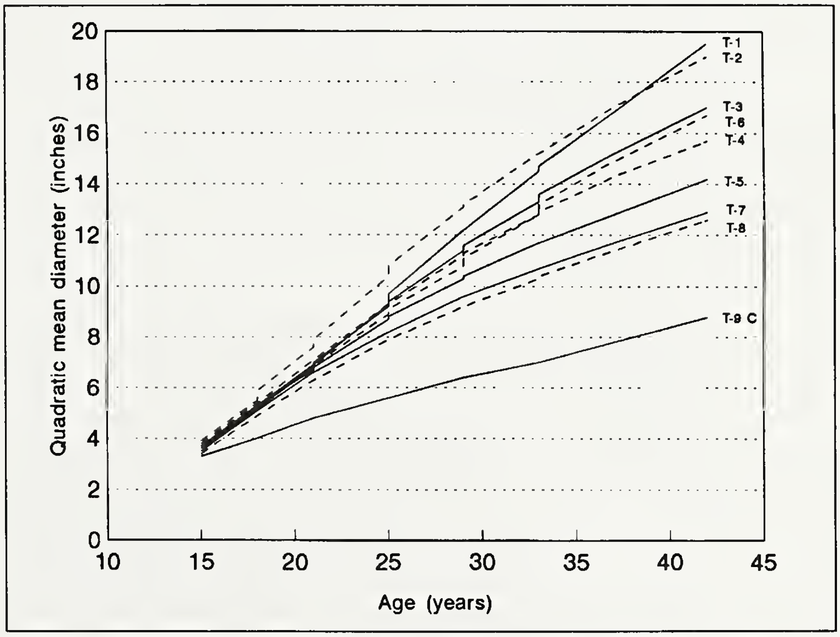

Figure 8—Quadratic mean diameter by age for increasing and decreasing treatments.

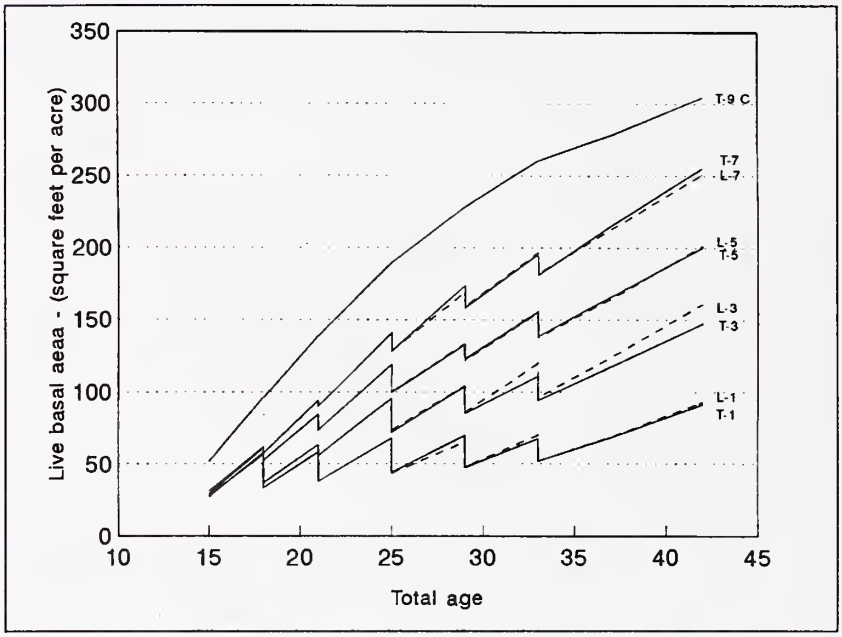

Figure 9—Live basal area by age for fixed early (T) and late (L) thinning treatments.

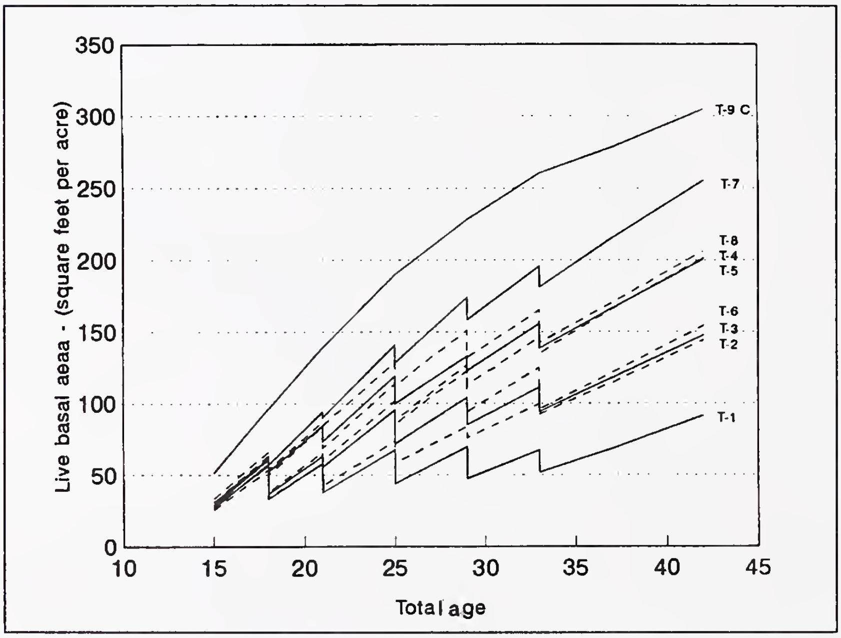

Figure 10—Live basal area by age for increasing and decreasing treatments.

Initial volume after cutting at age 15 ranged from 286 to 384 cubic feet on the treatments and averaged 560 on the control. At age 33, after the final treatment cut, volume ranged between 1,446 and 5,339 cubic feet on treatments and was 7,217 on control. By age 42, control plots (T-9C) reached 10,718 cubic feet per acre (figs. 11 and 12).

Live standing board-foot volume (Scribner, expressed in 16-foot logs to a 6-inch top diameter) first exceeded 5,000 feet per acre at about age 25 for well-stocked treatments (figs. 13 and 14). By age 42, treatment 7 reached 40,000 board feet per acre; control (T-9C) and treatment 5 were not far behind. Volumes of treatments 1 and 3 were closely followed, respectively, by the volumes of late 1 and 3. Treatments 5 and 7 were 5,000 to 7,000 board feet greater than their respective late treatments. Treatment 4 produced nearly the same board-foot volume as the control but did so on only two-thirds of the basal area (fig. 10).

The relative amount of cumulative yield to date (live trees at age 42 plus trees cut in thinnings) by treatment is similar when expressed in terms of either basal area (not shown) or CVTS results for all trees. The relative cumulative yield by treatment is also similar considering either total accumulated 14-year production (at age 29) or production of only live material after 27 years (at age 42). (See cumulative yield, including thinnings in tables 13 and 14—table 31 in international units.) The pattern of these similar relative treatment results is given in figures 15 and 16 for cubic feet and board feet where initial treatment volume is included. The general pattern shows increasing production as level of growing stock increases, with the control (T-9C) having the most basal area and cubic-foot volume. That pattern changed when volume was expressed in board feet (Scribner 16-foot logs to a 6-inch top): control fell behind treatments 4, 5, and 7. Total cubic-foot yield at age 42 of Douglas-fir control is exceeded by the live volume of hemlock control (WHC) by 11 percent.

The effect of treatments on the volume developed by age 42 for important tree diameter classes is given in figure 17. Units of measure are in cubic and board feet. Clear patterns of increased larger diameter classes were developed by lower levels of growing stock. The patterns were similar in either cubic or board-foot units of measure.

Treatments developed widely different ranges of tree size. The number of trees per acre by 1-inch diameters is given for treatments at ages 15 and 42 in table 15.

The cumulative board-foot yield used as the basis for dollar value is shown in figure 18. Volume in units of Scribner board feet in 32-foot logs to a 4-inch top (inside bark) differs from the same unit of measure to other log lengths and top diameters and is the most common market place unit of measure. Tables showing cumulative yield in 32-foot logs are not shown. Standing live volume of the unthinned hemlock stand (WHC) at age 42 exceeded cumulative yield of Douglas-fir control (T-9C) by 38 percent. Cumulative yield of treatment 7 exceeded the cumulative yield of control (T-9C) by 7 percent. All other treatments produced less cumulative yield than the control.

The volume attained by each late thinning was within 10 percent of the volume of its matched early thinning (figs. 9, 11, and 13). Treatment L5 and L7 each developed less live net cubic-foot volume than their matched early treatments and averaged 95 and 91 percent, respectively, for all the growth periods since first late thinning. Late treatment L1 developed the same (99 percent) volume as treatment 1 for the periods.

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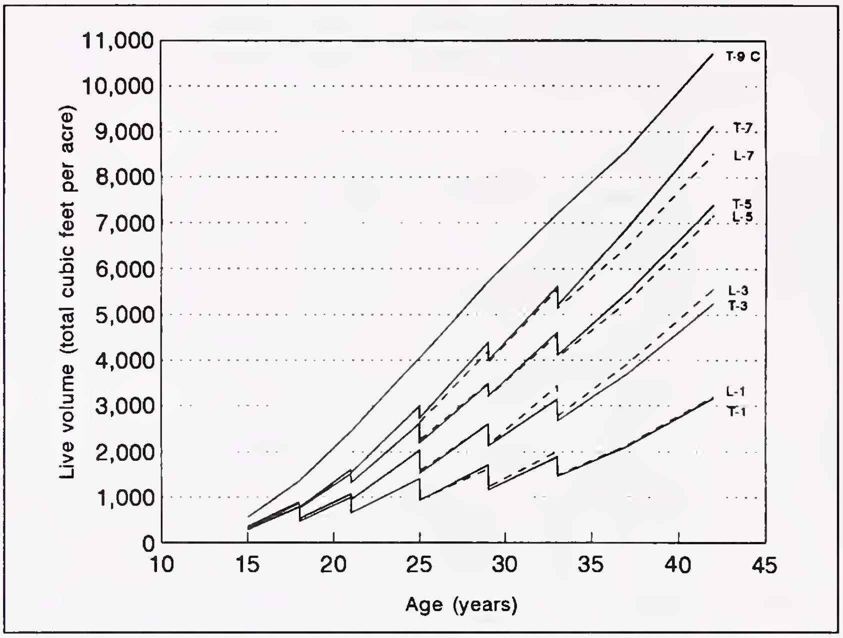


Figure 11—Cubic-foot volume by age for fixed early (T) and late (L) thinning treatments.

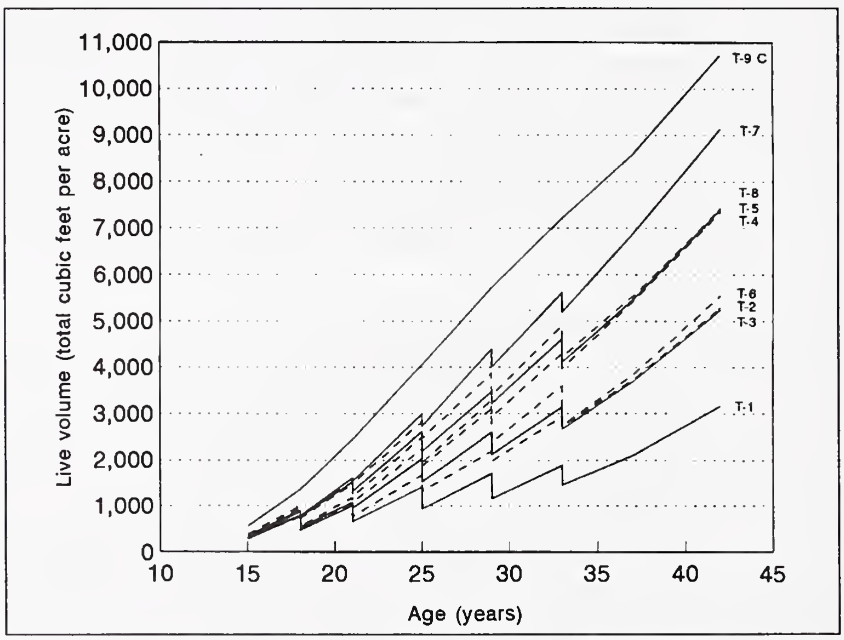


Figure 12—Cubic-foot volume by age for fixed, increasing, and decreasing treatments.

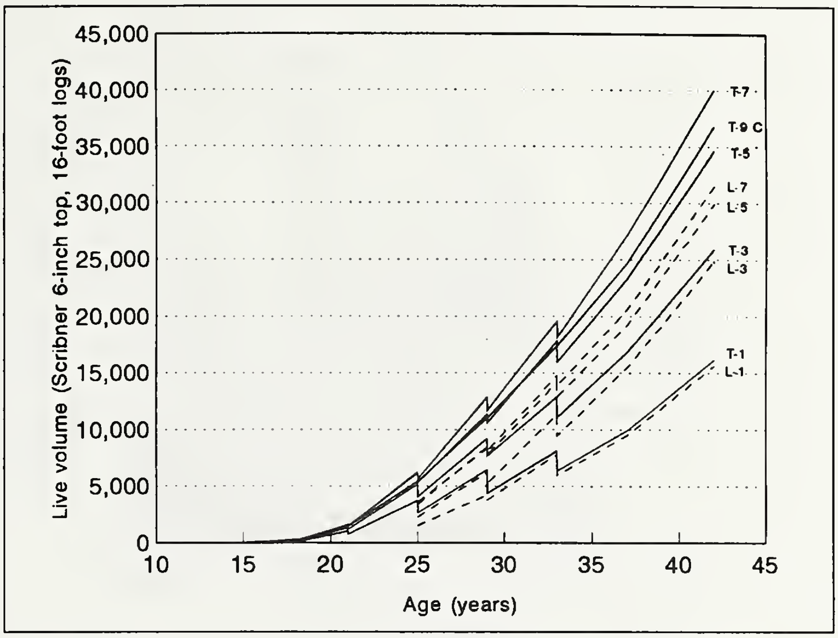


Figure 13—Board-foot volume by age for fixed early (T) and late (L) treatment thinnings.

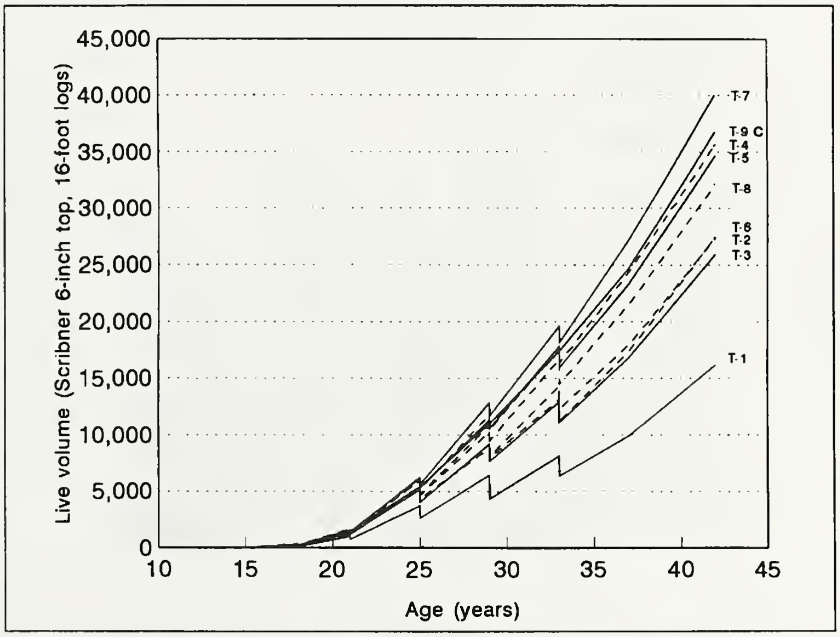


Figure 14—Board-foot volume by age for fixed, increasing, and decreasing treatments.

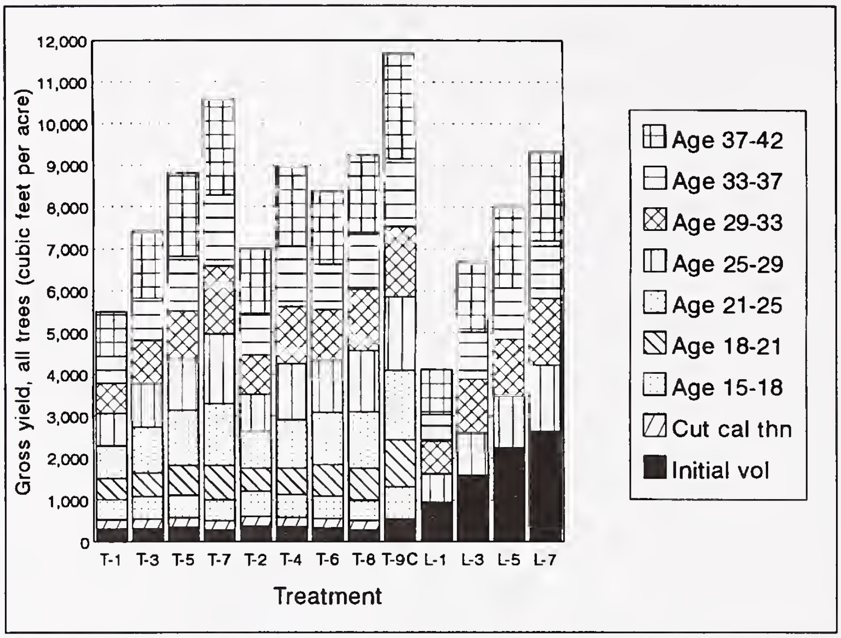


Figure 15—Gross yield in cubic feet by treatment including trees cut in the calibration thinning.

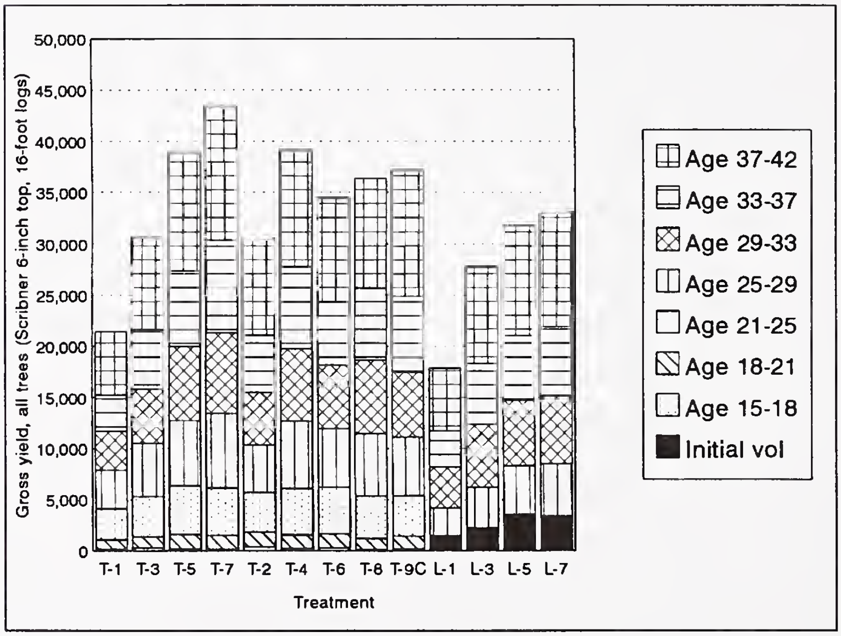
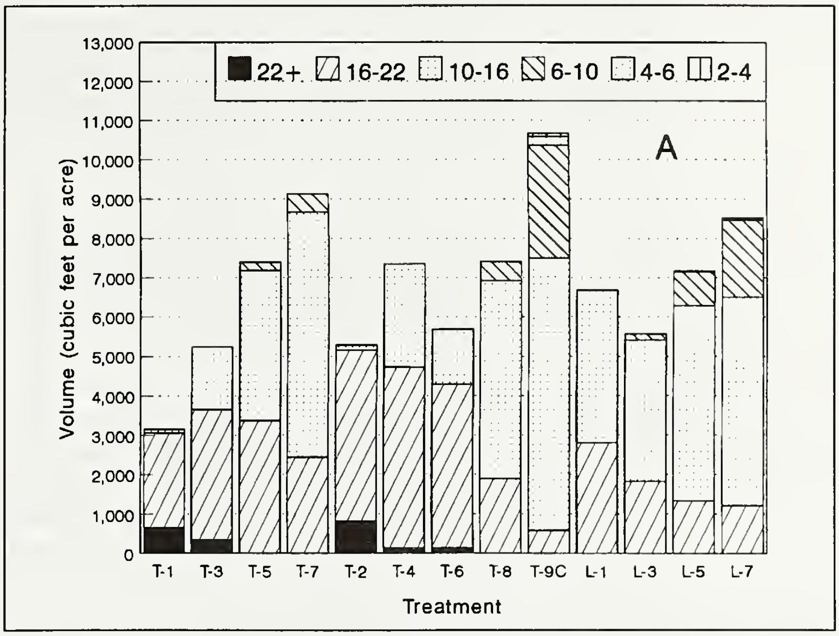


Figure 16—Gross yield in board feet by treatment including trees cut in the calibration thinning.



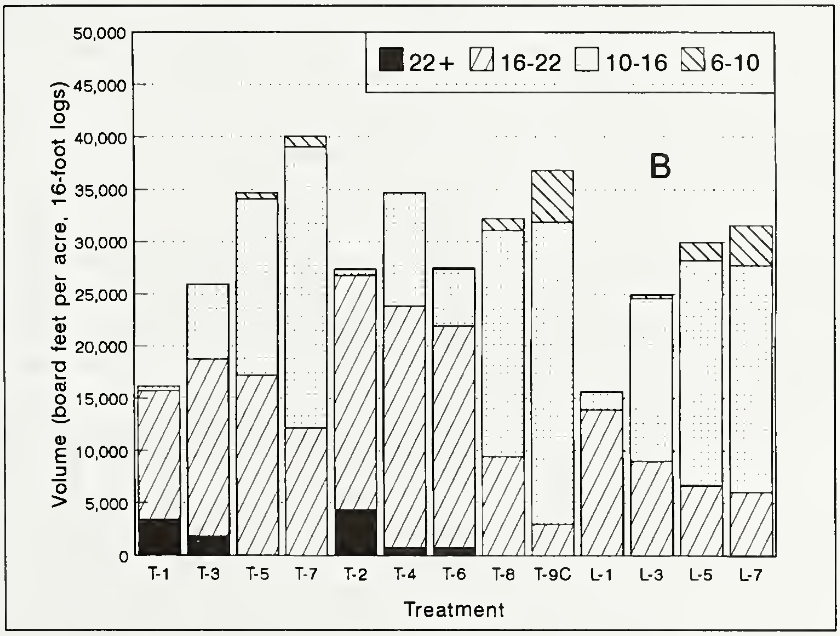


Figure 17—Standing volume at age 42 by tree diameter classes in inches for (A) cubic feet per acre and (B) board feet per acre (Scribner, 16-foot logs).

Late treatment L3 developed more volume than treatment 3, an average of 109 percent, for the growth periods since first late thinning. Basal area increment for L3 also was greater than treatment 3 (116 percent). Close examination of matched basal area immediately after thinning revealed a small systematic bias in treatment L3. Retained basal area was consistently higher than treatment 3. This accumulated to a sum of 11 percent for the four cuts in the period. The sum of comparable measurements for the other treatments was zero or 1 percent.

In terms of board feet, L5 and L7 grew considerably less over the period; 88 and 79 percent, respectively, of their early thinning counterparts.

All late treatments developed less board-foot volume than their respective early treatments.

Final Net Value

The accumulated dollar value as stumpage for treatments—including all costs and returns at 6-percent interest to age 42—is given in figure 18. There was a pattern to the values at 6-percent interest. Treatments 4, 5, 6, 7, L3, L5, and WHC had stumpage values greater than DF control (T-9C). Treatment 6 and L1 and L7 were close to control and the rest were less. This pattern also held for interest rates to 4 percent. At 7 percent, L1 and L7 slightly exceeded value of control. (Data not shown for 4 and 7 percent.) Clearly, thinning of young plantations produced greater value than planting to 600 trees without later thinning.

The main effect of delivered values (not shown) as opposed to stumpage (fig. 18) was to increase the overall value level. Also, the value for treatment 8, which was slightly below the level of control (T-9C) as stumpage, equaled or exceeded control when expressed as delivered values, depending on interest rate.

The value for unthinned natural western hemlock (WHC) was 11 percent higher than the stumpage value of the planted Douglas-fir control (T-9C, fig. 18B).

The initial thinning in the late thinning sequence contributed significantly to accumulated stumpage value at this age. By age 42, value attributable to treatments L3 and L5 was higher than the values resulting from thinning the stands early at growing stock levels 5 and 7. On the other hand, if the first late thinning was considered noncommercial, none of the late treatments would exceed the value of control (T-9C).

Increment, Cut Trees, and Mortality

Periodic annual growth (increment) data for all live trees is given in tables 16 through 19 (tables 32 through 34 for international units). Increment generally is expressed herein as either net, the periodic change in units of measure of live trees minus the quantity of trees that died during the period, or gross, the periodic change in units of measure including trees that died during the period. Survivor growth—the change in units of measure of trees that were alive at both the start and end of a period—is given in one place in table 16. Net increment and survivor growth were nearly identical on all treatments except for control which, in the last two periods, had survivor growth in diameter at about half of control net diameter growth. Annual diameter increment ranged from 0.1 to 0.6 inch per year and was consistently least on the control. Net annual basal area increment ranged from 4 to 15 square feet per acre per year during the 27-year period. Net annual volume increment ranged from 164 to 449 cubic feet per acre per year. Period-by-period increment of cubic-foot volume usually was greater on the control than on all treatments, except treatment 7.

Mean annual volume increment and periodic annual basal area increment by treatment and age are given in figures 19 and 20. Periodic and mean annual volume increment are given together by treatment in figure 21.

Basal area increment was greater at younger ages and at higher levels of growing stock, except for control (T-9C), which, in spite of greater growing stock, sometimes had less basal area increment than the thinning treatments. Basal area increment reached a maximum below age 25. Maximum mean annual volume increment has not been reached.

The relative amount and limited extent of short-term accelerated growth as the result of thinning is visible in the growth-to-growing-stock relation. Figure 22 illustrates periodic annual gross cubic-foot volume growth per acre, expressed as a percentage of unthinned Douglas-fir control volume growth, plotted over live basal area per acre (after thinning), expressed as a percentage of control basal area for the fixed-level treatments by age (except for age 29 for which all treatments are plotted). At age 29, volume growth of treatment 7 at 69 percent of control basal area growing stock, exceeded the volume growth of control by 9 percent. Treatment 7 also exceeded volume growth of control by 3 percent during the period beginning at age 33. Late thinning treatment L-7, not shown on figure 22, exceeded volume growth of control by 2 percent during the period beginning at age 29. Growth of all late-thinning treatments was slightly but consistently less than that of comparable early thinning treatments at similar levels of basal area growing stock.

Thinning also accelerated basal area growth (not shown). The pattern was similar to that for volume, but the percentage of increase was higher. Gross basal area growth reached 116 percent of control for treatment 7 at age 33 and exceeded growth of control at ages 25, 29, and 37. Late treatment L7 basal area growth also exceeded that of control for ages 29, 33, and 37. Growth percent of L7 averaged 3 percentage points lower than growth percent of treatment 7. Net basal area growth percentages, not shown in the figure, were higher than those given for gross basal area growth.

The record of trees cut by treatment and period is given in table 20 (table 35 in international units). Mortality is given in table 21 (table 36 in international units). Except for control, the amount of mortality was minor.

Crop Trees

Average height and diameter of crop trees, the 80 per acre selected at the start of the study on each plot, was summarized by treatment in tables 22 and 23. The crop trees were favored by treatment cuttings and by age 42 were larger in diameter than average quadratic mean diameter (table 9) on all treatments except 1, 2, and L1. The three exceptions were thinned heavily and only crop trees remained by age 42. The average diameter of the crop trees was smaller than the 80 largest diameter trees per acre (not given).

Because initial tree selection at calibration was by number of trees, there was greater basal area variation between treatments than in some other LOGS studies where tree selection achieved given levels of basal area. Treatment 2 had the highest level of basal area of the treatments at age 15 and also had the largest average tree diameter. The impact of this is apparent in table 23; diameter of treatment 2 crop trees began higher than all other treatments and remained the highest until age 42, when it was surpassed by treatment 1. This illustrates the continuing advantage of a better greater starting diameter for thinned stands.

Stand Development Tables

The stand development table 24 (table 37 in international units) presents thinning, yield, mortality, and growth of height, volume, and basal area by age in a “yield table” format. This is the most concise summary of the material presented in the report.

Text continued on page 33

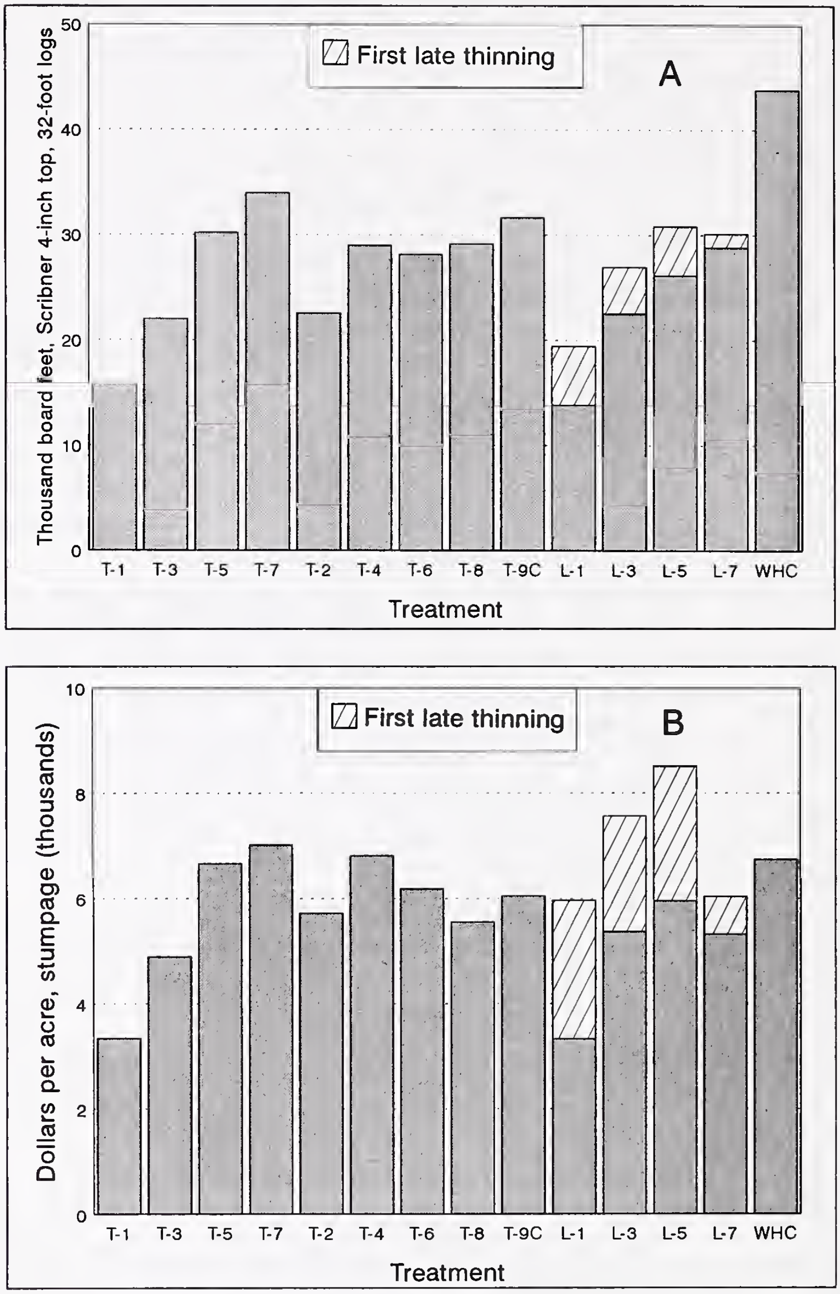


Figure 18—Accumulated results at age 42 by treatment: (A) board feet and (B) dollar value per acre including planting cost and cost and value of thinnings, all carried at 6 percent compound interest.

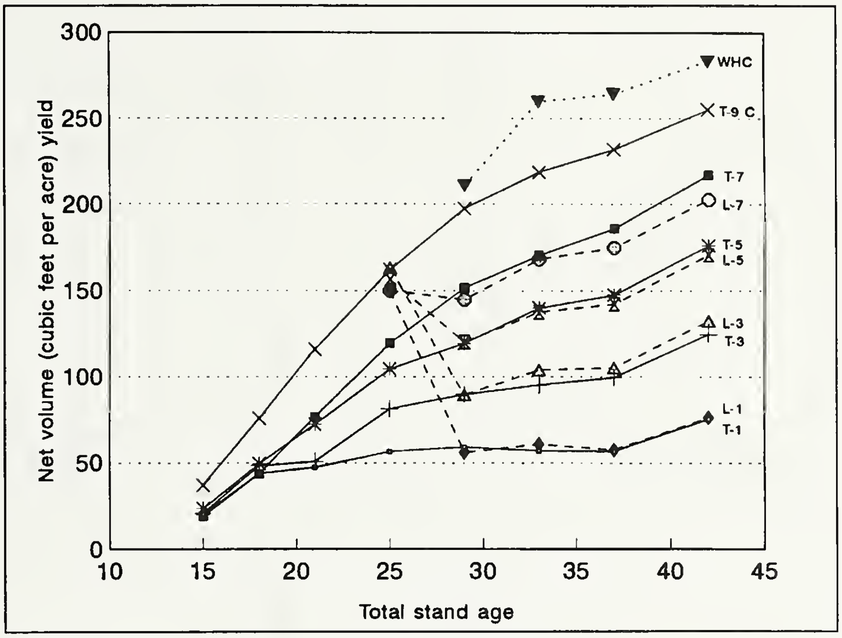


Figure 19—Mean annual increment (MAI) in volume by stand age for western hemlock (WHC), fixed early treatments (T-), and late treatments (L-).

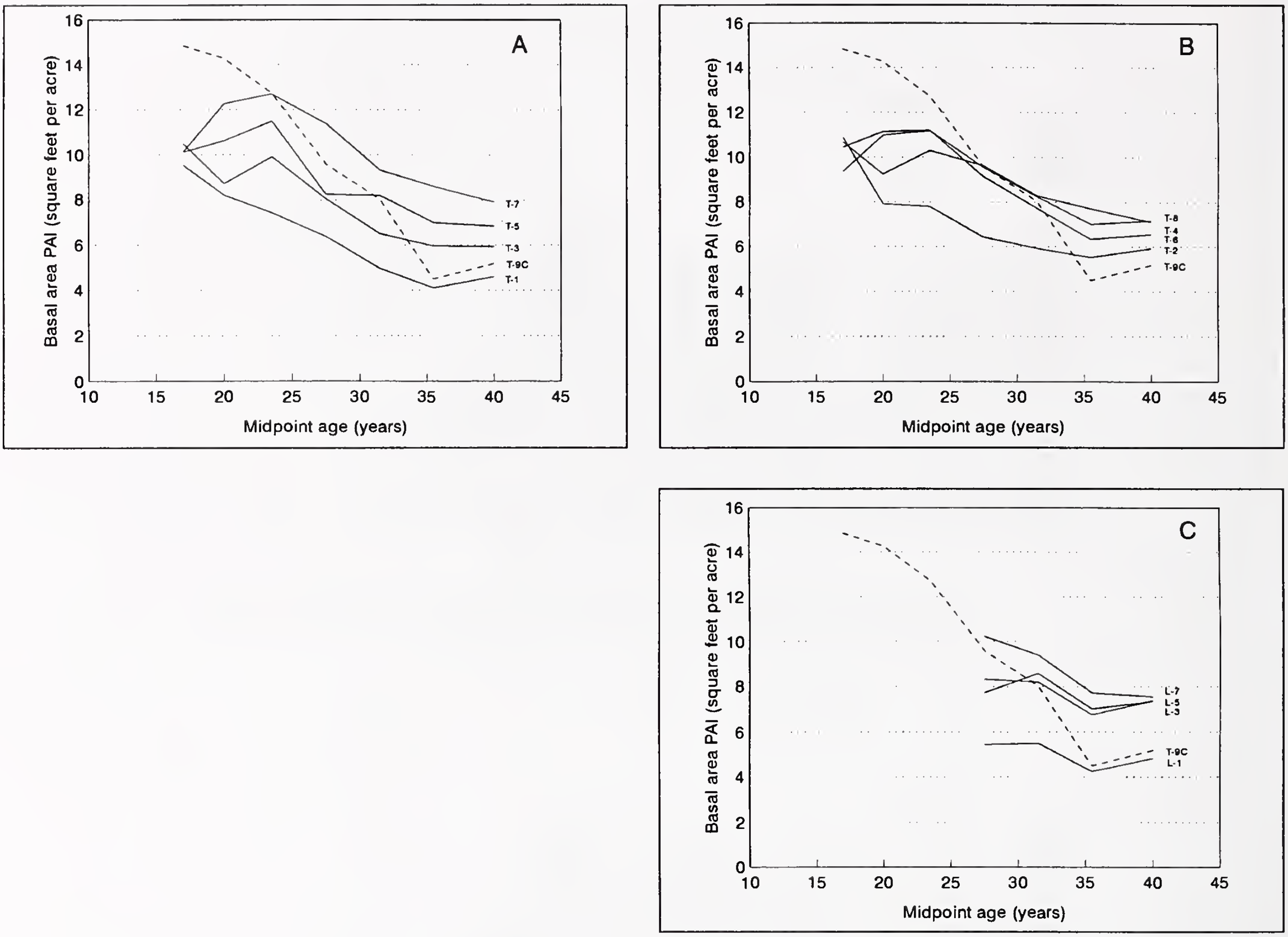


Figure 20—Net periodic annual increment (PAI) in basal area by age for (A) fixed treatments and control, (B) increasing and decreasing treatments, and (C) late-thinning treatments.

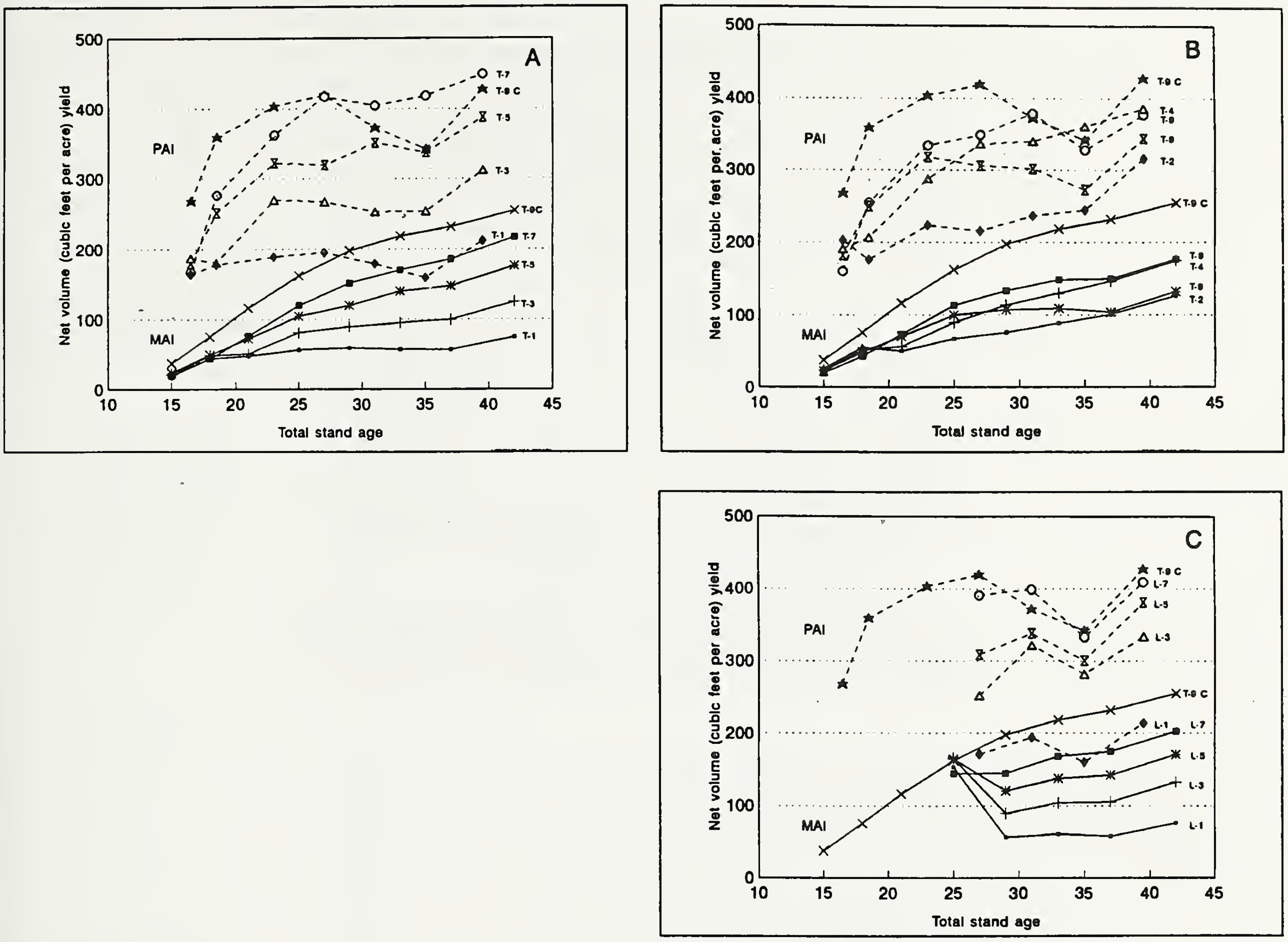


Figure 21—Comparison of curves of mean annual increment (MAI) in volume and of periodic annual increment (PAI) by stand age for (A) fixed, (B) increasing and decreasing, and (C) late thinning treatments.

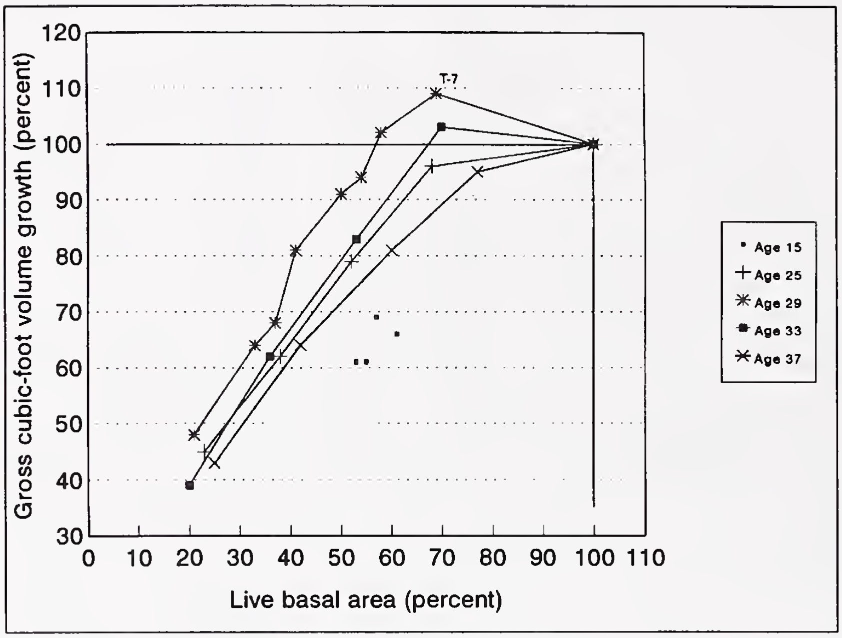


Figure 22—Volume growth to basal area growing stock relations of treatment averages expressed as percentages of unthinned control by age of stand.

Discussion

Species

As much as 20 percent of basal area of some plots was western hemlock. The growth and yield results from this study generally parallel results from other high site LOGS studies free of a hemlock component. (Curtis and Marshall 1986). We therefore expected no adverse influence by the western hemlock component on results of this study. The results from the standard LOGS analysis presented here did not compute hemlock volume and growth from a western hemlock tree volume equation. Instead, we assigned volumes from the Douglas-fir volume equation to western hemlock. We made a separate analysis (data not shown) by using an appropriate equation for the western hemlock component and found no important difference from volume and growth figures reported here.

Site Index and Height-40

The tendency of Kings' (1966) site index values for young Douglas-fir to decline with increasing age is a common observation in Northwest plantations. One of several plausible explanations is that Kings' (1966) site index curves, which use total tree height and age at breast height (4.5 feet) were based on natural stock which usually crosses the breast-height threshold from a highly competitive early establishment period. Plantations, on the other hand, often cross the threshold from a more vigorous nursery-based start, and they continue an elevated height growth rate for several years until they settle down to more usual height growth trends. The effect of this behavior is that in the earliest years above breast height, sample trees from plantations overestimate site index as defined by King's curves.

Site index computed from selective site trees sampled period by period, in the field, was more reasonable than site index based on height estimates from smoothed trends of height and diameter. Both procedures were applied to the same standard site index curves.

Height-40 estimated from height-diameter trends was an average of 1.1 feet taller than the average of the height-40 sample trees that were selected as field samples each remeasurement period. At breast-height age 8, 1.1 feet of height represents about six points of site index. (Individual tree ages of the height-40 trees average 0.6 year older than the nominal breast-height age (8.0) of the study. If nominal age had been used instead of known individual tree ages, the overestimate of height at age 8 would have been 1.8 feet and about 10 points of site index.)

Growth and Yield

Growth and yield of the basic study treatments generally behaved as expected from results of other LOGS installations. Differences in growth were confirmed by the analysis of variance. Higher levels of growing stock gave greater increment and greater volume yields. The assumption that there is a nearly constant gross volume increment over a wide range of growing stock was not supported by the results of this—or other—LOGS studies. The late thinning treatments also confirmed the point; if the initial cut (to waste) wood-volume was included as part of gross cumulative yield each late thinning treatment produced more total yield per acre than its comparable early treatment. The reason; each acre carried *more* growing stock for a longer period of time. However, with the first thinning removal considered as waste and excluded from total yield (as shown in figs. 15 and 16), the late thinning treatments each produced *less* total yield (including ongoing thinning) than did each respective early treatment.

The benefits of thinning were twofold. The reduced levels of growing stock redistributed growth to different diameter classes than on unthinned stands. Important proportionate shifts of yield to larger log-grade diameter classes began 10 years after first thinning. The thinning treatments favored development of large-diameter trees (see board-foot units, fig. 12). The second benefit was increased, total board-foot yield from the harvest of early thinnings. This is most evident in figure 16.

Volume by Tree Sizes

Treatment 2, an early heavy thinning followed by successive lighter thinnings, produced the greatest number of 16-inch and larger diameter trees. Treatment 2 was a balance between two opposing factors; low production from severe understocking (treatments 1 and L-1) and increased individual tree growth from a reduced level of growing stock. The lowest level of growing stock produced 22-inch and larger tree diameter classes most rapidly. It should be possible to write a general silvicultural prescription that would produce the relative diameter class distributions comparable to any of the study treatments.

Dollar Value: Final Net Value at Age 42

Because no two local log markets have identical conditions, absolute local dollar values are of limited interest. Relative value, on the other hand, helps interpret the usefulness of the results of treatments. Dollar value was estimated by holding logging costs and log values of variables not affected by log size as constants and by assigning local varying costs and values to variables influenced by log size. Then all costs and values, on a per-acre basis, were carried at interest until age 42, constituting a final net value analysis.

The cost and value, if any, of wood removed in the calibration thinning was not included in the value analysis because the major function served by that thinning was to balance starting conditions for the experiment. In practice, the equivalent of that thinning would be accomplished as part of the first thinning. We therefore believe that our interpretation of practical worth of treatments should not be influenced by assigning either cost or value to the calibration thinning. We do not think that growth effects induced by the calibration thinning would alter the interpretation of value results.

As of age 42, early dollar returns from the commercial value of the first late thinning exceeded the value of size differences created by early thinning treatments. Age 42 is, however, not yet the final answer to questions about treatment worth. Trees in the lower stocked wider spacings are approaching a size where significant log grade and value increases will occur.

Another major change is likely in both the Douglas-fir control and the unthinned western hemlock. There has not yet been substantial mortality in either. With the expected onset of mortality, the wood volume and relative value of both will be reduced whereas that of other treatments will continue to increase. Those volume and value increases will probably continue for several decades.

Thinning young plantations to produce larger trees is worthwhile. The thinning process (with accumulated values and altered stand structures) produced greater final net stumpage value at age 42 than the alternative of planting and leaving 600 stems per acre without further tending.

Differences between dollar value of treatments help interpret noncommodity applications. Wildlife specialists who have visited the Francis plots believe that some of the stem distributions (fig. 17 and table 15) and other attributes created by treatments are desirable for some forms of wildlife.[2] If a specific treatment was prescribed to meet wildlife needs, value differences from alternative treatments (fig. 18) would directly estimate the "cost"; that is, relative loss of value in meeting that need. The similar values across the wide range of Douglas-fir plantation growing-stock regimes suggest that carefully applied silvicultural prescriptions might meet some wildlife needs at little or no loss of value to the landowner.

Crop Trees

On nonthinned control plots, trees shifted their relative dominance; some original crop trees selected at age 15 were in subdominant diameter classes 14 years later, and average diameter of crop trees was 1.5 inches smaller than the diameter of the 80 largest trees per acre.

The average size of the 80 largest trees per acre was 0.5 to 0.8 inch larger at age 15 than the selected 80 crop trees per acre. This resulted from the defined spacing requirement specified by the study plan that four crop trees must appear in each quarter plot and that none be closer than 13.5 feet to another crop tree. The requirement sacrificed tree size for spacing. By age 29, the 80 largest trees per acre were as much as an inch larger than the 80 crop trees. Vigorous healthy-appearing trees selected as crop trees on spaced plots occasionally died from various causes.

There seems to be little use in selecting fixed crop trees at such early ages.

Increment, Late Versus Early Thinning

If treatment L3 is disregarded because of the systematic error in thinned growing stock level (explained in RESULTS), the increment of the other three late treatments averaged 5-percent cubic-foot and 10-percent board-foot volume less for the period between age 25 and 42 than the increment of the early thinned treatments.

Because the late-thinning plots had a higher average site index (128) than the four matched basic plots (124), the reported increment for late thinning would be greater than if growing as site index 124. A four-point change in site index translates into increment differences of 5 percent of cubic-foot annual volume increment and 7 percent of annual board-foot volume increment, the estimated percentages that the late thinning increment should be reduced to correct for the higher site index. (This is based on the basal area stocking and age of the treatments and estimations from a local empirical yield table [Chambers 1980]). By using the corrections, one could generalize that increment for ages 25 to 42 following late first thinning was about 10-percent less cubic-foot volume and 17-percent less board-foot volume than that of stands continuously thinned from early age, when both were thinned to the same levels of basal area growing stock and site index is identical at 124.

Acceleration of Growth by Thinning

Both basal area and volume growth increased for short periods as a result of thinning, especially on treatment 7. Percentage of volume increase from thinning was comparable to that reported for spruce by Assmann (1970, p. 230), and occurred at comparable levels of basal area growing stock (60 to 100 percent of control), and for a roughly similar type of thinning. The acceleration of growth was small and limited to a short period. This leads to three points of interpretation: (1) Results of this study support the idea that, for practical purposes, the gross growth in cubic feet of a fully

[2] Personal communication. 1995. Andrew Carey, research wildlife biologist, Forestry Sciences Laboratory, 3625 93d Ave. SW, Olympia, WA 98512-9193.

stocked stand of a given species generally represents the maximum production of which the site is capable. (2) Because the modest growth acceleration occurred primarily at 70 percent of full stocking, and there were no comparable data at 80 to 90 percent of full stocking, we do not know how much or how long lasting growth acceleration might be as a result of thinning to higher levels of growing-stock stands (between 70 and 100 percent). (3) Perhaps what is seen here as a volume growth acceleration should be interpreted as a short-term reduction of growth on controls rather than results of acceleration of growth caused by thinning. This point needs further evaluation and a more general interpretation based on combined information from other installations in the LOGS study.

Future Use of the Study

The trends of MAI and CAI indicate clearly that all treatments are still far from culmination of volume increment. This suggests that these stands are still far short of any reasonable rotation age. Also, with major mortality expected in the near future on the control, coupled with increases in density expected on the thinned plots, there likely will be major shifts among treatments in relative cumulative net volume production totals over the next decade or two.

In view of the reported changes in tree size and stand structure among treatments, and expected changes in log grades and values, it is important that the study be maintained for at least the next two decades.

The study also has major value as an on-the-ground demonstration of the effectiveness of thinning in young stands to produce alternative stand conditions that may be desired to meet aesthetic or wildlife goals, along with timber production.

Acknowledgments

We appreciate the work of C. J. Chambers, Biometrician for the Department of Natural Resources, for adapting and running routine programs that assigned log grade board-foot volume and current market values for the trees in the value analysis in this study.

English Equivalents

1 centimeter = 0.3937 inch

1 meter = 3.2808 feet

1 square meter = 10.7643 square feet

1 cubic meter = 35.3107 cubic feet

1 hectare = 2.47105 acres

1 square meter per hectare = 4.3560 square feet per acre

1 cubic meter per hectare = 14.2913 cubic feet per acre

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Appendix 1: Description of Experiment

The experiment was designed to test several thinning regimes beginning in young stands made alike at the start through a "calibration" thinning. Thereafter, through the time required for 60 feet of height growth, growing stock was controlled by allowing a specified addition to the growing stock between successive thinnings. Any extra growth was cut and was one of the measured effects of the thinning regime.

Experimental Design

A single experiment consists of eight thinning regimes plus unthinned plots whose growth is the basis for treatment in these regimes. There are three plots per treatment, arranged in a completely randomized design for a total of 27 one-fifth acre plots.

Interaction of site quality and treatment can be evaluated by replicating installations on each site quality class. Cooperative effort has made this replication possible.

Crop tree selection and details of the initial "calibration" thinning are given in the methods section.

Treatments

The eight thinning regimes differ in the amount of basal area allowed to accumulate in the growing stock. The amount of growth retained at any thinning is a predetermined percentage of the gross increase found in the unthinned plots since the last thinning (see the table on the inside front cover). The average residual basal area for all thinned plots after the calibration thinning is the foundation on which all future growing stock accumulation is based. As used in the study, the three control plots may be thought of as providing a "local gross yield table" for the study area.

For example, the following procedure was used to determine the level of growing stock for each treatment for the beginning of the third treatment period. The average gross square-foot basal area increment per acre of the control plots equals net basal area increment plus mortality.

Net basal area increment per acre	50.8	(12.7	4 years)
Basal area of mortality per acre	2.0	(0.5	4 years)
Gross basal area increment per acre	52.8		

the calculated basal area level in square feet per acre by treatment at the beginning of the third treatment period is:

Treatment no.	Basal area to be retained[1]	Basal areaat beginning second treatment period[2]	+	Gross basal area increment	=	Calculated basal area at beginning of third treatment
	Percent	*-------- Square feet per acre --------*				
1	10	38.0		5.3		43.5[3]
2	30	42.6		15.9		58.5
3	30	55.8		15.9		71.7
	50	60.3		26.5		86.8
5	50	73.3		26.5		99.8
6	30	68.9		15.9		84.8
7	70	90.1		37.1		127.2
8	50	84.4		26.5		110.9

[1] See the treatment schedule on the inside front cover.

[2] See table 10.

[3] Example calculation: 10 percent of 52.8 = 5.3; 38.2 + 5.3 = 43.5.

Thinning Interval

After the calibration thinning, thinnings were made whenever average height growth of crop trees comes closest to each multiple of 10 feet.

Control of Type of Thinning

As far as possible, type of thinning is eliminated as a variable in the treatment. The thinning specifications are described in detail in "Methods."

Table 6--Height-40; mean height of 40 largest trees per acre by treatment, total age, and year at beginning of period[a]

Treatment	1963 (15)[b]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
				Feet				
Fixed:								
1	26.3	35.0	43.5	54.9	65.2	75.1	83.9	96.8
3	27.4	35.2	43.2	55.3	66.8	75.3	84.9	98.5
5	29.2	36.6	45.1	56.6	70.5	80.3	89.0	101.5
7	26.1	34.5	43.5	54.9	65.8	75.5	85.9	96.5
Average				55.4	67.1	76.5	85.9	98.3
Increasing:								
2	28.7	35.5	44.3	56.6	70.0	79.7	88.6	102.1
4	28.4	36.8	45.9	57.0	69.2	77.4	86.1	97.5
Decreasing:								
6	26.9	36.3	44.6	56.1	64.5	74.4	85.0	100.0
8	26.5	35.2	44.3	54.9	67.1	76.5	84.6	96.3
Unthinned:								
Control	27.3	35.7	44.6	54.4	68.6	76.9	85.1	97.5
Late thinned:								
Late 1	--	--	--	55.8	65.4	74.0	81.6	92.8
Late 3	--	--	--	55.1	65.0	74.6	82.2	93.4
Late 5	--	--	--	58.9	70.1	79.4	86.0	97.9
Late 7	--	--	--	54.7	64.5	73.3	80.0	91.9
Average				56.1	66.2	75.3	82.4	94.0
WHC[c]					63	72	80	90

-- = missing data.

[a] Respective average ages for WHC for 1977-90 are 26, 30, 34, and 39 years. Height-40 is computed from a sample of 4 to 6 trees taken from the diameter range of the 40 largest per acre.

[b] Stand age in parenthesis.

[c] WHC - western hemlock.

Table 7--Mean diameter of 40 largest trees per acre by treatment, total age, and year at beginning of period

Treatment	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Inches							
Fixed:								
1	4.9	6.8	8.4	10.8	13.3	15.2	17.1	19.7
3	5.3	7.3	8.9	11.4	13.6	15.2	16.7	18.7
5	5.2	7.1	8.8	11.2	13.1	14.7	16.1	17.9
7	5.0	6.9	8.6	10.7	12.5	13.8	15.2	16.6
Increasing:								
2	5.6	7.6	9.3	11.9	14.2	16.3	18.0	20.2
4	5.2	7.1	8.9	11.4	13.4	15.1	16.7	18.5
Decreasing:								
6	5.1	7.1	8.9	11.2	13.1	14.9	16.8	19.0
8	4.8	6.7	8.4	10.4	12.0	13.5	15.0	16.5
Unthinned:								
Control	5.3	7.0	8.5	10.2	11.5	12.7	13.6	14.9
Late thinned:								
Late 1	--	--	--	9.1	11.1	13.3	15.1	17.6
Late 3	--	--	--	9.4	11.1	12.7	14.3	16.3
Late 5	--	--	--	10.0	11.5	13.0	14.4	16.2
Late 7	--	--	--	9.9	11.5	13.0	14.3	15.8

-- = missing data.

[a] Stand age in parenthesis.

Table 8--Number of live trees per acre by treatment, plot, treatment period, year, and stand age

Treatment	Plot	Live trees													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
		After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Trees per acre													
Fixed:															
1	6	405	395	185	185	125	125	75	75	50	50	40	40	40	40
	20	405	400	235	235	140	135	80	80	55	55	40	40	40	40
	27	405	400	290	285	175	175	105	105	75	75	55	55	55	55
Avg.		405	398	237	235	147	145	87	87	60	60	45	45	45	45
3	9	405	405	275	275	230	230	175	170	145	145	125	125	125	125
	10	405	405	245	245	225	225	155	155	115	115	90	90	90	90
	22	405	405	210	210	175	175	125	125	95	95	75	75	75	75
Avg.		405	405	243	243	210	210	152	150	118	118	97	97	97	97
5	8	405	400	335	330	285	285	235	225	205	205	190	190	190	185
	16	405	405	330	330	285	280	230	225	205	205	180	180	180	175
	18	405	405	360	360	305	305	250	240	220	220	185	185	185	185
Avg.		405	403	342	340	292	290	238	230	210	210	185	185	185	182
7	1	405	405	390	390	355	350	320	320	290	290	270	265	265	260
	21	405	405	405	405	405	405	370	365	335	335	305	305	305	295
	23	405	405	405	405	390	390	350	350	320	320	300	300	300	295
Avg.		405	405	400	400	383	382	347	345	315	315	292	290	290	283
Increasing:															
2	3	405	405	190	190	130	130	100	95	90	90	80	80	80	80
	5	405	400	185	185	130	130	95	95	80	80	75	75	75	75
	11	405	405	175	175	115	115	80	80	70	70	65	65	65	65
Avg.		405	403	183	183	125	125	92	90	80	80	73	73	73	73
4	12	405	405	250	250	230	230	195	190	175	175	160	160	160	160
	14	405	405	255	255	225	220	200	200	170	170	160	160	160	160
	15	405	405	220	220	200	200	165	165	145	145	130	130	130	130
Avg.		405	405	242	242	218	217	187	185	163	163	150	150	150	150
Decreasing:															
6	2	405	405	270	270	215	215	155	155	115	115	85	85	85	85
	13	405	405	330	325	255	255	190	190	130	130	95	95	95	95
	26	405	400	400	400	335	335	245	245	190	190	130	130	130	130
Avg.		405	403	333	332	268	268	197	197	145	145	103	103	103	103
8	7	405	405	405	395	360	350	315	315	275	275	240	235	235	235
	24	405	405	405	405	405	400	345	345	290	290	240	235	235	235
	25	405	405	405	395	395	395	330	325	290	290	250	250	250	250
Avg.		405	405	405	398	387	382	330	328	285	285	243	240	240	240
Unthinned:															
Control	4	1110	1345	1345	1415	1415	1410	1410	1355	1355	1355	1355	1160	1160	985
	17	685	820	820	870	870	850	850	820	820	825	825	670	670	590
	19	870	1060	1060	1095	1095	1060	1060	970	970	865	865	740	740	640
Avg.		888	1075	1075	1127	1127	1107	1107	1048	1048	1015	1015	857	857	738

Table 8--Number of live trees per acre by treatment, plot, treatment period, year and stand age (continued)

		Live trees													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Trees per acre													
Late Thinning:															
Late 1	32	--	--	--	--	--	1540	160	160	90	90	60	60	60	60
	34	--	--	--	--	--	990	160	160	85	85	60	60	60	60
	37	--	--	--	--	--	940	165	165	95	95	65	65	65	65
Avg.		--	--	--	--	--	1157	162	162	90	90	62	62	62	62
Late 3	30	--	--	--	--	--	1410	275	275	220	220	170	170	170	170
	31	--	--	--	--	--	1510	270	270	215	215	165	165	165	165
	33	--	--	--	--	--	1150	275	270	215	210	155	155	155	155
Avg.		--	--	--	--	--	1357	273	272	217	215	163	163	163	163
Late 5	35	--	--	--	--	--	1045	380	380	330	330	275	270	270	265
	36	--	--	--	--	--	905	375	375	335	335	300	295	295	295
	38	--	--	--	--	--	870	375	370	350	345	305	285	285	260
Avg.		--	--	--	--	--	940	377	375	338	337	293	283	283	273
Late 7	28	--	--	--	--	--	1350	520	515	465	465	430	420	420	420
	29	--	--	--	--	--	1250	590	590	540	540	485	480	480	475
	39	--	--	--	--	--	880	465	460	450	445	410	400	400	375
Avg.		--	--	--	--	--	1160	525	522	485	483	442	433	433	423
WHC Avg.[b]		--	--	--	--	--	--	--	2738	2738	1960	1960	1213	1213	1017

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock. Western hemlock is 1 year younger than the age given for Douglas-fir.

Table 9--Quadratic mean diameter for all live trees by treatment, plot, treatment period, year, and stand age

		Quadratic Mean Diameter													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Inches													
Fixed:															
1	6	4.0	5.6	5.7	7.5	7.5	10.0	10.5	13.1	13.1	15.5	15.4	17.6	17.6	20.3
	20	3.4	5.0	5.1	6.8	7.1	9.5	10.0	12.5	12.7	15.1	15.5	17.8	17.8	20.6
	27	3.2	4.7	4.6	6.1	6.2	8.4	8.8	11.1	10.9	13.0	13.1	15.1	15.1	17.5
Avg.		3.6	5.1	5.2	6.8	6.9	9.3	9.7	12.2	12.2	14.5	14.7	16.8	16.8	19.5
3	9	3.5	5.1	5.0	6.6	6.7	8.7	8.7	10.4	10.3	11.7	11.8	13.1	13.1	14.5
	10	3.5	5.0	5.1	6.7	6.8	8.9	9.2	11.3	11.6	13.5	13.9	15.8	15.8	17.7
	22	3.9	5.6	5.8	7.5	7.6	9.9	10.3	12.3	12.9	14.6	15.1	16.8	16.8	18.9
Avg.		3.7	5.2	5.3	6.9	7.0	9.2	9.4	11.4	11.6	13.3	13.6	15.2	15.2	17.0
5	8	3.8	5.3	5.3	6.8	6.9	8.7	8.8	10.3	10.4	11.6	11.5	12.6	12.6	14.0
	16	3.9	5.4	5.4	6.8	6.9	8.8	8.9	10.4	10.5	11.9	11.9	13.1	13.1	14.4
	18	3.6	5.1	5.2	6.6	6.7	8.6	8.6	10.2	10.2	11.6	11.7	12.9	12.9	14.3
Avg.		3.7	5.3	5.3	6.7	6.8	8.7	8.8	10.3	10.4	11.7	11.7	12.8	12.8	14.2
7	1	3.7	5.3	5.3	6.9	6.9	8.6	8.6	10.0	10.0	11.1	11.1	12.2	12.2	13.4
	21	3.3	4.8	4.8	6.3	6.3	8.0	8.0	9.4	9.3	10.5	10.5	11.5	11.5	12.8
	23	3.6	5.2	5.2	6.5	6.6	8.2	8.2	9.5	9.5	10.5	10.5	11.4	11.4	12.5
Avg.		3.5	5.1	5.1	6.6	6.6	8.2	8.2	9.6	9.6	10.7	10.7	11.7	11.7	12.9
Increasing:															
2	3	3.9	5.5	5.8	7.5	7.7	10.2	10.4	12.4	12.5	14.3	14.5	16.0	16.0	18.0
	5	3.9	5.4	5.8	7.6	7.8	10.2	10.6	12.9	13.2	15.0	15.0	16.6	16.6	18.7
	11	3.9	5.5	6.0	7.8	8.2	10.8	11.5	14.1	14.1	16.3	16.2	18.3	18.3	20.5
Avg.		3.9	5.5	5.9	7.6	7.9	10.4	10.8	13.1	13.2	15.2	15.2	17.0	17.0	19.0
4	12	3.7	5.2	5.3	6.9	6.9	9.0	9.1	10.8	10.8	12.3	12.5	13.8	13.8	15.3
	14	3.7	5.3	5.2	6.9	7.0	9.1	9.1	11.0	11.0	12.5	12.5	13.9	13.9	15.4
	15	3.9	5.5	5.6	7.4	7.4	9.8	9.8	11.9	12.0	13.7	13.7	15.2	15.2	16.6
Avg.		3.8	5.4	5.4	7.1	7.1	9.3	9.3	11.2	11.3	12.8	12.9	14.3	14.3	15.7
Decreasing:															
6	2	4.0	5.7	5.9	7.6	7.7	9.8	10.1	11.9	12.3	14.0	14.5	16.2	16.2	18.1
	13	3.7	5.3	5.4	6.9	7.0	9.1	9.2	11.1	11.5	13.3	13.7	15.3	15.3	17.2
	26	3.1	4.7	4.7	6.1	6.2	7.9	8.0	9.5	9.6	11.1	11.5	13.1	13.1	14.9
Avg.		3.6	5.2	5.3	6.9	6.9	8.9	9.1	10.8	11.1	12.8	13.2	14.9	14.9	16.7
8	7	3.7	5.2	5.2	6.6	6.6	8.1	8.1	9.3	9.4	10.4	10.4	11.4	11.4	12.5
	24	3.2	4.7	4.7	6.1	6.1	7.7	7.8	9.0	9.1	10.3	10.4	11.6	11.6	12.8
	25	3.3	4.9	4.9	6.3	6.3	7.8	7.9	9.2	9.2	10.2	10.3	11.3	11.3	12.4
Avg.		3.4	4.9	4.9	6.3	6.3	7.9	7.9	9.2	9.2	10.3	10.4	11.4	11.4	12.6
Unthinned:															
Control	4	3.3	4.0	4.0	4.6	4.6	5.3	5.3	5.8	5.8	6.2	6.2	6.9	6.9	7.9
	17	3.2	4.0	4.0	4.8	4.8	5.8	5.8	6.6	6.6	7.1	7.1	8.2	8.2	9.1
	19	3.3	4.2	4.2	4.9	4.9	5.9	5.9	6.7	6.7	7.5	7.5	8.4	8.4	9.5
Avg.		3.3	4.0	4.0	4.8	4.8	5.6	5.6	6.4	6.4	7.0	7.0	7.8	7.8	8.8

Table 9--Quadratic mean diameter for all live trees by treatment, plot, treatment period, year, and stand age (continued)

		Quadratic Mean Diameter													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
							Inches								
Late thinning:															
Late 1	32	--	--	--	--	--	4.8	7.0	8.7	9.9	12.2	12.7	14.8	14.8	17.3
	34	--	--	--	--	--	5.8	7.1	8.7	10.2	12.1	12.6	14.4	14.4	16.7
	37	--	--	--	--	--	5.5	7.0	8.4	9.6	11.5	12.0	13.7	13.7	15.9
Avg.		--	--	--	--	--	5.4	7.0	8.6	9.9	12.0	12.4	14.3	14.3	16.6
Late 3	30	--	--	--	--	--	4.7	6.9	8.3	8.4	10.0	10.2	11.4	11.4	13.0
	31	--	--	--	--	--	5.1	7.0	8.4	8.6	10.2	10.4	12.0	12.0	13.6
	33	--	--	--	--	--	5.6	7.1	8.4	8.5	10.2	10.6	12.0	12.0	13.7
Avg.		--	--	--	--	--	5.1	7.0	8.4	8.5	10.1	10.4	11.8	11.8	13.5
Late 5	35	--	--	--	--	--	5.7	7.0	8.1	8.2	9.4	9.6	10.7	10.7	12.0
	36	--	--	--	--	--	5.7	7.0	8.1	8.2	9.1	9.2	10.1	10.1	11.2
	38	--	--	--	--	--	6.5	7.0	8.0	8.0	9.0	9.1	10.2	10.2	11.8
Avg.		--	--	--	--	--	6.0	7.0	8.1	8.1	9.2	9.3	10.3	10.3	11.6
Late 7	28	--	--	--	--	--	4.9	6.8	7.9	7.9	8.8	8.8	9.6	9.6	10.6
	29	--	--	--	--	--	4.9	6.3	7.3	7.3	8.2	8.3	9.0	9.0	9.8
	39	--	--	--	--	--	6.3	7.1	8.1	8.1	9.0	9.1	9.9	9.9	11.0
Avg.		--	--	--	--	--	5.4	6.7	7.7	7.8	8.7	8.7	9.5	9.5	10.5
Avg. WHC[b]		--	-	-	--	--	--	--	4.2	4.2	5.2	5.2	6.7	6.7	7.6

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock. Western hemlock is 1 year younger than the age given for Douglas-fir.

Table 10--Basal area per acre for all live trees by treatment, plot, treatment period, year and stand age

		Basal areas													
		Calibration	Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Square feet per acre													
Fixed:															
1	6	36.1	68.4	32.7	56.3	38.5	68.8	44.8	70.0	46.6	65.4	51.9	67.4	67.4	90.0
	20	25.6	54.0	33.6	59.9	38.4	66.6	43.3	68.5	48.0	68.3	52.4	69.2	69.2	92.5
	27	23.0	48.1	34.1	58.2	37.1	67.7	44.4	70.6	48.2	68.8	51.6	68.6	68.6	91.7
Avg.		28.2	56.8	33.5	58.2	38.0	67.7	44.1	69.7	47.6	67.5	52.0	68.4	68.4	91.4
3	9	27.6	56.9	38.0	64.8	55.7	94.8	71.9	100.7	84.1	108.7	94.6	116.2	116.2	143.1
	10	27.4	56.1	34.8	59.8	56.0	97.7	71.9	107.8	84.9	114.0	94.7	121.8	121.8	154.3
	22	33.7	69.9	38.1	64.9	55.7	94.0	71.8	103.9	85.9	110.3	92.8	115.7	115.7	145.5
Avg.		29.5	61.0	37.0	63.2	55.8	95.5	71.9	104.1	85.0	111.0	94.1	117.9	117.9	147.6
5	8	31.5	62.0	51.9	83.2	73.3	117.8	99.7	130.5	121.4	149.5	138.1	164.4	164.4	198.9
	16	33.3	64.5	52.6	83.8	73.1	117.6	99.4	132.5	123.5	157.4	140.1	167.5	167.5	198.1
	18	28.3	57.7	52.4	85.5	73.6	122.5	100.1	135.3	123.7	160.1	137.1	167.4	167.4	205.0
Avg.		31.1	61.4	52.3	84.2	73.3	119.3	99.7	132.8	122.8	155.7	138.4	166.4	166.4	200.7
7	1	30.4	62.6	60.8	99.8	91.1	140.3	128.3	174.7	158.4	194.8	181.1	214.8	214.8	252.8
	21	23.6	51.5	51.5	88.0	88.0	140.2	128.2	174.2	158.4	199.6	181.9	220.3	220.3	262.6
	23	28.2	59.3	59.3	94.2	91.3	142.1	128.6	172.8	158.4	192.7	180.6	211.8	211.8	250.4
Avg.		27.4	57.8	57.2	94.0	90.1	140.9	128.3	173.9	158.4	195.7	181.2	215.6	215.6	255.3
Increasing:															
2	3	33.5	66.9	34.6	57.7	42.5	74.4	58.5	79.9	76.5	99.7	91.4	112.0	112.0	141.1
	5	32.8	64.3	33.6	58.1	42.8	73.5	58.4	85.6	76.0	98.4	92.4	113.3	113.3	143.0
	11	34.4	67.4	34.5	58.2	42.5	73.5	57.9	86.6	75.4	100.9	93.4	118.3	118.3	148.4
Avg.		33.6	66.2	34.2	58.0	42.6	73.8	58.3	84.0	76.0	99.7	92.4	114.5	114.5	144.2
4	12	29.7	60.3	38.0	65.1	60.2	100.8	87.2	121.2	112.1	144.6	135.3	166.9	166.9	203.8
	14	30.8	62.3	38.3	67.0	60.3	100.0	91.2	131.6	112.9	144.4	136.6	167.7	167.7	206.1
	15	33.3	67.3	38.1	65.5	60.3	103.8	86.7	127.9	113.6	149.2	133.9	163.7	163.7	195.2
Avg.		31.3	63.3	38.1	65.9	60.3	101.5	88.4	126.9	112.9	146.0	135.2	166.1	166.1	201.7
Decreasing:															
6	2	35.5	71.7	51.5	84.7	69.2	113.6	85.6	120.3	94.2	122.3	97.3	121.3	121.3	151.6
	13	31.0	62.6	52.2	84.9	68.2	114.0	87.5	126.7	93.1	124.5	96.7	120.8	120.8	152.6
	26	21.2	47.5	47.5	81.8	69.3	113.6	84.9	120.9	95.0	128.1	94.1	122.1	122.1	158.4
Avg.		29.2	60.6	50.4	83.8	68.9	113.7	86.0	122.6	94.1	125.0	96.0	121.4	121.4	154.2
8	7	30.2	60.2	60.2	92.7	85.6	126.1	113.3	149.4	131.6	161.2	140.8	167.1	167.1	201.2
	24	23.0	48.9	48.9	82.1	82.1	129.1	113.0	153.8	131.1	168.4	140.7	171.1	171.1	209.5
	25	24.1	52.4	52.4	85.6	85.6	132.2	111.9	149.8	133.5	165.4	145.5	173.2	173.2	208.3
Avg.		25.7	53.9	53.9	86.8	84.4	129.1	112.7	151.0	132.1	165.0	142.4	170.4	170.4	206.4
Unthinned:															
Control	4	64.9	116.7	116.7	163.1	163.1	215.4	215.4	252.3	252.3	286.7	286.7	305.2	305.2	331.2
	17	37.7	71.1	71.1	107.6	107.6	154.3	154.3	192.4	192.4	226.2	226.2	243.4	243.4	268.5
	19	52.0	100.5	100.5	146.1	146.1	199.9	199.9	240.0	240.0	268.0	268.0	286.5	286.5	313.1
Avg.		51.5	96.1	96.1	138.9	138.9	189.9	189.9	228.2	228.2	260.3	260.3	278.4	278.4	304.3

Table 10--Basal area per acre for all live trees by treatment, plot, treatment period, year and stand age (continued)

		Basal areas													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
							Square feet per acre								
Late thinning:															
Late 1	32	--	--	--	--	--	189.5	42.9	65.9	48.2	73.0	52.8	71.7	71.7	97.6
	34	--	--	--	--	--	182.0	43.6	66.4	47.8	68.1	51.6	68.1	68.1	91.4
	37	--	--	--	--	--	155.6	43.8	63.3	48.1	69.0	51.4	66.9	66.9	90.1
Avg.		--	--	--	--	--	175.7	43.5	65.2	48.0	70.0	51.9	68.9	68.9	93.0
Late 3	30	--	--	--	--	--	166.5	72.3	103.5	84.9	119.0	95.8	121.3	121.3	157.9
	31	--	--	--	--	--	212.0	72.0	104.9	86.7	123.0	98.2	129.6	129.6	167.4
	33	--	--	--	--	--	195.0	76.1	104.7	85.7	118.2	94.9	122.4	122.4	158.3
Avg.		--	--	--	--	--	191.2	73.4	104.4	85.8	120.1	96.3	124.4	124.4	161.2
Late 5	35	--	--	--	--	--	187.0	100.9	137.6	122.1	158.5	136.8	168.5	168.5	208.1
	36	--	--	--	--	--	161.0	100.5	134.3	121.6	152.8	138.3	163.2	163.2	200.9
	38	--	--	--	--	--	201.5	99.5	128.9	121.9	152.9	138.4	163.0	163.0	196.5
Avg.		--	--	--	--	--	183.2	100.3	133.6	121.9	154.7	137.8	164.9	164.9	201.8
Late 7	28	--	--	--	--	--	179.0	129.8	173.2	158.2	195.9	180.8	211.4	211.4	255.9
	29	--	--	--	--	--	163.5	128.0	171.2	158.3	197.0	181.0	212.2	212.2	250.1
	39	--	--	--	--	--	184.5	127.4	163.6	161.4	197.6	184.9	215.8	215.8	246.7
Avg.		--	--	--	--	--	175.7	128.4	169.3	159.3	196.8	182.2	213.1	213.1	250.9
Avg. WHC[b]		--	--	--	--	--	--	--	564.6	264.6	291.5	291.5	296.0	296.0	319.4

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock. Western hemlock is 1 year younger than the age given for Douglas-fir.

Table 11--Total stem cubic-foot volume per acre for all live trees by treatment, plot, treatment period, year and stand age

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Cubic feet per acre													
Fixed:															
1	6	410	1000	486	1011	697	1527	1020	1844	1209	1914	1518	2155	2155	3148
	20	268	740	462	1019	651	1371	894	1619	1131	1818	1427	2051	2051	3111
	27	233	644	454	978	626	1350	898	1686	1167	1925	1446	2094	2094	3220
Avg.		304	794	467	1002	658	1416	938	1716	1169	1886	1464	2100	2100	3160
3	9	292	805	537	1089	942	2017	1529	2490	2077	3081	2694	3609	3609	5014
	10	284	786	487	998	937	2071	1525	2678	2116	3174	2631	3732	3732	5435
	22	366	1032	570	1134	977	2012	1541	2632	2188	3161	2667	3700	3700	5273
Avg.		314	875	531	1074	952	2033	1532	2600	2127	3139	2664	3680	3680	5241
5	8	360	904	757	1498	1322	2587	2201	3418	3185	4433	4093	5363	5363	7301
	16	387	952	777	1529	1337	2606	2214	3503	3275	4736	4225	5573	5573	7379
	18	318	827	752	1526	1317	2651	2161	3487	3181	4680	4005	5433	5433	7511
Avg.		355	894	762	1518	1325	2615	2192	3469	3214	4616	4108	5457	5457	7397
7	1	322	875	851	1744	1593	3013	2755	4461	4049	5639	5242	6956	6956	9218
	21	239	674	674	1474	1474	2936	2683	4344	3945	5675	5166	6926	6926	9185
	23	296	814	814	1615	1566	3028	2743	4383	4021	5554	5206	6753	6753	8963
Avg.		286	788	780	1611	1545	2992	2727	4396	4005	5623	5204	6878	6878	9122
Increasing:															
2	3	384	1002	522	1033	765	1672	1314	2067	1977	2924	2706	3673	3673	5247
	5	377	975	524	1078	805	1716	1381	2332	2076	3026	2846	3813	3813	5384
	11	391	1005	519	1042	764	1639	1299	2192	1898	2840	2644	3652	3652	5241
Avg.		384	994	522	1051	778	1676	1331	2197	1984	2930	2732	3713	3713	5291
4	12	329	873	550	1141	1056	2172	1879	3094	2858	4194	3926	5372	5372	7361
	14	353	922	568	1216	1101	2242	2051	3480	2999	4341	4112	5622	5622	7646
	15	382	991	562	1184	1091	2293	1915	3300	2929	4328	3876	5250	5250	7034
Avg.		354	929	560	1180	1083	2236	1948	3291	2929	4288	3971	5415	5415	7347
Decreasing:															
6	2	407	1061	770	1528	1254	2530	1920	3061	2411	3566	2841	3979	3979	5743
	13	344	895	746	1476	1182	2448	1869	3139	2278	3429	2622	3654	3654	5257
	26	233	664	664	1427	1211	2481	1859	3123	2452	3767	2748	3847	3847	5644
Avg.		328	873	727	1477	1216	2486	1882	3107	2380	3588	2737	3827	3827	5548
8	7	344	880	880	1665	1540	2788	2508	3872	3416	4838	4229	5454	5454	7263
	24	251	673	673	1416	1416	2796	2446	3897	3320	4955	4133	5496	5496	7451
	25	268	745	745	1514	1514	2900	2458	3835	3418	4913	4323	5665	5665	7561
Avg.		287	766	766	1532	1490	2828	2470	3868	3385	4902	4228	5539	5539	7425
Unthinned:															
Control	4	712	1657	1657	2848	2848	4570	4570	6284	6284	7832	7832	9259	9259	11478
	17	403	996	996	1880	1880	3278	3278	4820	4820	6246	6246	7519	7519	9463
	19	565	1436	1436	2589	2589	4312	4312	6083	6083	7573	7573	8975	8975	11214
Avg.		560	1363	1363	2439	2439	4053	4053	5729	5729	7217	7217	8584	8584	10718

Table 11--Total stem cubic-foot volume per acre for all live trees by treatment, plot, treatment period, year and stand age (continued)

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Cubic feet per acre													
Late thinning:															
Late 1	32	--	--	--	--	--	--	940	1646	1231	2083	1492	2177	2177	3292
	34	--	--	--	--	--	--	965	1689	1254	2012	1548	2210	2210	3286
	37	--	--	--	--	--	--	940	1556	1210	1926	1431	1998	1998	3011
Avg.		--	--	--	--	--	3749	948	1630	1232	2007	1490	2128	2128	3196
Late 3	30	--	--	--	--	--	--	1514	2507	2051	3319	2670	3702	3702	5301
	31	--	--	--	--	--	--	1571	2631	2191	3525	2823	4079	4079	5805
	33	--	--	--	--	--	--	1673	2642	2176	3442	2797	3896	3896	5587
Avg.		--	--	--	--	--	4080	1586	2593	2140	3429	2763	3892	3892	5564
Late 5	35	--	--	--	--	--	--	2263	3582	3185	4656	4035	5388	5388	7416
	36	--	--	--	--	--	--	2241	3492	3168	4447	4027	5134	5134	6982
	38	--	--	--	--	--	--	2259	3401	3220	4522	4111	5265	5265	7111
Avg.		--	--	--	--	--	3909	2254	3491	3191	4542	4058	5263	5263	7170
Late 7	28	--	--	--	--	--	--	2661	4305	3934	5540	5111	6432	6432	8690
	29	--	--	--	--	--	--	2572	4186	3874	5494	5051	6346	6346	8329
	39	--	--	--	--	--	--	2669	4103	4049	5610	5254	6632	6632	8533
Avg.		--	--	--	--	--	3749	2634	4198	3952	5548	5139	6470	6470	8517
Avg. WHC[b]		--	--	--	--	--	--	--	6121	6121	8575	8575	9775	9775	11903

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock. Western hemlock is 1 year younger than the age given for Douglas-fir.

Table 12--Board-foot volume in 16-foot logs to a 6-inch top, Scribner scale, for all live trees by treatment, plot, treatment period, year, and stand age

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Board feet per acre													
Fixed:															
1	6	0	333	162	1496	1101	4610	3229	7414	4842	8657	6849	10458	10458	16317
	20	9	136	53	1000	720	3694	2575	6137	4316	7890	6297	9754	9754	16000
	27	0	33	24	545	409	2847	2084	5784	3942	7865	5951	9505	9505	16095
Avg.		3	167	80	1014	743	3717	2629	6445	4367	8137	6366	9906	9906	16137
3	9	0	156	141	1094	1014	4667	3556	8106	6661	11713	10303	15314	15314	23345
	10	11	205	65	915	898	4973	3917	9467	7692	13226	11142	17246	17246	27293
	22	3	520	349	1843	1648	5829	4670	10073	8630	13819	11835	17733	17733	27176
Avg.		5	294	185	1284	1187	5156	4048	9216	7661	12919	11093	16764	16764	25938
5	8	0	202	197	1614	1449	6151	5416	11216	10580	17008	15683	22568	22568	33957
	16	0	294	268	1822	1620	6510	5615	11672	11046	18656	16742	24193	24193	34919
	18	0	128	117	1308	1199	6020	4881	11112	10119	17791	15331	23149	23149	35190
Avg.		0	208	194	1581	1422	6227	5304	11333	10582	17818	15919	23303	23303	34689
7	1	2	264	264	2010	1897	6868	6310	13919	12625	20549	19096	28643	28643	41709
	21	0	54	54	1040	1040	5466	5016	12052	10849	19189	17464	26843	26843	39818
	23	0	182	182	1472	1445	6113	5602	12630	11606	19026	17838	26085	26085	38587
Avg.		1	167	167	1507	1461	6149	5642	12867	11693	19588	18133	27190	27190	40038
Increasing:															
2	3	0	419	228	1524	1220	5130	4091	7997	7678	12772	11930	17424	17424	26846
	5	0	263	216	1754	1410	5357	4532	9403	8524	13738	12937	18510	18510	28005
	11	19	484	299	1782	1477	5345	4501	9048	7806	12882	12008	17701	17701	27299
Avg.		6	389	248	1687	1369	5277	4375	8816	8003	13131	12292	17879	17879	27383
4	12	0	173	133	1251	1191	5412	4748	10590	9805	16691	15743	23692	23692	35265
	14	0	243	109	1459	1379	5874	5399	12272	10651	17662	16766	25162	25162	37012
	15	0	294	207	1733	1617	6601	5561	12392	11020	18453	16516	24207	24207	34751
Avg.		0	237	150	1481	1396	5962	5236	11751	10492	17602	16341	24354	24354	35676
Decreasing:															
6	2	5	631	478	2468	2115	7340	5749	11344	9168	15347	12472	18984	18984	29716
	13	0	204	169	1532	1272	5997	4687	10713	8034	14024	10862	16580	16580	25947
	26	0	35	35	788	666	4494	3486	8883	7028	13640	10275	16369	16369	26781
Avg.		2	290	227	1596	1351	5944	4641	10313	8077	14337	11203	17311	17311	27481
8	7	0	214	214	1613	1556	5713	5129	11135	9865	16623	14569	21169	21169	31429
	24	0	32	32	832	832	4930	4440	10649	9081	16810	14120	21459	21459	32494
	25	0	104	104	1229	1229	5448	4713	10718	9530	16602	14764	21847	21847	32625
Avg.		0	117	117	1225	1206	5364	4761	10834	9492	16678	14484	21492	21492	32183
Unthinned:															
Control	4	0	240	240	1638	1638	5852	5852	11225	11225	17378	17378	24494	24494	36740
	17	0	54	54	862	862	3964	3964	9063	9063	15061	15061	22152	22152	33403
	19	1	305	305	1834	1834	6434	6434	12766	12766	19690	19690	27418	27418	40208
Avg.		0	200	200	1445	1445	5417	5417	11018	11018	17376	17376	24688	24688	36783

Table 12--Board-foot volume in 16-foot logs to a 6-inch top, Scribner scale, for all live trees by treatment, plot, treatment period, year, and stand age (continued)

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Board feet per acre													
Late thinning:															
Late 1	32	--	--	--	--	--	--	1464	4292	3761	8185	6021	9775	9775	16152
	34	--	--	--	--	--	--	1546	4439	3981	7978	6330	10023	10023	16287
	37	--	--	--	--	--	--	1472	3907	3616	7234	5559	8651	8651	14383
Avg.		--	--	--	--	--	--	1494	4213	3786	7799	5970	9483	9483	15607
Late 3	30	--	--	--	--	--	--	1852	5664	4644	10556	8753	14112	14112	23060
	31	--	--	--	--	--	--	2238	6328	5456	11819	9660	16328	16328	26134
	33	--	--	--	--	--	--	2707	6671	5608	11709	9961	15837	15837	25516
Avg.		--	--	--	--	--	--	2266	6221	5236	11361	9458	15426	15426	24904
Late 5	35	--	--	--	--	--	--	3404	8429	7666	14571	12928	19992	19992	31396
	36	--	--	--	--	--	--	3578	8362	7797	13718	12496	18078	18078	28225
	38	--	--	--	--	--	--	3724	8240	7889	14156	13190	19510	19510	30272
Avg.		--	--	--	--	--	--	3569	8344	7784	14149	12871	19193	19193	29964
Late 7	28	--	--	--	--	--	--	3065	8431	7806	14568	13422	20191	20191	32057
	29	--	--	--	--	--	--	2389	6939	6558	12771	12103	18293	18293	28497
	39	--	--	--	--	--	--	4745	10029	10007	16918	16027	23252	23252	34071
Avg.		--	--	--	--	--	--	3400	8466	8124	14752	13851	20579	20579	31542
Avg. WHC[b]		--	--	--	--	--	--	--	4623	4623	11113	11113	18518	18518	29546

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock. Western hemlock is 1 year younger than the age given for Douglas-fir.

Table 13--Total yield in cubic feet by treatment, year, and stand age

Treatment	Yield							
	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Cubic feet per acre							
	Net yield							
Fixed:								
1	304	794	1329	2087	2866	3582	4219	5278
3	314	875	1417	2498	3566	4578	5594	7154
5	355	894	1650	2939	4216	5619	6968	8908
7	286	788	1619	3067	4736	6354	8028	10271
Increasing:								
2	384	994	1523	2420	3286	4232	5212	6791
4	354	929	1549	2702	4045	5404	6847	8780
Decreasing:								
6	328	873	1623	2894	4119	5326	6417	8137
8	287	766	1532	2870	4267	5784	7095	8981
Unthinned:								
Control	560	1363	2439	4053	5729	7217	8584	10718
Late thinning:								
Late 1	--	--	--	948	1630	2406	3044	4112
Late 3	--	--	--	1586	2593	3882	5011	6683
Late 5	--	--	--	2254	3491	4842	6047	7954
Late 7	--	--	--	2634	4198	5794	7125	9173
	Gross yield							
Fixed:								
1	304	802	1340	2111	2889	3606	4242	5301
3	314	875	1417	2498	3578	4590	5606	7166
5	355	897	1655	2952	4337	5739	7088	9081
7	286	788	1619	3072	4745	6363	8050	10369
Increasing:								
2	384	998	1527	2425	3337	4283	5263	6841
4	354	929	1549	2709	4063	5422	6865	8798
Decreasing:								
6	328	874	1633	2903	4128	5336	6426	8146
8	287	766	1546	2913	4312	5829	7154	9040
Unthinned:								
Control	560	1375	2463	4112	5861	7387	9019	11469
Late thinning:[b]								
Late 1	--	--	--	948	1630	2406	3044	4112
Late 3	--	--	--	1586	2600	3892	5021	6693
Late 5	--	--	--	2254	3494	4845	6079	8016
Late 7	--	--	--	2634	4224	5832	7210	9333

-- = missing data.

[a] Stand age in parenthesis.

[b] Wood cut in initial late thinning, in 1973, not included in cumulative yield.

Table 14--Total yield in board feet by treatment, year, and stand age

Treatment	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Total Yield							
	Scribner board feet per acre, 16-foot logs							
	Net yield							
Fixed:								
1	3	167	1101	4075	7891	11662	15202	21433
3	5	294	1393	5362	10530	15788	21459	30633
5	0	208	1596	6400	12430	19666	27051	38436
7	1	167	1507	6195	13420	21315	30372	43220
Increasing:								
2	6	389	1828	5736	10177	15305	20892	30397
4	0	237	1568	6135	12650	19760	27773	39095
Decreasing:								
6	2	290	1659	6252	11924	18185	24292	34463
8	0	117	1225	5383	11456	18642	25649	36341
Unthinned:								
Control	0	200	1445	5417	11018	17376	24688	36783
Late thinning:								
Late 1	--	--	--	1494	4213	8225	11738	17862
Late 3	--	--	--	2266	6221	12346	18314	27792
Late 5	--	--	--	3569	8344	14708	21031	31802
Late 7	--	--	--	3400	8466	15094	21822	32785
	Gross yield							
Fixed:								
1	3	167	1101	4100	7917	11687	15227	21459
3	5	294	1393	5362	10545	15803	21474	30648
5	0	208	1596	6404	12746	19982	27367	38913
7	1	167	1507	6195	13420	21315	30389	43399
Increasing:								
2	6	389	1828	5736	10370	15498	21085	30589
4	0	237	1568	6138	12667	19777	27790	39112
Decreasing:								
6	2	290	1666	6259	11932	18192	24300	34470
8	0	117	1225	5415	11488	18674	25682	36373
Unthinned:								
Control	0	200	1445	5432	11133	17491	24885	37150
Late thinning:								
Late 1	--	--	--	1494	4213	8225	11738	17862
Late 3	--	--	--	2266	6221	12346	18314	27792
Late 5	--	--	--	3569	8344	14708	21031	31809
Late 7	--	--	--	3400	8535	15165	21922	33094

-- = missing data.

[a] Stand age in parenthesis.

Table 15--Number of live trees per acre, by diameter class, treatment at start of the calibration (age 15 in 1963) and at the end of the last measured treatment period (age 42 in 1990)

	Treatments																	
	1		2		3		4		5		6		7		8		Control	
D.b.h. class	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End
									Trees per acre									
Inches:																		
2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--
3	65	--	48	--	50	--	38	--	35	--	77	--	80	--	82	--	312	57
4	162	--	133	--	180	--	158	--	163	--	143	--	157	--	177	--	272	65
5	130	--	137	--	112	--	137	--	142	--	122	--	120	--	115	--	220	37
6	40	--	68	--	53	--	65	--	60	--	48	--	40	--	27	3	75	42
7	7	--	17	--	8	--	7	--	5	--	15	--	8	--	5	7	8	80
8	2	--	2	--	2	--	--	--	--	2	--	--	--	8	--	5	--	67
9	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--	15	--	87
10	--	--	--	--	--	--	--	--	--	13	--	2	--	17	--	15	--	50
11	--	--	--	--	--	--	--	3	--	10	--	2	--	40	--	22	--	52
12	--	--	--	--	--	3	--	2	--	25	--	2	--	28	--	23	--	70
13	--	2	--	--	--	0	--	15	--	13	--	8	--	30	--	30	--	57
14	--	2	--	2	--	10	--	13	--	13	--	5	--	38	--	40	--	28
15	--	0	--	0	--	18	--	20	--	28	--	8	--	33	--	35	--	22
16	--	0	--	2	--	12	--	18	--	23	--	10	--	32	--	12	--	17
17	--	5	--	2	--	8	--	33	--	13	--	13	--	23	--	15	--	5
18	--	2	--	12	--	8	--	12	--	20	--	18	--	15	--	12	--	5
19	--	5	--	23	--	12	--	15	--	10	--	10	--	3	--	5	--	--
20	--	7	--	12	--	13	--	15	--	5	--	10	--	2	--	2	--	--
21	--	13	--	3	--	5	--	0	--	3	--	7	--	--	--	--	--	--
22	--	3	--	10	--	3	--	2	--	2	--	7	--	--	--	--	--	--
23	--	5	--	5	--	2	--	2	--	--	--	2	--	--	--	--	--	--
24	--	0	--	2	--	0	--	--	--	--	--	--	--	--	--	--	--	--
25	--	0	--	0	--	2	--	--	--	--	--	--	--	--	--	--	--	--
26	--	2	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	405	45	405	73	405	97	405	150	405	182	405	103	405	283	405	240	888	738

Table 15--Number of live trees per acre, by diameter class, treatment at start of the calibration (age 15 in 1963) and at the end of the last measured treatment period (age 42 in 1990) (continued)

	Treatments													
	Late 1[a]			Late 3[a]			Late 5[a]			Late 7[a]			WHC[b]	
	Start		End	Start		End	Start		End	Start		End	Start	End[b]
Dbh class	before cut	after cut		before cut	after cut		before cut	after cut		before cut	after cut			
	Trees per acre													
Inches:														
1	--	--	--	--	--	--	--	--	--	--	--	--	247	--
2	195	--	--	249	--	--	170	--	--	233	--	--	568	--
3	177	--	--	249	--	--	123	2	--	205	5	--	610	10
4	173	17	--	225	22	--	115	42	--	155	46	2	468	82
5	182	35	--	193	35	--	112	73	--	150	112	3	334	188
6	152	23	--	157	63	2	80	57	10	137	116	12	218	159
7	110	18	--	117	50	0	108	70	15	115	107	45	148	153
8	95	37	--	95	55	3	90	60	22	75	70	42	87	127
9	47	20	--	55	37	5	70	43	17	50	45	50	37	120
10	18	10	--	17	8	5	42	22	28	20	12	53	18	75
11	3	2	--	7	3	13	20	8	27	13	7	32	3	47
12	2	--	3	--	--	13	8	--	30	5	3	55	--	28
13	--	--	0	--	--	18	0	--	25	2	2	52	--	18
14	--	--	2	--	--	30	2	--	25	--	--	28	--	7
15	--	--	2	--	--	18	--	--	22	--	--	22	--	3
16	--	--	5	--	--	22	--	--	28	--	--	7	--	--
17	--	--	20	--	--	13	--	--	10	--	--	12	--	--
18	--	--	12	--	--	15	--	--	5	--	--	5	--	--
19	--	--	12	--	--	5	--	--	8	--	--	2	--	--
20	--	--	3	--	--	--	--	--	--	--	--	2	--	--
21	--	--	3	--	--	--	--	--	--	--	--	0	--	--
22	--	--	--	--	--	--	--	--	--	--	--	2	--	--
23	--	--	--	--	--	--	--	--	--	--	--	--	--	--
24	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
26	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	1154	162	62	1357	273	163	940	377	272	1160	525	423	2738	1017

-- = missing data.

[a] "Start" for all late thinnings was 1973 at age 25 before thinning cut, and WHC was 1977. Western hemlock is one year younger than the ages given for Douglas-fir.

[b] WHC = western hemlock.

Table 16--Periodic annual quadratic mean diameter growth by treatment, treatment period, year, and stand age

Treatment	Calib. (1963-66) (15-18)[a]	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-90) (37-42)	Total (1963-90) (15-42)
	Diameter growth							
	Inches per year							Total Inches
	Net growth							
Fixed:								
1	.52	.55	.60	.62	.58	.54	.53	15.18
3	.53	.54	.54	.49	.41	.41	.36	12.45
5	.51	.48	.47	.38	.33	.28	.28	10.22
7	.53	.48	.42	.34	.27	.25	.23	9.33
Increasing:								
2	.53	.59	.63	.57	.48	.43	.41	13.88
4	.53	.56	.54	.48	.39	.35	.29	11.74
Decreasing:								
6	.54	.52	.49	.44	.42	.41	.37	12.09
8	.51	.46	.39	.32	.27	.26	.23	9.02
Unthinned:								
Control	.26	.24	.22	.18	.14	.22	.20	5.57
Late thinning:								
Late 1	--	--	--	.40	.51	.47	.46	7.84
Late 3	--	--	--	.34	.40	.36	.33	6.03
Late 5	--	--	--	.27	.26	.26	.26	4.50
Late 7	--	--	--	.26	.22	.20	.19	3.65
	Survivor growth[b]							
Fixed:								
1	.52	.55	.60	.62	.58	.54	.53	15.20
3	.53	.54	.54	.49	.41	.41	.36	12.44
5	.51	.48	.47	.39	.33	.28	.27	10.20
7	.53	.48	.41	.34	.27	.25	.22	9.22
Increasing:								
2	.53	.59	.63	.59	.48	.43	.41	13.96
4	.53	.56	.54	.47	.39	.35	.29	11.73
Decreasing:								
6	.54	.52	.49	.44	.42	.41	.37	12.10
8	.51	.46	.39	.31	.27	.25	.23	8.95
Unthinned:								
Control	.27	.24	.21	.15	.12	.11	.11	4.43
Late thinning:								
Late 1	--	--	--	.40	.51	.47	.46	7.84
Late 3	--	--	--	.34	.39	.36	.33	6.00
Late 5	--	--	--	.27	.26	.23	.23	4.21
Late 7	--	--	--	.26	.22	.19	.17	3.54

-- = missing data.

[a] Stand age in parenthesis.

[b] Includes only trees alive at the end of each period.

Table 17--Periodic annual basal area growth by treatment, treatment period, year, and stand age

Treatment	Calib. (1963-66) (15-18)[a]	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-90) (37-42)	Total (1963-90) (15-42)
	Basal area growth							
	Square feet per acre per year							Total ft² per acre
	Net growth							
Fixed:								
1	9.54	8.22	7.44	6.39	4.97	4.10	4.60	167.88
3	10.48	8.73	9.92	8.06	6.51	5.96	5.94	209.18
5	10.12	10.63	11.49	8.26	8.21	7.00	6.85	236.33
7	10.15	12.27	12.69	11.39	9.33	8.61	7.92	274.90
Increasing:								
2	10.89	7.92	7.80	6.44	5.93	5.53	5.93	188.85
4	10.68	9.25	10.30	9.63	8.29	7.72	7.12	239.15
Decreasing:								
6	10.45	11.14	11.20	9.15	7.72	6.35	6.56	235.25
8	9.37	10.98	11.18	9.56	8.24	7.02	7.18	240.96
Unthinned:								
Control	14.85	14.29	12.73	9.59	8.03	4.50	5.18	252.72
Late thinning:								
Late 1	--	--	--	5.44	5.50	4.25	4.82	84.86
Late 3	--	--	--	7.73	8.58	7.03	7.36	130.14
Late 5	--	--	--	8.32	8.20	6.77	7.39	130.10
Late 7	--	--	--	10.23	9.39	7.73	7.56	147.18
	Gross growth							
Fixed:								
1	9.73	8.29	7.60	6.39	4.97	4.10	4.60	169.30
3	10.48	8.73	9.92	8.18	6.51	5.96	5.94	209.67
5	10.18	10.70	11.59	9.32	8.21	7.00	7.17	242.96
7	10.15	12.27	12.75	11.43	9.33	8.73	8.40	278.21
Increasing:								
2	10.98	7.92	7.80	6.88	5.93	5.53	5.93	190.89
4	10.68	9.25	10.39	9.76	8.29	7.72	7.12	240.04
Decreasing:								
6	10.48	11.30	11.20	9.15	7.72	6.35	6.56	235.79
8	9.37	11.27	11.52	9.57	8.24	7.15	7.18	243.77
Unthinned								
Control	15.13	14.56	13.23	10.51	8.54	7.52	7.59	286.19
Late thinning:								
Late 1	--	--	--	5.44	5.50	4.25	4.82	84.86
Late 3	--	--	--	7.81	8.62	7.03	7.36	130.61
Late 5	--	--	--	8.36	8.20	7.11	7.65	132.93
Late 7	--	--	--	10.49	9.51	8.16	8.05	152.89

-- = missing data.

[a] Stand age data in parenthesis.

Table 18--Periodic annual cubic-foot volume growth by treatment, teatment period, year, and stand age

Treatment	Calib. (1963-66) (15-18)	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-19) (37-42)	Total (1963-90) (15-42)
	Cubic Foot Per Acre Per Year							Total ft^3 per acre
	Net growth							
Fixed:								
1	164	178	189	195	179	159	212	4974
3	187	181	270	267	253	254	312	6841
5	180	252	322	319	351	337	388	8553
7	167	277	362	417	404	418	449	9986
Increasing:								
2	203	176	224	216	237	245	316	6406
4	191	207	288	336	340	361	386	8425
Decreasing:								
6	182	250	318	306	302	273	344	7809
8	160	255	334	349	379	328	377	8694
Unthinned:								
Control	268	359	403	419	372	342	427	10159
Late thinning:								
Late 1	--	--	--	171	194	160	214	3163
Late 3	--	--	--	252	322	282	334	5097
Late 5	--	--	--	309	338	301	381	5700
Late 7	--	--	--	391	399	333	409	6539
	Gross growth							
Fixed:								
1	166	179	193	195	179	159	212	4998
3	187	181	270	270	253	254	312	6852
5	181	253	324	346	351	337	399	8726
7	167	277	363	418	404	422	464	10083
Increasing:								
2	205	176	224	228	237	245	316	6457
4	191	207	290	338	340	361	386	8443
Decreasing:								
6	182	253	318	306	302	273	344	7818
8	160	260	342	350	379	331	377	8753
Unthinned:								
Control	272	363	412	437	382	408	490	10909
Late thinning:								
Late 1	--	--	--	171	194	160	214	3163
Late 3	--	--	--	253	323	282	334	5107
Late 5	--	--	--	310	338	309	387	5762
Late 7	--	--	--	398	402	344	425	6699

-- = missing data.

[a] Stand age in parenthesis.

Table 19--Periodic annual board-foot volume growth in 16-foot logs to a 6-inch top, Scribner scale, by treatment, treatment period, year, and stand age

Treatment numbers	Calib. (1963-66) (15-18)	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-19) (37-42)	Total (1963-90) (15-42)
	Volume growth							
	Board feet per acre per year							
	Net growth							
Fixed:								
1	55	311	744	954	943	885	1246	21430
3	96	366	992	1292	1314	1418	1835	30629
5	69	462	1201	1507	1809	1846	2277	38436
7	55	447	1172	1806	1974	2264	2570	43220
Increasing:								
2	127	480	977	1110	1282	1397	1901	30391
4	79	444	1142	1629	1778	2003	2264	39095
Decreasing								
6	96	456	1148	1418	1565	1527	2034	34461
8	39	369	1040	1518	1797	1752	2138	36341
Unthinned:								
Control	66	415	993	1400	1590	1828	2419	36783
Late thinning:								
Late 1	--	--	--	680	1003	878	1225	16369
Late 3	--	--	--	989	1531	1492	1896	25526
Late 5	--	--	--	1194	1591	1581	2154	28233
Late 7	--	--	--	1267	1657	1682	2193	29386
	Gross growth							
Fixed:								
1	55	311	750	954	943	885	1246	21456
3	96	366	992	1296	1314	1418	1835	30643
5	69	462	1202	1585	1809	1846	2309	38913
7	55	447	1172	1806	1974	2269	2602	43398
Increasing:								
2	127	480	977	1158	1282	1397	1901	30583
4	79	444	1142	1632	1778	2003	2264	39112
Decreasing:								
6	96	459	1148	1418	1565	1527	2034	34469
8	39	369	1048	1518	1797	1752	2138	36373
Unthinned:								
Control	66	415	997	1425	1590	1849	2453	37150
Late thinning:								
Late 1	--	--	--	680	1003	878	1225	16369
Late 3	--	--	--	989	1531	1492	1896	25526
Late 5	--	--	--	1194	1591	1581	2156	28240
Late 7	--	--	--	1284	1658	1689	2234	29694

-- = missing data.

[a] Stand age in parenthesis.

Table 20--Live trees cut by treatment at start of period

Treatment	Live trees cut, by period						
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	Total
			Trees per acre				
Fixed:							
1	161.7	88.3	58.3	26.7	15.0	0	350.0
3	161.7	33.3	58.3	31.7	21.7	0	306.7
5	61.7	48.3	51.7	20.0	25.0	0	206.7
7	5.0	16.7	35.0	30.0	23.3	0	110.0
Increasing:							
2	220.0	58.3	33.3	10.0	6.7	0	328.3
4	163.3	23.3	30.0	21.7	13.3	0	251.7
Decreasing:							
6	70.0	63.3	71.7	51.7	41.7	0	298.3
8	0	11.7	51.7	43.3	41.7	0	148.3
Unthinned:							
Control	0	0	0	0	0	0	0
Late thinning:							
Late 1	0	0	995.0	71.7	28.3	0	100.0
Late 3	0	0	1084.0	55.0	51.7	0	106.7
Late 5	0	0	563.0	36.7	43.3	0	80.0
Late 7	0	0	635.0	36.7	41.7	0	78.3
			Quadratic mean diameter--inches				
Fixed:							
1	5.1	6.5	8.6	12.3	13.8	0	
3	5.2	6.4	8.6	10.5	12.0	0	
5	5.2	6.4	8.3	9.5	11.3	0	
7	4.8	6.5	8.1	9.7	10.7	0	
Increasing:							
2	5.2	7.0	9.2	12.2	14.1	0	
4	5.3	6.6	9.0	10.9	12.2	0	
Decreasing:							
6	5.2	6.6	8.4	10.1	11.3	0	
8	0	6.1	7.6	8.9	10.0	0	
Control	0	0	0	0	0	0	
Late thinning:							
Late 1	0	0	4.9	6.6	10.8	0	
Late 3	0	0	4.5	7.9	9.2	0	
Late 5	0	0	5.2	7.6	8.5	0	
Late 7	0	0	3.7	7.1	8.0	0	

Table 20--Live trees cut by treatment at start of period (continued)

Treatment	Live trees cut, by period						
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	Total
			Basal area--square feet per acre				
Fixed:							
1	23.3	20.2	23.6	22.1	15.5	0	104.7
3	24.0	7.4	23.6	19.1	17.0	0	91.1
5	9.2	10.8	19.6	9.9	17.3	0	66.7
7	.6	3.9	12.5	15.5	14.5	0	47.0
Increasing:							
2	32.0	15.4	15.5	8.1	7.3	0	78.2
4	25.2	5.6	13.1	14.0	10.8	0	68.7
Decreasing:							
6	10.2	14.9	27.7	28.5	29.0	0	110.3
8	0	2.4	16.4	18.9	22.6	0	60.3
Unthinned:							
Control	0	0	0	0	0	0	0
Late thinning:							
Late 1	0	0	132.2	17.2	18.1	0	35.3
Late 3	0	0	117.8	18.6	23.8	0	42.4
Late 5	0	0	83.0	11.7	16.9	0	28.6
Late 7	0	0	47.3	10.0	14.6	0	24.7
			Volume--cubic feet per acre				
Fixed:							
1	327	344	478	547	422	0	2119
3	343	122	501	473	475	0	1914
5	132	192	423	256	509	0	1511
7	8	66	265	391	418	0	1149
Increasing:							
2	472	273	344	213	198	0	1500
4	369	98	287	362	317	0	1433
Decreasing:							
6	147	261	604	727	851	0	2590
8	0	42	358	483	674	0	1556
Unthinned:							
Control	0	0	0	0	0	0	0
Late thinning:							
Late 1	0	0	2882	399	517	0	916
Late 3	0	0	2546	454	665	0	1119
Late 5	0	0	1862	300	484	0	784
Late 7	0	0	970	246	409	0	655

Table 20--Live trees cut by treatment at start of period (continued)

Treatment	Live trees cut, by period						
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	Total
Volume--Scribner board-ft. per acre, 16-ft. logs, to a 6-inch top							
Fixed:							
1	87	270	1088	2079	1772	0	5296
3	109	97	1108	1555	1826	0	4695
5	14	159	923	752	1900	0	3747
7	0	46	507	1174	1455	0	3182
Increasing:							
2	141	318	902	813	839	0	3014
4	87	86	726	1260	1260	0	3419
Decreasing:							
6	63	245	1303	2236	3134	0	6981
8	0	19	603	1342	2194	0	4158
Unthinned:							
Control	0	0	0	0	0	0	0
Late thinning:							
Late 1	0	0	--	427	1829	0	2255
Late 3	0	0	--	985	1904	0	2888
Late 5	0	0	--	560	1278	0	1838
Late 7	0	0	--	342	902	0	1244

-- = missing data.

[a] stand age in parenthesis.

Table 21--Periodic annual mortality, all trees, by treatment, period, year, and stand age

Treatment	Periodic annual mortality, end of period							
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)	Total
				Trees per acre				
Fixed:								
1	7	2	2	0	0	0	0	11
3	0	0	0	2	0	0	0	2
5	2	2	2	8	0	0	3	17
7	0	0	2	2	0	2	7	13
Increasing:								
2	2	0	0	2	0	0	0	4
4	0	0	2	2	0	0	0	4
Decreasing:								
6	2	2	0	0	0	0	0	4
8	0	7	5	2	0	3	0	17
Unthinned:								
Control	8	15	42	68	37	158	118	446
Late thinning:								
Late 1	--	--	--	0	0	0	0	0
Late 3	--	--	--	2	2	0	0	4
Late 5	--	--	--	2	0	10	10	22
Late 7	--	--	--	3	3	10	10	26
				Quadratic mean diameter--inches				
Fixed:								
1	3.85	4.46	7.66	.00	.00	.00	.00	
3	.00	.00	.00	6.67	.00	.00	.00	
5	4.02	4.39	6.03	9.85	.00	.00	9.90	
7	.00	.00	4.94	4.10	.00	6.66	7.88	
Increasing:								
2	5.13	.00	.00	12.69	.00	.00	.00	
4	.00	.00	5.85	6.84	.00	.00	.00	
Decreasing:								
6	2.76	6.47	.00	.00	.00	.00	.00	
8	.00	4.78	7.09	2.47	.00	5.55	.00	
Unthinned:								
Control	4.39	3.15	2.95	3.15	3.19	3.74	4.33	
Late thinning:								
Late 1	--	--	--	.00	.00	.00	.00	
Late 3	--	--	--	5.39	3.67	.00	.00	4.61
Late 5	--	--	--	3.83	.00	4.95	4.94	4.86
Late 7	--	--	--	7.99	5.45	5.63	6.70	6.34

Table 21--Periodic annual mortality, all trees, by treatment, period, year, and stand age (continued)

Treatment	Periodic annual mortality, end of period							
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)	Total
	Basal area--square feet per acre							
Fixed:								
1	.57	.22	.64	.00	.00	.00	.00	1.42
3	.00	.00	.00	.48	.00	.00	.00	.48
5	.18	.21	.40	4.24	.00	.00	1.60	6.62
7	.00	.00	.27	.18	.00	.48	2.37	3.31
Increasing:								
2	.29	.00	.00	1.76	.00	.00	.00	2.04
4	.00	.00	.37	.51	.00	.00	.00	.88
Decreasing:								
6	.08	.46	.00	.00	.00	.00	.00	.54
8	.00	.87	1.37	.07	.00	.50	.00	2.81
Unthinned:								
Control	.84	.81	1.99	3.68	2.05	12.05	12.05	33.47
Late thinning:								
Late 1	--	--	--	.00	.00	.00	.00	.00
Late 3	--	--	--	.32	.15	.00	.00	.46
Late 5	--	--	--	.16	.00	1.34	1.33	2.83
Late 7	--	--	--	1.04	.49	1.73	2.45	5.71
	Volume--cubic feet per acre							
Fixed:								
1	7.10	3.42	12.80	.00	.00	.00	.00	23.32
3	.00	.00	.00	11.80	.00	.00	.00	11.80
5	2.26	3.27	7.65	107.19	.00	.00	52.61	172.98
7	.00	.00	5.13	3.91	.00	13.58	74.68	97.30
Increasing:								
2	4.29	.00	.00	46.26	.00	.00	.00	50.55
4	.00	.00	7.17	10.95	.00	.00	.00	18.12
Decreasing:								
6	.97	8.13	.00	.00	.00	.00	.00	9.10
8	.00	14.04	29.64	.85	.00	14.19	.00	58.72
Unthinned:								
Control	12.07	12.20	34.12	73.42	38.05	264.90	316.09	750.86
Late thinning:								
Late 1	--	--	--	.00	.00	.00	.00	.00
Late 3	--	--	--	6.64	2.69	.00	.00	9.33
Late 5	--	--	--	3.01	.00	29.00	29.52	62.33
Late 7	--	--	--	25.93	12.42	46.38	75.53	160.26

Table 21--Periodic annual mortality, all trees, by treatment, period, year, and stand age (continued)

Treatment	Periodic annual mortality, end of period							
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)	Total
	Volume--Scribner board ft. per acre, 16-ft. logs to 6-inch top							
Fixed:								
1	.00	.00	25.35	.00	.00	.00	.00	25.35
3	.00	.00	.00	14.33	.00	.00	.00	14.33
5	.00	.00	4.00	312.00	.00	.00	160.38	476.40
7	.00	.00	.00	.00	.00	17.15	161.61	178.76
Increased:								
2	.00	.00	.00	192.70	.00	.00	.00	192.70
4	.00	.00	2.47	14.68	.00	.00	.00	17.16
Decreased:								
6	.00	7.64	.00	.00	.00	.00	.00	7.64
8	.00	.00	32.35	.00	.00	.00	.00	32.35
Unthinned:								
Control	.00	.00	15.62	99.12	.00	82.08	169.95	366.76
Late thinning:								
Late 1	--	--	--	.00	.00	.00	.00	.00
Late 3	--	--	--	.00	.00	.00	.00	.00
Late 5	--	--	--	.00	.00	.00	7.53	7.53
Late 7	--	--	--	68.90	1.73	29.12	208.62	308.37

-- = missing data.

[a] Stand age, end of period in parenthesis.

Table 22--Mean height of crop trees by treatment, total age, and year at beginning of period

Treatment	Height, by period							
	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Feet							
Fixed:								
1	23.8	32.8	41.8	52.9	62.9	74.4	83.1	95.7
2	24.2	34.4	42.3	53.8	64.2	73.5	82.1	94.4
5	26.0	35.3	44.1	55.4	66.5	76.3	84.8	96.3
7	23.4	32.6	41.7	52.6	63.0	72.0	80.5	90.7
Increasing:								
2	27.4	37.2	45.5	58.1	68.0	78.5	87.4	100.4
4	25.7	34.8	43.9	55.4	66.3	75.7	84.7	96.1
Decreasing:								
6	25.7	34.9	43.5	54.8	64.1	73.8	82.7	95.6
8	25.0	33.9	42.8	53.7	63.4	73.4	80.9	90.0
Unthinned:								
Control	25.6	35.4	44.0	54.0	63.3	70.6	77.4	88.5
Late thinned:								
Late 1	--	--	--	53.9	63.1	72.5	79.6	90.9
Late 3	--	--	--	53.3	62.7	72.6	79.7	90.1
Late 5	--	--	--	55.8	66.1	75.3	82.2	92.7
Late 7	--	--	--	51.6	62.0	70.8	77.0	87.1

-- = missing data.

[a] Stand age in parenthesis.

Table 23--Mean diameter of crop trees by treatment, total age and year at beginning of period

Treatment numbers	1963 (15)	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
				Inches				
Fixed:								
1	3.7	5.4	7.1	9.6	12.1	14.6	16.7	19.3
3	4.1	5.8	7.5	9.9	12.0	13.7	15.3	17.1
5	4.2	5.8	7.4	9.6	11.3	12.8	14.1	15.6
7	3.9	5.5	7.0	8.9	10.3	11.5	12.6	13.8
Increasing:								
2	4.7	6.5	8.3	10.9	13.2	15.1	16.9	18.9
4	4.1	5.7	7.5	9.8	11.8	13.5	14.9	16.5
Decreasing:								
6	4.2	5.9	7.6	9.8	11.7	13.5	15.1	17.1
8	3.8	5.4	6.9	8.6	9.9	11.0	12.0	13.1
Unthinned:								
Control	4.2	5.7	7.0	8.3	9.2	10.0	10.6	11.5
Late thinned:								
Late 1	--	--	--	8.3	10.1	12.4	14.2	16.5
Late 3	--	--	--	8.2	9.7	11.5	13.0	14.8
Late 5	--	--	--	8.3	9.7	11.0	12.2	13.7
Late 7	--	--	--	8.3	9.6	10.7	11.2	12.9

Table 24--Stand development by treatment, per-acre basis

	After thinning						Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H40[a]	Trees left	Avg dbh	Basal area	Total vol	Trees cut[b]	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	DBH PAI	BA PAI	Vol PAI	Vol MAI
	Yrs	*Ft*	*No.*	*In*	*ft²*	*Ft³*	*No.*	*In*	*Ft²*	*Ft³*	*Ft³*		*No.*	*In*	*Ft²*	*Ft³*	*Ft³*	*Ft³*	*In*	*Ft²*	*Ft³*	*Ft³*
Treatment 1, fixed:																						
1963	15	28	405	3.6	28.2	304	0	0.0	0.0	0	0.0	.00	0	0.0	0.0	0	304	304	.00	0.0	0	20
1966	18	36	237	5.2	33.5	467	62	5.1	23.3	327	2.0	.99	7	.0	.6	7	794	802	.52	9.5	164	44
1969	21	44	147	6.9	38.0	658	88	6.5	20.2	344	4.1	.97	2	.0	.2	3	1329	1340	.55	8.2	178	63
1973	25	55	87	9.7	44.1	938	58	8.6	23.6	478	8.4	.93	2	.0	.6	13	2087	2111	.60	7.4	189	83
1977	29	65	60	12.2	47.6	1169	27	12.3	22.1	547	20.7	1.01	0	.0	.0	0	2866	2889	.62	6.4	195	99
1981	33	75	45	14.7	52.0	1464	15	13.8	15.5	422	29.8	.97	0	.0	.0	0	3582	3606	.58	5.0	179	109
1985	37	84	45	16.8	68.4	2100	0	.0	.0	0	.0	.00	0	.0	.0	0	4219	4242	.54	4.1	159	114
1990	42	97	45	19.5	91.4	3160	0	.0	.0	0	.0	.00	0	.0	.0	0	5278	5301	.53	4.6	212	126
Treatment 3, fixed:																						
1963	15	28	405	3.7	29.5	314	0	.0	.0	0	.0	.00	0	.0	.0	0	314	314	.00	.0	0	21
1966	18	38	243	5.3	37.0	531	162	5.2	24.0	343	2.1	.99	0	.0	.0	0	875	875	.53	10.5	187	49
1969	21	46	210	7.0	55.8	952	33	6.4	7.4	122	3.6	.91	0	.0	.0	0	1417	1417	.54	8.7	181	67
1973	25	56	152	9.4	71.9	1532	58	8.6	23.6	501	8.7	.95	0	.0	.0	0	2498	2498	.54	9.9	270	100
1977	29	67	118	11.6	85.0	2127	32	10.5	19.1	473	15.1	.94	2	.0	.5	12	3566	3578	.49	8.1	267	123
1981	33	75	97	13.6	94.1	2664	22	12.0	17.0	475	21.9	.91	0	.0	.0	0	4578	4590	.41	6.5	253	139
1985	37	85	97	15.2	117.9	3680	0	.0	.0	0	.0	.00	0	.0	.0	0	5594	5606	.41	6.0	254	151
1990	42	98	97	17.0	147.6	5241	0	.0	.0	0	.0	.00	0	.0	.0	0	7154	7166	.36	5.9	312	170
Treatment 5, fixed:																						
1963	15	29	405	3.7	31.1	355	0	.0	.0	0	.0	.00	0	.0	.0	0	355	355	.00	.0	0	24
1966	18	40	342	5.3	52.3	762	62	5.2	9.2	132	2.1	.97	2	.0	.2	2	894	897	.51	10.1	180	50
1969	21	48	292	6.8	73.3	1325	48	6.4	10.8	192	4.0	.95	2	.0	.2	3	1650	1655	.48	10.6	252	79
1973	25	60	238	8.8	99.7	2192	52	8.3	19.6	423	8.2	.96	2	.0	.4	8	2939	2952	.47	11.5	322	118
1977	29	71	210	10.4	122.8	3214	20	9.5	9.9	256	12.8	.93	8	.0	4.2	107	4216	4337	.38	8.3	319	145
1981	33	80	185	11.7	138.4	4108	25	11.3	17.3	509	20.8	.97	0	.0	.0	0	5619	5739	.33	8.2	351	170
1985	37	89	185	12.8	166.4	5457	0	.0	.0	0	.0	.00	0	.0	.0	0	6968	7088	.28	7.0	337	188
1990	42	101	182	14.2	200.7	7397	0	.0	.0	0	.0	.00	3	.0	1.6	53	8908	9081	.28	6.8	388	212
Treatment 7, fixed:																						
1963	15	27	405	3.5	27.4	286	0	.0	.0	0	.0	.00	0	.0	.0	0	286	286	.00	.0	0	19
1966	18	37	400	5.1	57.2	780	5	4.8	.6	8	.5	.30	0	.0	.0	0	788	788	.53	10.1	167	44
1969	21	46	383	6.6	90.1	1545	17	6.5	3.9	66	2.5	.63	0	.0	.0	0	1619	1619	.48	12.3	277	77
1973	25	56	347	8.2	128.3	2727	35	8.1	12.5	265	7.7	.99	2	.0	.3	5	3067	3072	.42	12.7	362	123
1977	29	66	315	9.6	158.4	4005	30	9.7	15.5	391	13.0	1.01	2	.0	.2	4	4736	4745	.34	11.4	417	163
1981	33	75	292	10.7	181.2	5204	23	10.7	14.5	418	18.1	1.00	0	.0	.0	0	6354	6363	.27	9.3	404	193
1985	37	86	290	11.7	215.6	6878	0	.0	.0	0	.0	.00	2	.0	.5	14	8028	8050	.25	8.6	418	217
1990	42	97	283	12.9	255.3	9122	0	.0	.0	0	.0	.00	7	.0	2.4	75	10271	10369	.23	7.9	449	245

Table 24--Stand development by treatment, per-acre basis (continued)

			After thinning				Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H40[a]	Trees left	Avg dbh	Basal area	Total vol	Trees cut[b]	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	DBH PAI	BA PAI	Vol PAI	Vol MAI
	Yrs	*Ft*	*No.*	*In*	*Ft^2*	*Ft^3*	*No.*	*In*	*Ft^2*	*Ft^3*	*Ft^3*		*No.*	*In*	*Ft^2*	*Ft^3*	*Ft^3*	*ft^3*	*In*	*Ft^3*	*Ft^3*	*Ft^3*
Treatment 2, increasing:																						
1963	15	30	405	3.9	3.6	384	0	.0	.0	0	.0	.00	0	.0	.0	0	384	384	.00	.0	0	26
1966	18	40	183	5.9	4.2	522	220	5.2	32.0	472	2.1	.94	2	.0	.3	4	994	998	.53	10.9	203	55
1969	21	48	125	7.9	42.6	778	58	7.0	15.4	273	4.7	.91	0	.0	.0	0	1523	1527	.59	7.9	176	73
1973	25	60	92	10.8	58.3	1331	33	9.2	15.5	344	10.4	.89	0	.0	.0	0	2420	2425	.63	7.8	224	97
1977	29	70	80	13.2	76.0	1984	10	12.2	8.1	213	21.5	.92	2	.0	1.8	46	3286	3337	.57	6.4	216	113
1981	33	80	73	15.2	92.4	2732	7	14.1	7.3	198	32.3	.96	0	.0	.0	0	4232	4283	.48	5.9	237	128
1985	37	89	73	17.0	114.5	3713	0	.0	.0	0	.0	.00	0	.0	.0	0	5212	5263	.43	5.5	245	141
1990	42	102	73	19.0	144.2	5291	0	.0	.0	0	.0	.00	0	.0	.0	0	6791	6841	.41	5.9	316	162
Treatment 4, increasing:																						
1963	15	30	405	3.8	31.3	354	0	.0	.0	0	.0	.00	0	.0	.0	0	354	354	.00	.0	0	24
1966	18	38	242	5.4	38.1	560	163	5.3	25.2	369	2.3	.99	0	.0	.0	0	929	929	.53	10.7	191	52
1969	21	47	218	7.1	60.3	1083	23	6.6	5.6	98	4.2	.94	0	.0	.0	0	1549	1549	.56	9.2	207	74
1973	25	58	187	9.3	88.4	1948	30	9.0	13.1	287	9.6	.96	2	.0	.4	7	2702	2709	.54	10.3	288	108
1977	29	69	163	11.3	112.9	2929	22	10.9	14.0	362	16.8	.97	2	.0	.5	11	4045	4063	.48	9.6	336	139
1981	33	77	150	12.9	135.2	3971	13	12.2	10.8	317	23.7	.94	0	.0	.0	0	5404	5422	.39	8.3	340	164
1985	37	86	150	14.3	166.1	5415	0	.0	.0	0	.0	.00	0	.0	.0	0	6847	6865	.35	7.7	361	185
1990	42	98	150	15.7	201.7	7347	0	.0	.0	0	.0	.00	0	.0	.0	0	8780	8798	.29	7.1	386	209
Treatment 6, decreasing:																						
1963	15	28	405	3.6	29.2	328	0	.0	.0	0	.0	.00	0	.0	.0	0	328	.00	.00	.0	0	22
1966	18	37	333	5.3	50.4	727	70	5.2	10.2	147	1.4	.62	2	.0	.1	1	873	874	.54	10.4	182	49
1969	21	45	268	6.9	68.9	1216	63	6.6	14.9	261	4.2	.96	2	.0	.5	8	1623	1633	.52	11.1	250	77
1973	25	56	197	9.1	86.0	1882	72	8.4	27.7	604	8.7	.95	0	.0	.0	0	2894	2903	.49	11.2	318	116
1977	29	64	145	11.1	94.1	2380	52	10.1	28.5	727	14.3	.94	0	.0	.0	0	4119	4128	.44	9.2	306	142
1981	33	74	103	13.2	96.0	2737	42	11.3	29.0	851	21.4	.90	0	.0	.0	0	5326	5336	.42	7.7	302	161
1985	37	85	103	14.9	121.4	3827	0	.0	.0	0	.0	.00	0	.0	.0	0	6417	6426	.41	6.3	272	173
1990	42	100	103	16.7	154.2	5548	0	.0	.0	0	.0	.00	0	.0	.0	0	8137	8146	.37	6.6	344	194
Treatment 8, decreasing:																						
1963	15	28	405	3.4	25.7	287	0	.0	.0	0	.0	.00	0	.0	.0	0	287	287	.00	.0	0	19
1966	18	38	405	4.9	53.9	766	0	.0	.0	0	.0	.00	0	.0	.0	0	766	766	.51	9.4	160	43
1969	21	47	387	6.3	84.4	1490	12	6.1	2.4	42	1.2	.31	7	.0	.9	14	1532	1546	.46	11.0	255	73
1973	25	56	330	7.9	112.7	2470	52	7.6	16.4	358	7.1	.98	5	.0	1.4	30	2870	2913	.39	11.2	334	115
1977	29	67	285	9.2	132.1	3385	43	8.9	18.9	483	11.3	.98	2	.0	.1	1	4267	4312	.32	9.6	349	147
1981	33	77	243	10.4	142.4	4228	42	10.0	22.6	674	16.2	.97	0	.0	.0	0	5784	5829	.27	8.2	379	175
1985	37	85	240	11.4	170.4	5539	0	.0	.0	0	.0	.00	3	.0	.5	14	7095	7154	.26	7.0	328	192
1990	42	96	240	12.6	206.4	7425	0	.0	.0	0	.0	.00	0	.0	.0	0	8981	9040	.23	7.2	377	214

Table 24--Stand development by treatment, per-acre basis (continued)

			After thinning				Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H40[a]	Trees left	Avg dbh	Basal area	Total vol	Trees cut[b]	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	DBH PAI	BA PAI	Vol PAI	Vol MAI
	Yrs	*Ft*	*No.*	*In*	*Ft²*	*Ft³*	*No.*	*In*	*Ft²*	*Ft³*	*Ft³*		*No.*	*In*	*Ft²*	*Ft³*	*Ft³*	*Ft³*	*In*	*Ft²*	*Ft³*	*Ft³*
Treatment 9, unthinned control																						
1963	15	29	888	3.3	51.5	560	0	.0	.0	0	.0	.00	0	.0	.0	0	560	560	.00	.0	0	37
1966	18	39	1075	4.0	96.1	1363	0	.0	.0	0	.0	.00	8	.0	.8	12	1363	1375	.26	14.8	268	76
1969	21	47	1127	4.8	138.9	2439	0	.0	.0	0	.0	.00	15	.0	.8	12	2439	2463	.24	14.3	359	116
1973	25	58	1107	5.6	189.9	4053	0	.0	.0	0	.0	.00	42	.0	2.0	34	4053	4112	.22	12.7	403	162
1977	29	69	1048	6.4	228.2	5729	0	.0	.0	0	.0	.00	68	.0	3.7	73	5729	5861	.18	9.6	419	198
1981	33	77	1015	7.0	260.3	7217	0	.0	.0	0	.0	.00	37	.0	2.0	38	7217	7387	.14	8.0	372	219
1985	37	85	857	7.8	278.4	8584	0	.0	.0	0	.0	.00	158	.0	12.0	265	8584	9019	.22	4.5	342	232
1990	42	97	738	8.8	304.3	10718	0	.0	.0	0	.0	.00	118	.0	12.0	316	10718	11469	.20	5.2	427	255
Late thinning, L1																						
1973	25	56	162	7.0	43.5	948	995[e]	4.9	132.2	2882	2.9	.91	0	.0	.0	0	948	948	.00	.0	0	38
1977	29	65	90	9.9	48.0	1232	72	6.6	17.2	399	5.6	.77	0	.0	.0	0	1630	1630	.40	5.4	171	56
1981	33	74	62	12.4	51.9	1490	28	10.8	18.1	517	18.3	.91	0	.0	.0	0	2406	2406	.51	5.5	194	73
1985	37	82	62	14.3	68.9	2128	0	.0	.0	0	.0	.00	0	.0	.0	0	3044	3044	.47	4.2	160	82
1990	42	93	62	16.6	93.0	3196	0	.0	.0	0	.0	.00	0	.0	.0	0	4112	4112	.46	4.8	214	98
Late thinning, L3																						
1973	25	55	273	7.0	73.4	1586	1084[e]	4.5	117.8	2546	2.3	.88	0	.0	.0	0	1586	1586	.00	.0	0	63
1977	29	65	217	8.5	85.8	2140	55	7.9	18.6	454	8.2	.94	2	.0	.3	7	2593	2600	.34	7.7	252	89
1981	33	75	163	10.4	96.3	2763	52	9.2	23.8	665	12.9	.91	2	.0	.1	3	3882	3892	.40	8.6	322	118
1985	37	82	163	11.8	124.4	3892	0	.0	.0	0	.0	.00	0	.0	.0	0	5011	5021	.36	7.0	282	135
1990	42	93	163	13.5	161.2	5564	0	.0	.0	0	.0	.00	0	.0	.0	0	6683	6693	.33	7.4	334	159
Late thinning, L5																						
1973	25	59	377	7.0	100.3	2254	563[e]	5.2	83.0	1862	3.3	.87	0	.0	.0	0	2254	2254	.00	.0	0	90
1977	29	70	338	8.1	121.9	3191	37	7.6	11.7	300	8.4	.95	2	.0	.2	3	3491	3494	.27	8.3	309	120
1981	33	79	293	9.3	137.8	4058	43	8.5	16.9	484	11.2	.92	0	.0	.0	0	4842	4845	.26	8.2	338	147
1985	37	86	283	10.3	164.9	5263	0	.0	.0	0	.0	.00	10	.0	1.3	30	6047	6079	.26	6.8	301	163
1990	42	98	272	11.7	201.7	7167	0	.0	.0	0	.0	.00	10	.0	1.3	30	7954	8016	.26	7.4	381	189
Late thinning, L7																						
1973	25	55	525	6.7	128.4	2634	635[e]	3.7	47.0	970	1.5	.68	0	.0	.0	0	2634	2634	.00	.0	0	105
1977	29	65	485	7.8	159.3	3952	37	7.1	10.0	246	6.3	.89	3	.0	1.0	26	4198	4224	.26	10.2	391	145
1981	33	73	442	8.7	182.2	5139	42	8.0	14.6	409	10.2	.94	3	.0	.5	12	5794	5832	.22	9.4	399	176
1985	37	80	433	9.5	213.1	6470	0	.0	.0	0	.0	.00	10	.0	1.7	46	7125	7210	.20	7.7	333	193
1990	42	92	423	10.5	250.9	8517	0	.0	.0	0	.0	.00	10	.0	2.5	76	9173	9333	.19	7.6	409	218

[a] Ht-40: Average height of the 40 largest trees per acre (estimated from d.b.h. and ht-d.b.h. curves).

[b] Volume: All volumes are total stem, inside bark.

[c] d/D: Average d.b.h. cut/average d.b.h. before thinning.

[d] Total yield: Net = standing + thinning Gross = standing + thinning + mortality.
Yield does not include any volume removed in a calibration cut.

[e] Trees and volume cut in initial late thinning, in 1973, ae not included in yields.

HEIGHT, 100 LARGEST TREES PER HECTARE

Table 25--Mean height of 100 largest trees per hectare by treatment, total age and year at beginning of period

Treatment	Height							
	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Meters							
Fixed:								
1	8.5	11.0	13.5	16.9	19.9	22.9	25.6	29.5
3	8.6	11.6	13.9	17.1	20.4	23.0	25.9	30.0
5	9.0	12.1	14.6	18.2	21.5	24.5	27.1	30.9
7	8.2	11.4	13.9	17.0	20.1	23.0	26.2	29.4
Increasing:								
2	9.1	12.1	14.6	18.4	21.4	24.3	27.0	31.1
4	9.1	11.4	14.4	17.8	21.1	23.6	26.3	29.7
Decreasing:								
6	8.4	11.3	13.7	17.1	19.7	22.7	25.9	30.5
8	8.4	11.5	14.2	17.1	20.5	23.3	25.8	29.4
Unthinned:								
Control	8.9	11.8	14.5	17.8	20.9	23.4	26.0	29.7
Late thinning:								
Late 1	--	--	--	17.0	20.0	22.6	24.9	28.3
Late 3	--	--	--	16.8	19.8	22.8	25.1	28.5
Late 5	--	--	--	18.0	21.4	24.2	26.2	29.9
Late 7	--	--	--	16.7	19.7	22.4	24.4	28.0
WHC[b]	--	--	--	--	19.2	21.9	24.4	27.4

-- = missing data.

[a] Stand age in parenthesis.

[b] WHC = western hemlock.

Table 26--Mean diameter of 100 largest trees per hectare by treatment, total age and year at beginning of period

Treatment	Diameter							
	1963 (15)[a]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Centimeters							
Fixed:								
1	12.4	17.3	21.3	27.4	33.8	38.6	43.4	50.0
3	13.5	18.5	22.6	28.9	34.5	38.6	42.4	47.5
5	13.6	18.0	22.3	28.4	33.3	37.3	40.9	45.5
7	12.7	17.5	21.8	27.2	31.7	35.0	38.6	42.2
Increasing:								
2	14.2	19.3	23.6	30.2	36.1	41.4	38.6	51.3
4	13.2	18.0	22.6	28.9	34.0	38.3	42.4	47.0
Decreasing:								
6	12.9	18.0	22.6	28.4	33.3	37.8	45.7	48.3
8	12.2	17.0	21.3	26.4	30.5	34.3	38.1	41.9
Unthinned:								
Control	13.5	17.8	21.6	25.9	29.2	32.2	34.5	37.8
Late thinned:								
Late 1	--	--	--	23.1	28.2	33.8	38.3	44.7
Late 3	--	--	--	23.9	28.2	32.2	36.3	41.4
Late 5	--	--	--	25.4	29.2	33.0	36.6	41.1
Late 7	--	--	--	25.1	29.2	33.0	36.3	40.1

-- = missing data.

[a] Stand age in parenthesis.

Table 27--Number of live trees per hectare by treatment, plot, treatment period, year, and stand age

Treatment	Plot	Live trees													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
		After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Trees per hectare													
Fixed:															
1	6	1000	976	457	457	309	309	185	185	124	124	99	99	99	99
	20	1000	988	580	580	346	333	198	198	136	136	99	99	99	99
	27	1000	988	716	704	432	432	259	259	185	185	136	136	136	136
Avg.		1000	984	585	580	362	358	214	214	148	148	111	111	111	111
3	9	1000	1000	679	679	568	568	432	420	358	358	309	309	309	309
	10	1000	1000	605	605	556	556	383	383	284	284	222	222	222	222
	22	1000	1000	519	519	432	432	309	309	235	235	185	185	185	185
Avg.		1000	1000	601	601	519	519	375	371	292	292	239	239	239	239
5	8	1000	988	827	815	704	704	580	556	506	506	469	469	469	457
	16	1000	1000	815	815	704	692	568	556	506	506	445	445	445	432
	18	1000	1000	889	889	753	753	618	593	543	543	457	457	457	457
Avg.		1000	996	844	840	720	716	589	568	519	519	457	457	457	449
7	1	1000	1000	963	963	877	865	790	790	716	716	667	655	655	642
	21	1000	1000	1000	1000	1000	1000	914	902	827	827	753	753	753	729
	23	1000	1000	1000	1000	963	963	865	865	790	790	741	741	741	729
Avg.		1000	1000	988	988	947	943	856	852	778	778	720	716	716	700
Increasing:															
2	3	1000	1000	469	469	321	321	247	235	222	222	198	198	198	198
	5	1000	988	457	457	321	321	235	235	198	198	185	185	185	185
	11	1000	1000	432	432	284	284	198	198	173	173	161	161	161	161
Avg.		1000	996	453	453	309	309	226	222	198	198	181	181	181	181
4	12	1000	1000	618	618	568	568	482	469	432	432	395	395	395	395
	14	1000	1000	630	630	556	543	494	494	420	420	395	395	395	395
	15	1000	1000	543	543	494	494	408	408	358	358	321	321	321	321
Avg.		1000	1000	597	597	539	535	461	457	403	403	371	371	371	371
Decreasing:															
6	2	1000	1000	667	667	531	531	383	383	284	284	210	210	210	210
	13	1000	1000	815	803	630	630	469	469	321	321	235	235	235	235
	26	1000	988	988	988	827	827	605	605	469	469	321	321	321	321
Avg.		1000	996	823	819	663	663	486	486	358	358	255	255	255	255
8	7	1000	1000	1000	976	889	865	778	778	679	679	593	580	580	580
	24	1000	1000	1000	1000	1000	988	852	852	716	716	593	580	580	580
	25	1000	1000	1000	976	976	976	815	803	716	716	618	618	618	618
Avg.		1000	1000	1000	984	955	943	815	811	704	704	601	593	593	593
Unthinned:															
Control	4	2742	3322	3322	3495	3495	3483	3483	3347	3347	3347	3347	2865	2865	2433
	17	1692	2025	2025	2149	2149	2100	2100	2025	2025	2038	2038	1655	1655	1457
	19	2149	2618	2618	2705	2705	2618	2618	2396	2396	2137	2137	1828	1828	1581
Avg.		2194	2655	2655	2783	2783	2733	2733	2589	2589	2507	2507	2116	2116	1824

Table 27--Number of live trees per hectare by treatment, plot, treatment period, year, and stand age (continued)

		Live trees													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Trees per hectare													
Late thinned:															
Late 1	32	--	--	--	--	--	--	395	395	222	222	148	148	148	148
	34	--	--	--	--	--	--	395	395	210	210	148	148	148	148
	37	--	--	--	--	--	--	408	408	235	235	161	161	161	161
Avg.		--	--	--	--	--	--	399	399	222	222	152	152	152	152
Late 3	30	--	--	--	--	--	--	679	679	543	543	420	420	420	420
	31	--	--	--	--	--	--	667	667	531	531	408	408	408	408
	33	--	--	--	--	--	--	679	667	531	519	383	383	383	383
Avg.		--	--	--	--	--	--	675	671	535	531	403	403	403	403
Late 5	35	--	--	--	--	--	--	939	939	815	815	679	667	667	655
	36	--	--	--	--	--	--	926	926	827	827	741	729	729	729
	38	--	--	--	--	--	--	926	914	865	852	753	704	704	642
Avg.		--	--	--	--	--	--	930	926	836	832	725	700	700	675
Late 7	28	--	--	--	--	--	--	1284	1272	1149	1149	1062	1037	1037	1037
	29	--	--	--	--	--	--	1457	1457	1334	1334	1198	1186	1186	1173
	39	--	--	--	--	--	--	1149	1136	1112	1099	1013	988	988	926
Avg.		--	--	--	--	--	--	1297	1289	1198	1194	1091	1070	1070	1046

-- = missing data.

[a] Stand age in parenthesis.

Table 28--Quadratic mean diameter (centimeters) for all live trees, by treatment, plot, treatment period, year and stand age

		Quadratic mean diameter													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Centimeters													
Fixed:															
1	6	10.3	14.3	14.5	19.0	19.1	25.6	26.6	33.3	33.2	39.4	39.2	44.7	44.7	51.7
	20	8.7	12.7	13.0	17.4	18.0	24.2	25.3	31.9	32.2	38.4	39.4	45.3	45.3	52.4
	27	8.2	11.9	11.8	15.6	15.9	21.4	22.4	28.2	27.6	33.0	33.4	38.4	38.4	44.5
Avg.		9.0	13.0	13.1	17.3	17.7	23.7	24.8	31.1	31.0	36.9	37.3	42.8	42.8	49.5
3	9	9.0	12.9	12.8	16.7	16.9	22.1	22.1	26.5	26.2	29.8	30.0	33.2	33.2	36.8
	10	8.9	12.8	13.0	17.0	17.2	22.7	23.4	28.7	29.6	34.3	35.3	40.1	40.1	45.1
	22	9.9	14.3	14.7	19.1	19.4	25.2	26.1	31.4	32.7	37.1	38.3	42.8	42.8	48.0
Avg.		9.3	13.3	13.5	17.6	17.9	23.3	23.9	28.9	29.5	33.7	34.5	38.7	38.7	43.3
5	8	9.6	13.6	13.5	17.3	17.5	22.1	22.4	26.2	26.5	29.4	29.4	32.0	32.0	35.7
	16	9.9	13.7	13.7	17.3	17.4	22.3	22.6	26.4	26.7	30.2	30.4	33.2	33.2	36.6
	18	9.1	13.0	13.1	16.8	16.9	21.8	21.8	25.9	25.8	29.4	29.6	32.8	32.8	36.2
Avg.		9.5	13.4	13.5	17.1	17.3	22.1	22.3	26.2	26.3	29.7	29.8	32.7	32.7	36.2
7	1	9.4	13.5	13.6	17.4	17.4	21.8	21.8	25.4	25.4	28.2	28.2	31.0	31.0	34.0
	21	8.3	12.3	12.3	16.0	16.0	20.3	20.3	23.8	23.7	26.6	26.6	29.3	29.3	32.5
	23	9.1	13.2	13.2	16.6	16.7	20.8	20.9	24.2	24.2	26.7	26.7	28.9	28.9	31.7
Avg.		8.9	13.0	13.0	16.7	16.7	20.9	21.0	24.5	24.5	27.2	27.2	29.7	29.7	32.7
Increasing:															
2	3	9.9	14.0	14.7	19.0	19.7	26.0	26.3	31.6	31.7	36.2	36.8	40.7	40.7	45.7
	5	9.8	13.8	14.7	19.3	19.8	25.9	27.0	32.7	33.6	38.2	38.2	42.3	42.3	47.5
	11	10.0	14.1	15.3	19.9	20.9	27.5	29.3	35.8	35.7	41.3	41.3	46.5	46.5	52.0
Avg.		9.9	13.9	14.9	19.4	20.1	26.5	27.5	33.4	33.7	38.6	38.8	43.2	43.2	48.4
4	12	9.3	13.3	13.4	17.6	17.6	22.8	23.0	27.5	27.6	31.3	31.7	35.2	35.2	38.9
	14	9.5	13.5	13.3	17.6	17.8	23.2	23.3	27.9	28.1	31.7	31.8	35.3	35.3	39.1
	15	9.9	14.0	14.3	18.8	18.9	24.8	25.0	30.3	30.5	34.9	34.9	38.6	38.6	42.2
Avg.		9.6	13.6	13.7	18.0	18.1	23.6	23.7	28.6	28.7	32.7	32.8	36.4	36.4	40.0
Decreasing:															
6	2	10.2	14.5	15.0	19.3	19.5	25.0	25.6	30.3	31.2	35.5	36.8	41.1	41.1	46.0
	13	9.5	13.5	13.7	17.6	17.8	23.0	23.4	28.1	29.1	33.7	34.7	38.8	38.8	43.6
	26	7.9	11.9	11.9	15.6	15.7	20.0	20.3	24.2	24.4	28.3	29.3	33.4	33.4	38.0
Avg.		9.2	13.3	13.5	17.5	17.7	22.7	23.1	27.5	28.2	32.5	33.6	37.8	37.8	42.5
8	7	9.4	13.3	13.3	16.7	16.8	20.7	20.7	23.7	23.8	26.4	26.4	29.0	29.0	31.9
	24	8.2	12.0	12.0	15.5	15.5	19.6	19.7	23.0	23.1	26.2	26.4	29.4	29.4	32.5
	25	8.4	12.4	12.4	16.0	16.0	19.9	20.0	23.4	23.4	26.0	26.3	28.7	28.7	31.4
Avg.		8.7	12.5	12.5	16.1	16.1	20.1	20.1	23.4	23.4	26.2	26.3	29.0	29.0	31.9
Unthinned:															
Control	4	8.3	10.1	10.1	11.7	11.7	13.5	13.5	14.9	14.9	15.8	15.8	17.7	17.7	20.0
	17	8.1	10.1	10.1	12.1	12.1	14.7	14.7	16.7	16.7	18.0	18.0	20.8	20.8	23.2
	19	8.4	10.6	10.6	12.6	12.6	15.0	15.0	17.1	17.1	19.2	19.2	21.4	21.4	24.1
Avg.		8.3	10.3	10.3	12.1	12.1	14.4	14.4	16.2	16.2	17.7	17.7	19.9	19.9	22.4

Table 28--Quadratic mean diameter (centimeters) for all live trees, by treatment, plot, treatment period, year and stand age (continued)

		Quadratic mean diameter													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Centimeters													
Late thinned:															
Late 1	32	--	--	--	--	--	--	17.8	22.1	25.2	31.0	32.3	37.6	37.6	43.9
	34	--	--	--	--	--	--	18.0	22.2	25.8	30.8	31.9	36.7	36.7	42.5
	37	--	--	--	--	--	--	17.7	21.3	24.5	29.3	30.6	34.9	34.9	40.5
Avg.		--	--	--	--	--	--	17.9	21.9	25.2	30.4	31.6	36.4	36.4	42.3
Late 3	30	--	--	--	--	--	--	17.7	21.1	21.4	25.3	25.8	29.1	29.1	33.2
	31	--	--	--	--	--	--	17.8	21.5	21.9	26.0	26.6	30.5	30.5	34.7
	33	--	--	--	--	--	--	18.1	21.4	21.7	25.8	26.9	30.6	30.6	34.8
Avg.		--	--	--	--	--	--	17.8	21.3	21.7	25.7	26.5	30.1	30.1	34.2
Late 5	35	--	--	--	--	--	--	17.7	20.7	20.9	23.9	24.3	27.2	27.2	30.5
	36	--	--	--	--	--	--	17.8	20.6	20.7	23.3	23.4	25.6	25.6	28.4
	38	--	--	--	--	--	--	17.7	20.3	20.3	22.9	23.2	26.0	26.0	29.9
Avg.		--	--	--	--	--	--	17.8	20.5	20.7	23.3	23.6	26.3	26.3	29.6
Late 7	28	--	--	--	--	--	--	17.2	20.0	20.1	22.3	22.3	24.4	24.4	26.9
	29	--	--	--	--	--	--	16.0	18.5	18.6	20.8	21.0	22.9	22.9	25.0
	39	--	--	--	--	--	--	18.0	20.5	20.6	22.9	23.1	25.3	25.3	27.9
Avg.		--	--	--	--	--	--	17.1	19.7	19.8	22.0	22.2	24.2	24.2	26.6

-- = missing data.

[a] Stand age in parenthesis.

Table 29--Basal area per hectare for all live trees, by treatment, plot, treatment period, year, and stand age

		Basal area													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Square meters per hectare													
Fixed:															
1	6	8.3	15.7	7.5	13.0	8.8	15.8	10.3	16.1	10.7	15.0	11.9	15.5	15.5	20.7
	20	5.9	12.4	7.7	13.8	8.8	15.3	10.0	15.8	11.0	15.7	12.1	15.9	15.9	21.3
	27	5.3	11.1	7.8	13.4	8.5	15.6	10.2	16.2	11.1	15.8	11.9	15.8	15.8	21.1
Avg.		6.5	13.1	7.7	13.4	8.7	15.6	10.2	16.0	11.0	15.5	12.0	15.7	15.7	21.0
3	9	6.4	13.1	8.7	14.9	12.8	21.8	16.5	23.2	19.3	25.0	21.8	26.7	26.7	32.9
	10	6.3	12.9	8.0	13.8	12.9	22.5	16.5	24.8	19.5	26.2	21.8	28.0	28.0	35.5
	22	7.7	16.1	8.8	14.9	12.8	21.6	16.5	23.9	19.8	25.4	21.4	26.6	26.6	33.5
Avg.		6.8	14.0	8.5	14.5	12.8	22.0	16.5	23.9	19.5	25.5	21.6	27.1	27.1	34.0
5	8	7.2	14.3	11.9	19.1	16.9	27.1	22.9	30.0	27.9	34.4	31.8	37.8	37.8	45.7
	16	7.7	14.8	12.1	19.3	16.8	27.0	22.9	30.5	28.4	36.2	32.2	38.5	38.5	45.6
	18	6.5	13.3	12.0	19.7	16.9	28.2	23.0	31.1	28.4	36.8	31.5	38.5	38.5	47.1
Avg.		7.1	14.1	12.0	19.4	16.9	27.4	22.9	30.5	28.3	35.8	31.8	38.3	38.3	46.2
7	1	7.0	14.4	14.0	23.0	20.9	32.3	29.5	40.2	36.4	44.8	41.6	49.4	49.4	58.1
	21	5.4	11.9	11.9	20.2	20.2	32.2	29.5	40.1	36.4	45.9	41.8	50.7	50.7	60.4
	23	6.5	13.6	13.6	21.7	21.0	32.7	29.6	39.7	36.4	44.3	41.5	48.7	48.7	57.6
Avg.		6.3	13.3	13.2	21.6	20.7	32.4	29.5	40.0	36.4	45.0	41.7	49.6	49.6	58.7
Increasing:															
2	3	7.7	15.4	7.9	13.3	9.8	17.1	13.5	18.4	17.6	22.9	21.0	25.8	25.8	32.5
	5	7.5	14.8	7.7	13.4	9.8	16.9	13.4	19.7	17.5	22.6	21.2	26.0	26.0	32.9
	11	7.9	15.5	7.9	13.4	9.8	16.9	13.3	19.9	17.3	23.2	21.5	27.2	27.2	34.1
Avg.		7.7	15.2	7.9	13.3	9.8	17.0	13.4	19.3	17.5	22.9	21.3	26.3	26.3	33.2
4	12	6.8	13.9	8.7	15.0	13.9	23.2	20.1	27.9	25.8	33.2	31.1	38.4	38.4	46.9
	14	7.1	14.3	8.8	15.4	13.9	23.0	21.0	30.3	26.0	33.2	31.4	38.6	38.6	47.4
	15	7.7	15.5	8.8	15.1	13.9	23.9	19.9	29.4	26.1	34.3	30.8	37.7	37.7	44.9
Avg.		7.2	14.6	8.8	15.1	13.9	23.3	20.3	29.2	26.0	33.6	31.1	38.2	38.2	46.4
Decreasing:															
6	2	8.2	16.5	11.8	19.5	15.9	26.1	19.7	27.7	21.7	28.1	22.4	27.9	27.9	34.9
	13	7.1	14.4	12.0	19.5	15.7	26.2	20.1	29.1	21.4	28.6	22.2	27.8	27.8	35.1
	26	4.9	10.9	10.9	18.8	15.9	26.1	19.5	27.8	21.9	29.5	21.6	28.1	28.1	36.4
Avg.		6.7	13.9	11.6	19.3	15.9	26.2	19.8	28.2	21.6	28.7	22.1	27.9	27.9	35.5
8	7	6.9	13.9	13.9	21.3	19.7	29.0	26.1	34.4	30.3	37.1	32.4	38.4	38.4	46.3
	24	5.3	11.3	11.3	18.9	18.9	29.7	26.0	35.4	30.1	38.7	32.4	39.4	39.4	48.2
	25	5.5	12.1	12.1	19.7	19.7	30.4	25.7	34.4	30.7	38.0	33.5	39.8	39.8	47.9
Avg.		5.9	12.4	12.4	20.0	19.4	29.7	25.9	34.7	30.4	37.9	32.7	39.2	39.2	47.5
Unthinned:															
Control	4	14.9	26.8	26.8	37.5	37.5	49.5	49.5	58.0	58.0	66.0	66.0	70.2	70.2	76.2
	17	8.7	16.4	16.4	24.8	24.8	35.5	35.5	44.3	44.3	52.0	52.0	56.0	56.0	61.7
	19	12.0	23.1	23.1	33.6	33.6	46.0	46.0	55.2	55.2	61.7	61.7	65.9	65.9	72.0
Avg.		11.9	22.1	22.1	32.0	32.0	43.7	43.7	52.5	52.5	59.9	59.9	64.0	64.0	70.0

Table 29--Basal area per hectare for all live trees, by treatment, plot, treatment period, year, and stand age (continued)

		Basal area													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Square meters per hectare													
Late thinned:															
Late 1	32	--	--	--	--	--	--	9.9	15.2	11.1	16.8	12.2	16.5	16.5	22.4
	34	--	--	--	--	--	--	10.0	15.3	11.0	15.7	11.9	15.7	15.7	21.0
	37	--	--	--	--	--	--	10.1	14.6	11.1	15.9	11.8	15.4	15.4	20.7
Avg.		--	--	--	--	--	--	10.0	15.0	11.0	16.1	11.9	15.9	15.9	21.4
Late 3	30	--	--	--	--	--	--	16.6	23.8	19.5	27.4	22.0	27.9	27.9	36.3
	31	--	--	--	--	--	--	16.6	24.1	19.9	28.3	22.6	29.8	29.8	38.5
	33	--	--	--	--	--	--	17.5	24.1	19.7	27.2	21.8	28.1	28.1	36.4
Avg.		--	--	--	--	--	--	16.9	24.0	19.7	27.6	22.1	28.6	28.6	37.1
Late 5	35	--	--	--	--	--	--	23.2	31.6	28.1	36.5	31.5	38.8	38.8	47.9
	36	--	--	--	--	--	--	23.1	30.9	28.0	35.1	31.8	37.5	37.5	46.2
	38	--	--	--	--	--	--	22.9	29.6	28.0	35.2	31.8	37.5	37.5	45.2
Avg.		--	--	--	--	--	--	23.1	30.7	28.0	35.6	31.7	37.9	37.9	46.4
Late 7	28	--	--	--	--	--	--	29.8	39.8	36.4	45.1	41.6	48.6	48.6	58.9
	29	--	--	--	--	--	--	29.4	39.4	36.4	45.3	41.6	48.8	48.8	57.5
	39	--	--	--	--	--	--	29.3	37.6	37.1	45.4	42.5	49.6	49.6	56.7
Avg.		--	--	--	--	--	--	29.5	38.9	36.6	45.3	41.9	49.0	49.0	57.7

-- = missing data.

[a] Stand age in parenthesis.

Table 30--Total stem volume per hectare for all live trees by treatment, plot, treatment period, year, and stand age

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Cubic meters per hectare													
Fixed:															
1	6	29	70	34	71	49	107	71	129	85	134	106	151	151	220
	20	19	52	32	71	46	96	63	113	79	127	100	144	144	218
	27	16	45	32	68	44	94	63	118	82	135	101	147	147	225
Avg.		21	56	33	70	46	99	66	120	82	132	102	147	147	221
3	9	20	56	38	76	66	141	107	174	145	216	189	253	253	351
	10	20	55	34	70	66	145	107	187	148	222	184	261	261	380
	22	26	72	40	79	68	141	108	184	153	221	187	259	259	369
Avg.		22	61	37	75	67	142	107	182	149	220	186	258	258	367
5	8	25	63	53	105	93	181	154	239	223	310	287	375	375	511
	16	27	67	54	107	94	182	155	245	229	332	296	390	390	517
	18	22	58	53	107	92	186	151	244	223	328	280	380	380	526
Avg.		25	63	53	106	93	183	153	243	225	323	288	382	382	518
7	1	23	61	60	122	112	211	193	312	283	395	367	487	487	645
	21	17	47	47	103	103	205	188	304	276	397	362	485	485	643
	23	21	57	57	113	110	212	192	307	281	389	364	473	473	627
Avg.		20	55	55	113	108	209	191	308	280	394	364	481	481	639
Increasing:															
2	3	27	70	37	72	54	117	92	145	138	205	189	257	257	367
	5	26	68	37	75	56	120	97	163	145	212	199	267	267	377
	11	27	70	36	73	53	115	91	153	133	199	185	256	256	367
Avg.		27	70	37	74	54	117	93	154	139	205	191	260	260	370
4	12	23	61	38	80	74	152	132	217	200	294	275	376	376	515
	14	25	65	40	85	77	157	144	244	210	304	288	394	394	535
	15	27	69	39	83	76	161	134	231	205	303	271	368	368	492
Avg.		25	65	39	83	76	156	136	230	205	300	278	379	379	514
Decreasing:															
6	2	28	74	54	107	88	177	134	214	169	250	199	279	279	402
	13	24	63	52	103	83	171	131	220	159	240	184	256	256	368
	26	16	46	46	100	85	174	130	219	172	264	192	269	269	395
Avg.		23	61	51	103	85	174	132	218	167	251	192	268	268	388
8	7	24	62	62	117	108	195	176	271	239	339	296	382	382	508
	24	18	47	47	99	99	196	171	273	232	347	289	385	385	522
	25	19	52	52	106	106	203	172	268	239	344	303	397	397	529
Avg.		20	54	54	107	104	198	173	271	237	343	296	388	388	520
Unthinned:															
Control	4	50	116	116	199	199	320	320	440	440	548	548	648	648	803
	17	28	70	70	132	132	229	229	337	337	437	437	526	526	662
	19	40	100	100	181	181	302	302	426	426	530	530	628	628	785
Avg.		39	95	95	171	171	284	284	401	401	505	505	601	601	750

Table 30--Total stem volume per hectare for all live trees by treatment, plot, treatment period, year, and stand age (continued)

		Volume													
		Calibration		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6	
Treatment	Plot	After cut 1963 (15)[a]	Before cut 1966 (18)	After cut 1966 (18)	Before cut 1969 (21)	After cut 1969 (21)	Before cut 1973 (25)	After cut 1973 (25)	Before cut 1977 (29)	After cut 1977 (29)	Before cut 1981 (33)	After cut 1981 (33)	Before cut 1985 (37)	After cut 1985 (37)	Before cut 1990 (42)
		Cubic meters per hectare													
Late thinned:															
Late 1	32	--	--	--	--	--	--	66	115	86	146	104	152	152	230
	34	--	--	--	--	--	--	68	118	88	141	108	155	155	230
	37	--	--	--	--	--	--	66	109	85	135	100	140	140	211
Avg.		--	--	--	--	--	--	66	114	86	140	104	149	149	224
Late 3	30	--	--	--	--	--	--	106	176	144	232	187	259	259	371
	31	--	--	--	--	--	--	110	184	153	247	198	286	286	406
	33	--	--	--	--	--	--	117	185	152	241	196	273	273	391
Avg.		--	--	--	--	--	--	111	182	150	240	193	272	272	390
Late 5	35	--	--	--	--	--	--	158	251	223	326	282	377	377	519
	36	--	--	--	--	--	--	157	244	222	311	282	359	359	489
	38	--	--	--	--	--	--	158	238	225	317	288	369	369	498
Avg.		--	--	--	--	--	--	158	244	223	318	284	368	368	502
Late 7	28	--	--	--	--	--	--	186	301	275	388	358	450	450	608
	29	--	--	--	--	--	--	180	293	271	385	354	444	444	583
	39	--	--	--	--	--	--	187	287	283	393	368	464	464	597
Avg.		--	--	--	--	--	--	184	294	277	388	360	453	453	596

-- = missing data.

[a] Stand age in parenthesis.

Table 31--Total yield in cubic meters by treatment, year, and stand age

Treatment	Yield[a]							
	1963 (15)[b]	1966 (18)	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)
	Cubic meters per hectare							
	Net yield							
Fixed:								
1	21	56	93	146	201	251	295	369
3	22	61	99	175	250	320	392	501
5	25	63	115	206	295	393	488	624
7	20	55	113	215	332	445	562	719
Increasing:								
2	27	70	107	169	230	296	365	475
4	25	65	108	189	283	378	479	615
Decreasing:								
6	23	61	114	203	288	373	449	570
8	20	54	107	201	299	405	497	629
Unthinned:								
Control	39	95	171	284	401	505	601	750
Late thinning:								
Late 1	--	--	--	66	114	168	213	288
Late 3	--	--	--	111	182	272	351	468
Late 5	--	--	--	158	244	339	423	557
Late 7	--	--	--	184	294	406	499	642
	Gross yield							
Fixed:								
1	21	56	94	148	202	252	297	371
3	22	61	99	175	250	321	392	502
5	25	63	116	207	304	402	496	636
7	20	55	113	215	332	445	564	726
Increasing:								
2	27	70	107	170	234	300	368	479
4	25	65	108	190	284	380	481	616
Decreasing:								
6	23	61	114	203	289	373	450	570
8	20	54	108	204	302	408	501	633
Unthinned:								
Control	39	96	172	288	410	517	631	803
Late thinning:								
Late 1	--	--	--	66	114	168	213	288
Late 3	--	--	--	111	182	272	351	468
Late 5	--	--	--	158	245	339	426	561
Late 7	--	--	--	184	296	408	505	653

-- = missing data.

[a] Wood cut in initial late thinning, in 1973, is not included in cumulative yield.

[b] Stand age in parenthesis.

Table 32--Periodic annual quadratic mean diameter growth in centimeters by treatment, treatment period, year, and stand age

Treatment	Calib. (1963-66) (15-18)[a]	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-90) (37-42)	Total (1963-90) (15-42)
	Centimeters per year							Total cm
	Net growth							
Fixed:								
1	1.31	1.40	1.52	1.59	1.47	1.37	1.34	38.60
3	1.35	1.38	1.37	1.25	1.05	1.04	.92	31.66
5	1.30	1.22	1.20	.97	.83	.72	.71	25.98
7	1.35	1.23	1.06	.87	.68	.64	.60	23.74
Increasing:								
2	1.35	1.50	1.59	1.45	1.23	1.10	1.05	35.29
4	1.35	1.43	1.37	1.21	.99	.89	.74	29.86
Decreasing:								
6	1.36	1.32	1.26	1.12	1.07	1.04	.95	30.75
8	1.29	1.18	.99	.81	.69	.67	.58	22.93
Unthinned:								
Control	.67	.61	.56	.47	.36	.57	.50	14.15
Late thinning								
Late 1	--	--	--	1.00	1.30	1.20	1.18	19.94
Late 3	--	--	--	.87	1.02	.90	.83	15.34
Late 5	--	--	--	.69	.67	.67	.67	11.45
Late 7	--	--	--	.65	.56	.51	.48	9.28
	Survivor growth[b]							
Fixed:								
1	1.31	1.40	1.53	1.59	1.47	1.37	1.34	38.66
3	1.35	1.38	1.37	1.24	1.05	1.04	.92	31.63
5	1.30	1.22	1.20	.99	.83	.72	.68	25.93
7	1.35	1.23	1.05	.87	.68	.63	.56	23.46
Increasing:								
2	1.35	1.50	1.59	1.50	1.23	1.10	1.05	35.50
4	1.35	1.43	1.37	1.20	.99	.89	.74	29.82
Decreasing:								
6	1.36	1.33	1.26	1.12	1.07	1.04	.95	30.77
8	1.29	1.17	.99	.79	.69	.64	.58	22.76
Unthinned:								
Control	.69	.60	.52	.39	.30	.28	.29	11.26
Late thinning:								
Late 1	--	--	--	1.00	1.30	1.20	1.18	19.94
Late 3	--	--	--	.87	1.00	.90	.83	15.25
Late 5	--	--	--	.69	.66	.59	.59	10.71
Late 7	--	--	--	.65	.56	.48	.44	9.00

-- = missing data.

[a] Stand age in parenthesis.

[b] Includes only trees alive at the end of each period.

Table 33--Periodic annual basal area growth per hectare by treatment, treatment period, year, and stand age

Treatment	Basal area growth							
	Calib. (1963-66) (15-18)[a]	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-90) (37-42)	Total (1963-90) (15-42)
	Square meters per hectare per year							Total m²/ha
	Net growth							
Fixed:								
1	2.19	1.89	1.71	1.47	1.14	.94	1.06	38.61
3	2.41	2.01	2.28	1.85	1.50	1.37	1.37	48.11
5	2.33	2.45	2.64	1.90	1.89	1.61	1.57	54.36
7	2.33	2.82	2.92	2.62	2.15	1.98	1.82	63.23
Increasing:								
2	2.50	1.82	1.79	1.48	1.36	1.27	1.36	43.43
4	2.46	2.13	2.37	2.22	1.91	1.77	1.64	55.01
Decreasing:								
6	2.40	2.56	2.58	2.11	1.77	1.46	1.51	54.11
8	2.16	2.53	2.57	2.20	1.89	1.62	1.65	55.42
Unthinned:								
Control	3.41	3.29	2.93	2.21	1.85	1.04	1.19	58.13
Late thinning:								
Late 1	--	--	--	1.25	1.26	.98	1.11	19.52
Late 3	--	--	--	1.78	1.97	1.62	1.69	29.93
Late 5	--	--	--	1.91	1.89	1.56	1.70	29.92
Late 7	--	--	--	2.35	2.16	1.78	1.74	33.85
	Gross growth							
Fixed:								
1	2.24	1.91	1.75	1.47	1.14	.94	1.06	38.94
3	2.41	2.01	2.28	1.88	1.50	1.37	1.37	48.22
5	2.34	2.46	2.66	2.14	1.89	1.61	1.65	55.88
7	2.33	2.82	2.93	2.63	2.15	2.01	1.93	63.99
Increasing:								
2	2.53	1.82	1.79	1.58	1.36	1.27	1.36	43.90
4	2.46	2.13	2.39	2.24	1.91	1.77	1.64	55.21
Decreasing:								
6	2.41	2.60	2.58	2.11	1.77	1.46	1.51	54.23
8	2.16	2.59	2.65	2.20	1.89	1.64	1.65	56.07
Unthinned:								
Control	3.48	3.35	3.04	2.42	1.96	1.73	1.75	65.82
Late thinning:								
Late 1	--	--	--	1.25	1.26	.98	1.11	19.52
Late 3	--	--	--	1.80	1.98	1.62	1.69	30.04
Late 5	--	--	--	1.92	1.89	1.63	1.76	30.57
Late 7	--	--	--	2.41	2.19	1.88	1.85	35.16

-- = missing data.

[a] Stand age in parenthesis.

Table 34--Periodic annual cubic-meter volume growth by treatment, treatment period, year, and stand age

Treatment	Total volume growth							
	Calib. (1963-66) (15-18)[a]	Period 1 (1966-69) (18-21)	Period 2 (1969-73) (21-25)	Period 3 (1973-77) (25-29)	Period 4 (1977-81) (29-33)	Period 5 (1981-85) (33-37)	Period 6 (1985-90) (37-42)	Total (1963-90) (15-42)
	Cubic meters per hectare per year							Total m³/ha
	Net growth							
Fixed								
1	11	12	13	14	13	11	15	348
3	13	13	19	19	18	18	22	479
5	13	18	23	22	25	24	27	599
7	12	19	25	29	28	29	31	699
Increasing:								
2	14	12	16	15	17	17	22	448
4	13	14	20	23	24	25	27	590
Decreasing:								
6	13	18	22	21	21	19	24	547
8	11	18	23	24	27	23	26	609
Unthinned:								
Control	19	25	28	29	26	24	30	711
Late thinning:								
Late 1	--	--	--	12	14	11	15	221
Late 3	--	--	--	18	23	20	23	357
Late 5	--	--	--	22	24	21	27	399
Late 7	--	--	--	27	28	23	29	458
	Gross growth							
Fixed:								
1	12	13	13	14	13	11	15	350
3	13	13	19	19	18	18	22	480
5	13	18	23	24	25	24	28	611
7	12	19	25	29	28	30	32	706
Increasing:								
2	14	12	16	16	17	17	22	452
4	13	14	20	24	24	25	27	591
Decreasing:								
6	13	18	22	21	21	19	24	547
8	11	18	24	24	27	23	26	613
Unthinned:								
Control	19	25	29	31	27	29	34	764
Late thinning:								
Late 1	--	--	--	12	14	11	15	221
Late 3	--	--	--	18	23	20	23	357
Late 5	--	--	--	22	24	22	27	403
Late 7	--	--	--	28	28	24	30	469

-- = missing data.

[a] Stand age in parenthesis.

Table 35--Live trees cut per hectare by treatment age and year at start of period

Treatment	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	Total
	Live trees cut						
	Trees per hectare						Total trees/ha
Fixed:							
1	399.3	218.2	144.1	65.9	37.0	.0	864.5
3	399.3	82.3	144.1	78.2	53.5	.0	757.5
5	152.3	119.4	127.6	49.4	61.8	.0	510.5
7	12.3	41.2	86.5	74.1	57.6	.0	271.7
Increasing:							
2	543.4	144.1	82.3	24.7	16.5	.0	811.0
4	403.4	57.6	74.1	53.5	32.9	.0	621.6
Decreasing:							
6	172.9	156.4	177.0	127.6	102.9	.0	736.9
8	.0	28.8	127.6	107.0	102.9	.0	366.4
Unthinned:							
Control	.0	.0	.0	.0	.0	.0	.0
Late thinned:							
Late 1	--	--	--	177.0	70.0	.0	247.0
Late 3	--	--	--	135.9	127.6	.0	263.5
Late 5	--	--	--	90.6	107.0	.0	197.6
Late 7	--	--	--	90.6	102.9	.0	193.5
	Quadratic mean diameter--centimeters						
Fixed:							
1	13.1	16.5	21.9	31.3	35.0	.0	
3	13.3	16.2	21.9	26.8	30.5	.0	
5	13.3	16.3	21.2	24.3	28.6	.0	
7	12.2	16.6	20.6	24.7	27.2	.0	
Increasing:							
2	13.1	17.7	23.5	30.9	36.0	.0	
4	13.5	16.8	22.8	27.7	31.0	.0	
Decreasing:							
6	13.2	16.7	21.4	25.6	28.7	.0	
8	.0	15.6	19.4	22.8	25.4	.0	
Unthinned:							
Control	.0	.0	.0	.0	.0	.0	
Late thinned:							
Late 1	--	--	--	16.9	27.5	.0	
Late 3	--	--	--	20.0	23.4	.0	
Late 5	--	--	--	19.4	21.5	.0	
Late 7	--	--	--	18.0	20.4	.0	

Table 35--Live trees cut per hectare by treatment age and year at start of period (continued)

Treatment	Live trees cut						
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	Total
			Basal area--square meters per hectare				Total M²/ha
Fixed:							
1	5.4	4.6	5.4	5.1	3.6	.0	24.1
3	5.5	1.7	5.4	4.4	3.9	.0	21.0
5	2.1	2.5	4.5	2.3	4.0	.0	15.3
7	.1	.9	2.9	3.6	3.3	.0	10.8
Increasing:							
2	7.4	3.5	3.6	1.9	1.7	.0	18.0
4	5.8	1.3	3.0	3.2	2.5	.0	15.8
Decreasing:							
6	2.3	3.4	6.4	6.6	6.7	.0	25.4
8	.0	.5	3.8	4.4	5.2	.0	13.9
Unthinned:							
Control	.0	.0	.0	.0	.0	.0	.0
Late thinned:							
Late 1	--	--	--	4.0	4.2	.0	8.1
Late 3	--	--	--	4.3	5.5	.0	9.7
Late 5	--	--	--	2.7	3.9	.0	6.6
Late 7	--	--	--	2.3	3.4	.0	5.7
			Volume--cubic meters per hectare				Total M³/ha
Fixed:							
1	23	24	33	38	30	0	148
3	24	9	35	33	33	0	134
5	9	13	30	18	36	0	106
7	1	5	19	27	29	0	80
Increasing:							
2	33	19	24	15	14	0	105
4	26	7	20	25	22	0	100
Decreasing:							
6	10	18	42	51	60	0	181
8	0	3	25	34	47	0	109
Unthinned:							
Control	0	0	0	0	0	0	0
Late thinned:							
Late 1	--	--	--	28	36	0	64
Late 3	--	--	--	32	47	0	78
Late 5	--	--	--	21	34	0	55
Late 7	--	--	--	17	29	0	46

-- = missing data.

[a] Stand age in parenthesis.

Table 36--Periodic annual mortality per hectare, all trees, by treatment, period, year, and stand age

Treatment	Annual mortality, end of period							
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)	Total
				Trees per hectare				Total per ha
Fixed:								
1	16	4	4	0	0	0	0	24
3	0	0	0	4	0	0	0	4
5	4	4	4	21	0	0	8	41
7	0	0	4	4	0	4	16	28
Increasing:								
2	4	0	0	4	0	0	0	8
4	0	0	4	4	0	0	0	8
Decreasing:								
6	4	4	0	0	0	0	0	8
8	0	16	12	4	0	8	0	40
Thinned:								
Control	21	37	103	109	91	391	292	1104
Late thinned:								
Late 1	--	--	--	0	0	0	0	0
Late 3	--	--	--	4	4	0	0	8
Late 5	--	--	--	4	0	25	25	54
Late 7	--	--	--	8	8	25	25	66
				Quadratic mean diameter--centimeters				
Fixed:								
1	10.18	12.59	21.65	.00	.00	.00	.00	
3	.00	.00	.00	18.81	.00	.00	.00	
5	11.37	12.40	17.04	24.31	.00	.00	24.23	
7	.00	.00	13.97	11.59	.00	18.81	20.84	
Increasing:								
2	14.49	.00	.00	35.86	.00	.00	.00	
4	.00	.00	16.53	19.32	.00	.00	.00	
Decreasing:								
6	7.81	18.28	.00	.00	.00	.00	.00	
8	.00	12.64	18.28	6.99	.00	13.57	.00	
Unthinned:								
Control	10.82	8.01	7.53	7.99	8.12	9.50	10.99	
Late thinned:								
Late 1	--	--	--	.00	.00	.00	.00	
Late 3	--	--	--	15.23	10.36	.00	.00	
Late 5	--	--	--	10.82	.00	12.51	12.50	
Late 7	--	--	--	19.54	13.35	14.22	16.94	

Table 36--Periodic annual mortality per hectare, all trees, by treatment, period, year, and stand age (continued)

Treatment	Annual mortality, end of period							
	1966 (18)[a]	1969 (21)	1973 (25)	1977 (29)	1981 (33)	1985 (37)	1990 (42)	Total
	Basal area--square meters per hectare							Total m^2/ha
Fixed:								
1	.13	.05	.15	.00	.00	.00	.00	.33
3	.00	.00	.00	.11	.00	.00	.00	.11
5	.04	.05	.09	.97	.00	.00	.37	1.52
7	.00	.00	.06	.04	.00	.11	.55	.76
Increasing:								
2	.07	.00	.00	.40	.00	.00	.00	.47
4	.00	.00	.09	.12	.00	.00	.00	.20
Decreasing:								
6	.02	.11	.00	.00	.00	.00	.00	.12
8	.00	.20	.32	.02	.00	.12	.00	.65
Unthinned:								
Control	.19	.19	.46	.85	.47	2.77	2.77	7.70
Late thinned:								
Late 1	--	--	--	.00	.00	.00	.00	.00
Late 3	--	--	--	.07	.03	.00	.00	.11
Late 5	--	--	--	.04	.00	.31	.31	.65
Late 7	--	--	--	.24	.11	.40	.56	1.31
	Volume--cubic meters per hectare							Total m^3/ha
Fixed:								
1	.50	.24	.90	.00	.00	.00	.00	1.63
3	.00	.00	.00	.83	.00	.00	.00	.83
5	.16	.23	.54	7.50	.00	.00	3.68	12.11
7	.00	.00	.36	.27	.00	.95	5.23	6.81
Increasing:								
2	.30	.00	.00	3.24	.00	.00	.00	3.54
4	.00	.00	.50	.77	.00	.00	.00	1.27
Decreasing:								
6	.07	.57	.00	.00	.00	.00	.00	.64
8	.00	.98	2.07	.06	.00	.99	.00	4.11
Unthinned:								
Control	.85	.85	2.39	5.14	2.66	18.54	22.13	52.56
Late thinned:								
Late 1	--	--	--	.00	.00	.00	.00	.00
Late 3	--	--	--	.47	.19	.00	.00	.65
Late 5	--	--	--	.21	.00	2.09	2.07	4.36
Late 7	--	--	--	1.81	.87	3.25	5.29	11.22

-- = missing data.

[a] stand age in parenthesis.

STAND DEVELOPMENT TABLE, INTERNATIONAL UNITS

Table 37--Stand development table by treatment, per hectare basis

	After thinning						Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H100[a]	Trees left	Avg dbh	Basal area	Total vol[b]	Trees cut	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	dbh PAI	Ba PAI	Vol PAI	Vol MAI
	Yrs	*m*	*No*	*Cm*	m^2	m^3	*No*	*Cm*	m^2	m^3	m^3		*No*	*Cm*	m^2	m^3	m^3	m^3	*Cm*	m^2	m^3	m^3
Treatment 1																						
1963	15	8	1000	9.0	6.5	21	0	.0	.0	0	.0	.00	0	.0	.0	0	21	21	.00	.0	0	1
1966	18	11	585	13.1	7.7	33	399	13.1	5.4	23	.1	.99	16	.0	.1	0	56	56	1.31	2.2	11	3
1969	21	13	362	17.7	8.7	46	218	16.5	4.6	24	.1	.97	4	.0	.0	0	93	94	1.40	1.9	12	4
1973	25	17	214	24.8	10.2	66	144	21.9	5.4	33	.2	.93	4	.0	.1	1	146	148	1.52	1.7	13	6
1977	29	20	148	31.0	11.0	82	66	31.3	5.1	38	.6	1.01	0	.0	.0	0	201	202	1.59	1.5	14	7
1981	33	23	111	37.3	12.0	102	37	35.0	3.6	30	.8	.97	0	.0	.0	0	251	252	1.47	1.1	13	8
1985	37	26	111	42.8	15.7	147	0	.0	.0	0	.0	.00	0	.0	.0	0	295	297	1.37	.9	11	8
1990	42	30	111	49.5	21.0	221	0	.0	.0	0	.0	.00	0	.0	.0	0	369	371	1.34	1.1	15	9
Treatment 3																						
1963	15	9	1000	9.3	6.8	22	0	.0	.0	0	.0	.00	0	.0	.0	0	22	22	.00	.0	0	1
1966	18	12	601	13.5	8.5	37	399	13.3	5.5	24	.1	.99	0	.0	.0	0	61	61	1.35	2.4	13	3
1969	21	14	519	17.9	12.8	67	82	16.2	1.7	9	.1	.91	0	.0	.0	0	99	99	1.38	2.0	13	5
1973	25	17	375	23.9	16.5	107	144	21.9	5.4	35	.2	.95	0	.0	.0	0	175	175	1.37	2.3	19	7
1977	29	20	292	29.5	19.5	149	78	26.8	4.4	33	.4	.94	4	.0	.1	1	250	250	1.25	1.9	19	9
1981	33	23	239	34.5	21.6	186	54	30.5	3.9	33	.6	.91	0	.0	.0	0	320	321	1.05	1.5	18	10
1985	37	26	239	38.7	27.1	258	0	.0	.0	0	.0	.00	0	.0	.0	0	392	392	1.04	1.4	18	11
1990	42	30	239	43.3	34.0	367	0	.0	.0	0	.0	.00	0	.0	.0	0	501	502	.92	1.4	22	12
Treatment 5																						
1963	15	9	1000	9.5	7.1	25	0	.0	.0	0	.0	.00	0	.0	.0	0	25	25	.00	.0	0	2
1966	18	12	844	13.5	12.0	53	152	13.3	2.1	9	.1	.97	4	.0	.0	0	63	63	1.30	2.3	13	3
1969	21	15	720	17.3	16.9	93	119	16.3	2.5	13	.1	.95	4	.0	.0	0	115	116	1.22	2.4	18	5
1973	25	18	589	22.3	22.9	153	128	21.2	4.5	30	.2	.96	4	.0	.1	1	206	207	1.20	2.6	23	8
1977	29	22	519	26.3	28.3	225	49	24.3	2.3	18	.4	.93	21	.0	1.0	8	295	304	.97	1.9	22	10
1981	33	24	457	29.8	31.8	288	62	28.6	4.0	36	.6	.97	0	.0	.0	0	393	402	.83	1.9	25	12
1985	37	27	457	32.7	38.3	382	0	.0	.0	0	.0	.00	0	.0	.0	0	488	496	.72	1.6	24	13
1990	42	31	449	36.2	46.2	518	0	.0	.0	0	.0	.00	8	.0	.4	4	624	636	.71	1.6	27	15
Treatment 7																						
1963	15	8	1000	8.9	6.3	20	0	.0	.0	0	.0	.00	0	.0	.0	0	20	20	.00	.0	0	1
1966	18	11	988	13.0	13.2	55	12	12.2	.1	1	.0	.30	0	.0	.0	0	55	55	1.35	2.3	12	3
1969	21	14	947	16.7	20.7	108	41	16.6	.9	5	.1	.63	0	.0	.0	0	113	113	1.23	2.8	19	5
1973	25	17	856	21.0	29.5	191	86	20.6	2.9	19	.2	.99	4	.0	.1	0	215	215	1.06	2.9	25	9
1977	29	20	778	24.5	36.4	280	74	24.7	3.6	27	.4	1.01	4	.0	.0	0	332	332	.87	2.6	29	11
1981	33	23	720	27.2	41.7	364	58	27.2	3.3	29	.5	1.00	0	.0	.0	0	445	445	.68	2.1	28	13
1985	37	26	716	29.7	49.6	481	0	.0	.0	0	.0	.00	4	.0	.1	1	562	564	.64	2.0	29	15
1990	42	29	700	32.7	58.7	639	0	.0	.0	0	.0	.00	16	.0	.5	5	719	726	.60	1.8	31	17

Table 37--Stand development table by treatment, per hectare basis (continued)

			After thinning				Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H100[a]	Trees left	Avg dbh	Basal area	Total vol[b]	Trees cut	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	dbh PAI	Ba PAI	Vol PAI	Vol MAI
	Yrs	*m*	*No*	*Cm*	*m²*	*m³*	*No*	*Cm*	*m²*	*m³*	*m³*		*No*	*Cm*	*m²*	*m³*	*m³*	*m³*	*Cm*	*m²*	*m³*	*m³*
Treatment 2																						
1963	15	9	1000	9.9	7.7	27	0	.0	.0	0	.0	.00	0	.0	.0	0	27	27	.00	.0	0	2
1966	18	12	453	14.9	7.9	37	543	13.1	7.4	33	.1	.94	4	.0	.1	0	70	70	1.35	2.5	14	4
1969	21	15	309	20.1	9.8	54	144	17.7	3.5	19	.1	.91	0	.0	.0	0	107	107	1.50	1.8	12	5
1973	25	18	226	27.5	13.4	93	82	23.5	3.6	24	.3	.89	0	.0	.0	0	169	170	1.59	1.8	16	7
1977	29	21	198	33.7	17.5	139	25	30.9	1.9	15	.6	.92	4	.0	.4	3	230	234	1.45	1.5	15	8
1981	33	24	181	38.8	21.3	191	16	36.0	1.7	14	.9	.96	0	.0	.0	0	296	300	1.23	1.4	17	9
1985	37	27	181	43.2	26.3	260	0	.0	.0	0	.0	.00	0	.0	.0	0	365	368	1.10	1.3	17	10
1990	42	31	181	48.4	33.2	370	0	.0	.0	0	.0	.00	0	.0	.0	0	475	479	1.05	1.4	22	11
Treatment 4																						
1963	15	9	1000	9.6	7.2	25	0	.0	.0	0	.0	.00	0	.0	.0	0	25	25	.00	.0	0	2
1966	18	11	597	13.7	8.8	39	403	13.5	5.8	26	.1	.99	0	.0	.0	0	65	65	1.35	2.5	13	4
1969	21	14	539	18.1	13.9	76	58	16.8	1.3	7	.1	.94	0	.0	.0	0	108	108	1.43	2.1	14	5
1973	25	18	461	23.7	20.3	136	74	22.8	3.0	20	.3	.96	4	.0	.1	1	189	190	1.37	2.4	20	8
1977	29	21	403	28.7	26.0	205	54	27.7	3.2	25	.5	.97	4	.0	.1	1	283	284	1.21	2.2	23	10
1981	33	24	371	32.8	31.1	278	33	31.0	2.5	22	.7	.94	0	.0	.0	0	378	380	.99	1.9	24	11
1985	37	26	371	36.4	38.2	379	0	.0	.0	0	.0	.00	0	.0	.0	0	479	481	.89	1.8	25	13
1990	42	30	371	40.0	46.4	514	0	.0	.0	0	.0	.00	0	.0	.0	0	615	616	.74	1.6	27	15
Treatment 6																						
1963	15	8	1000	9.2	6.7	23	0	.0	.0	0	.0	.00	0	.0	.0	0	23	23	.00	.0	0	2
1966	18	11	823	13.5	11.6	51	173	13.2	2.3	10	.0	.62	4	.0	.0	0	61	61	1.36	2.4	13	3
1969	21	14	663	17.7	15.9	85	156	16.7	3.4	18	.1	.96	4	.0	.1	1	114	114	1.32	2.6	18	5
1973	25	17	486	23.1	19.8	132	177	21.4	6.4	42	.2	.95	0	.0	.0	0	203	203	1.26	2.6	22	8
1977	29	20	358	28.2	21.6	167	128	25.6	6.6	51	.4	.94	0	.0	.0	0	288	289	1.12	2.1	21	10
1981	33	23	255	33.6	22.1	192	103	28.7	6.7	60	.6	.90	0	.0	.0	0	373	373	1.07	1.8	21	11
1985	37	26	255	37.8	27.9	268	0	.0	.0	0	.0	.00	0	.0	.0	0	449	450	1.04	1.5	19	12
1990	42	31	255	42.5	35.5	388	0	.0	.0	0	.0	.00	0	.0	.0	0	570	570	.95	1.5	24	14
Treatment 8																						
1963	15	8	1000	8.7	5.9	20	0	.0	.0	0	.0	.00	0	.0	.0	0	20	20	.00	.0	0	1
1966	18	12	1000	12.5	12.4	54	0	.0	.0	0	.0	.00	0	.0	.0	0	54	54	1.29	2.2	11	3
1969	21	14	955	16.1	19.4	104	29	15.6	.5	3	.0	.31	16	.0	.2	1	107	108	1.18	2.5	18	5
1973	25	17	815	20.1	25.9	173	128	19.4	3.8	25	.2	.98	12	.0	.3	2	201	204	.99	2.6	23	8
1977	29	20	704	23.4	30.4	237	107	22.8	4.4	34	.3	.98	4	.0	.0	0	299	302	.81	2.2	24	10
1981	33	23	601	26.3	32.7	296	103	25.4	5.2	47	.5	.97	0	.0	.0	0	405	408	.69	1.9	27	12
1985	37	26	593	29.0	39.2	388	0	.0	.0	0	.0	.00	8	.0	.1	1	497	501	.67	1.6	23	13
1990	42	29	593	31.9	47.5	520	0	.0	.0	0	.0	.00	0	.0	.0	0	629	633	.58	1.7	26	15

Table 37--Stand development table by treatment, per hectare basis (continued)

			After thinning				Removed in thinning						Mortality				Yield[d]		Net growth			
Year	Stand age	H100[a]	Trees left	Avg dbh	Basal area	Total vol[b]	Trees cut	Avg dbh	Basal area	Total vol	Avg vol	Avg d/D[c]	Trees dead	Avg dbh	Basal area	Total vol	Net vol	Gross vol	dbh PAI	Ba PAI	Vol PAI	Vol MAI
	Yrs	*m*	*No*	*Cm*	*m²*	*m³*	*No*	*Cm*	*m²*	*m³*	*m³*		*No*	*Cm*	*m²*	*m³*	*m³*	*m³*	*Cm*	*m²*	*m³*	*m³*
Treatment 9, Unthinned control																						
1963	15	9	2194	8.3	11.9	39	0	.0	.0	0	.0	.00	0	.0	.0	0	39	39	.00	.0	0	3
1966	18	12	2655	10.3	22.1	95	0	.0	.0	0	.0	.00	21	.0	.2	1	95	96	.67	3.4	19	5
1969	21	14	2783	12.1	32.0	171	0	.0	.0	0	.0	.00	37	.0	.2	1	171	172	.61	3.3	25	8
1973	25	18	2733	14.4	43.7	284	0	.0	.0	0	.0	.00	103	.0	.5	2	284	288	.56	2.9	28	11
1977	29	21	2589	16.2	52.5	401	0	.0	.0	0	.0	.00	169	.0	.8	5	401	410	.47	2.2	29	14
1981	33	23	2507	17.7	59.9	505	0	.0	.0	0	.0	.00	91	.0	.5	3	505	517	.36	1.8	26	15
1985	37	26	2116	19.9	64.0	601	0	.0	.0	0	.0	.00	391	.0	2.8	19	601	631	.57	1.0	24	16
1990	42	30	1824	22.4	70.0	750	0	.0	.0	0	.0	.00	292	.0	2.8	22	750	803	.50	1.2	30	18
Late thinning, L1																						
1973	25	17	399	17.9	10.0	66	2451[e]	--	30.4	201	--	.91	0	.0	.0	0	66	66	.00	.0	0	3
1977	29	20	222	25.2	11.0	86	177	16.9	4.0	28	.2	.77	0	.0	.0	0	114	114	1.00	1.3	12	4
1981	33	23	152	31.6	11.9	104	70	27.5	4.2	36	.5	.91	0	.0	.0	0	168	168	1.30	1.3	14	5
1985	37	25	152	36.4	15.9	149	0	.0	.0	0	.0	.00	0	.0	.0	0	213	213	1.20	1.0	11	6
1990	42	28	152	42.3	21.4	224	0	.0	.0	0	.0	.00	0	.0	.0	0	288	288	1.18	1.1	15	7
Late thinning, L3																						
1973	25	17	675	17.8	16.9	111	2670[e]	--	27.1	177	--	.88	0	.0	.0	0	111	111	.00	.0	0	4
1977	29	20	535	21.7	19.7	150	136	20.0	4.3	32	.2	.94	4	.0	.1	0	182	182	.87	1.8	18	6
1981	33	23	403	26.5	22.1	193	128	23.4	5.5	47	.4	.91	4	.0	.0	0	272	272	1.02	2.0	23	8
1985	37	25	403	30.1	28.6	272	0	.0	.0	0	.0	.00	0	.0	.0	0	351	351	.90	1.6	20	9
1990	42	28	403	34.2	37.1	390	0	.0	.0	0	.0	.00	0	.0	.0	0	468	468	.83	1.7	23	11
Late thinning, L5																						
1973	25	18	930	17.8	23.1	158	1387[e]	--	19.1	129	--	.87	0	.0	.0	0	158	158	.00	.0	0	6
1977	29	21	836	20.7	28.0	223	91	19.4	2.7	21	.2	.95	4	.0	.0	0	244	245	.69	1.9	22	8
1981	33	24	725	23.6	31.7	284	107	21.5	3.9	34	.3	.92	0	.0	.0	0	339	339	.67	1.9	24	10
1985	37	26	700	26.3	37.9	368	0	.0	.0	0	.0	.00	25	.0	.3	2	423	426	.67	1.6	21	11
1990	42	30	671	29.7	46.4	502	0	.0	.0	0	.0	.13	25	.0	.3	2	557	561	.67	1.7	27	13
Late thinning, L7																						
1973	25	17	1297	17.1	29.5	184	1564[e]	--	10.8	67	--	.68	0	.0	.0	0	184	184	.00	.0	0	7
1977	29	20	1198	19.8	36.6	277	91	18.6	2.3	17	.2	.89	8	.0	.2	2	294	296	.65	2.4	27	10
1981	33	22	1091	22.2	41.9	360	103	20.4	3.4	29	.3	.94	8	.0	.1	1	406	408	.56	2.2	28	12
1985	37	24	1070	24.2	49.0	453	0	.0	.0	0	.0	.00	25	.0	.4	3	499	505	.51	1.8	23	13
1990	42	28	1046	26.6	57.7	596	0	.0	.0	0	.0	.00	25	.0	.6	5	642	653	.48	1.7	29	15

[a] Ht100: Average height of the 100 largest trees per hectare (estimated from d.b.h. and ht-d.b.h. curves).

[b] Volume: All volumes are total stem, inside bark.

[c] d/D: Average d.b.h. cut/average d.b.h. before thinning.

[d] Total yield: Net = standing + thinning Gross = standing + thinning + mortality.
Yield does not include any volume removed in a calibration cut.

[e] Trees and volume cut in initial late thinnings, in 1973, are not included in yields.

Hoyer, Gerald E.; Andersen, Norman A.; Marshall, David. 1996. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 13—the Francis study: 1963-90. Res. Pap. PNW-RP-488. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 91 p.

Results of the Francis installation of the levels-of-growing-stock study in Douglas-fir *(Pseudotsuga menziesii* (Mirb.) Franco), begun at stand age 15, are summarized together with results from additional first-thinning treatments started at age 25. To age 42 (5 years beyond the last planned thinning), total cubic-foot volume growth on this mid-site II Douglas-fir plantation has been strongly related to level of growing stock. Growth of lower levels of growing stock exceeded that of the control for only a brief period at age 30. Selection of a "best" treatment would depend on the unit of measure used: yield in total cubic-foot volume, merchantable cubic-foot volume, board-foot volume or dollar value. Close dollar values among several alternatives suggest that diverse stand structure objectives can be attained at age 42 with little difference in wood product-value per acre. General silvicultural prescriptions could be written to achieve the results of any of the treatments on similar sites.

Keywords: Thinning, growing stock, growth and yield, stand density, Douglas-fir, *Pseudotsuga menziesii*, series—Douglas-fir LOGS.

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