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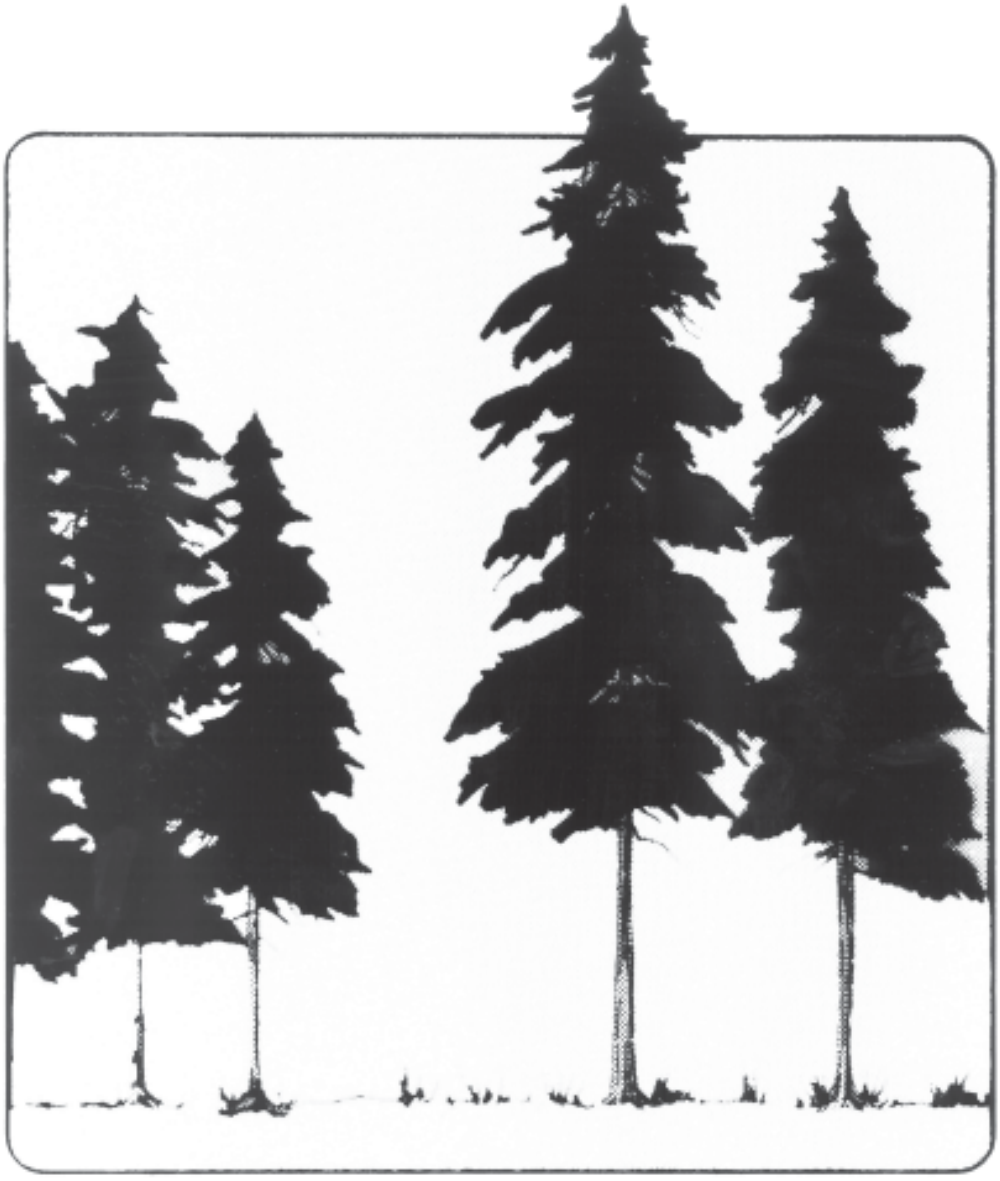
Levels-of-Growing-Stock Cooperative Study in Douglas-fir: Report No. 18—Rocky Brook, 1963–2006

Robert O. Curtis and David D. Marshall



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Authors

Robert O. Curtis is an emeritus scientist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3625 93rd Avenue SW, Olympia, WA 98512; **David D. Marshall** is a Biometrician, Weyerhaeuser Co., WTC 1A3, P.O. Box 9777, Federal Way, WA 98001.

Abstract

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This report documents the history and results of the Rocky Brook installation of the cooperative levels-of-growing-stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), over the 41-year period 1965 to 2006. This 1938 plantation is one of the two site-IV installations among the nine installations in the study. Much public ownership in the region is on similar poor-site lands. Results are generally consistent with those from the other LOGS installations, although growth has been much slower than in the installations on more productive sites. Volume production increased with growing stock. Periodic annual increment is still considerably greater than mean annual increment. On similar public lands, rotations considerably longer than indicated by conventional economic analysis could reduce land use conflicts and increase carbon sequestration, while maintaining or increasing long-term timber output and timber-related revenues. The principal future value of the data is for use (in combination with other data) in development of growth models.

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

Summary

This report documents the history and results of the Rocky Brook installation of the cooperative levels-of-growing-stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) over the period from 1965 to 2006. Rocky Brook is one of the two site-IV installations among the nine installations in the study. It is a 1938 plantation with extensive natural fill-in. Variation in site index among plots and among treatments is considerably greater than in other LOGS installations, and there has been considerable damage from *Phellinus weirii* and associated windfall. After allowance for within-installation site differences, results are qualitatively consistent with those from other LOGS installations, although growth has been much slower than in the installations on more productive sites. Volume production in thinned plots increased with level of growing stock. Thinning treatments have produced markedly different diameter distributions. Thinned plots have developed an understory of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and redcedar (*Thuja plicata* Donn ex D. Don). Periodic annual volume increment is still considerably greater than mean annual increment. On similar public lands, rotations considerably longer than indicated by conventional economic analysis could reduce land use conflicts and increase carbon sequestration, while maintaining or increasing long-term timber output and timber-related revenues. Rocky Brook has now completed the 60 ft of height increment specified in the study plan as the planned duration of the experiment. The principal future value of the data is for use (in combination with other data) in development of growth models. In view of the increasing prevalence of root disease and associated windfall, further remeasurements do not seem useful.

Introduction

The Rocky Brook levels-of-growing-stock (LOGS) installation is one of nine installations in a regional study established in young Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands according to a common work plan (Curtis and others 1997, Williamson and Staebler 1971) (fig. 1). This study is a cooperative effort involving the Canadian Forest Service, The British Columbia Ministry of Forests, Oregon State University, U.S. Department of Agriculture (USDA) Forest Service, Washington State Department of Natural Resources, and Weyerhaeuser Company. The objective of the study is to compare growth-growing stock relations, cumulative wood production, and tree size development under eight stand-density control regimes begun before the onset of severe competition and differing in the amount of growing stock retained. The original study plan was developed at Weyerhaeuser Company, Centralia, Washington. Procedural details were developed jointly with the Pacific Northwest (PNW) Research Station, USDA Forest Service, Portland, Oregon. The PNW Research Station served as the coordinating agency in study installation and analyses.

Regional study effort involving the Canadian Forest Service, The British Columbia Ministry of Forests, Oregon State University, U.S. Department of Agriculture (USDA) Forest Service, Washington State Department of Natural Resources, and Weyerhaeuser Company.

Figure 1—Locations of the nine installations of the levels-of-growing-stock cooperative study in Douglas-fir.

The various LOGS publications listed in appendix 1 contain detailed information on individual installations. As of 2007, all but the two lowest site-productivity installations (Rocky Brook and Shawnigan) had completed the prescribed treatments and published reports, and have been either terminated or put on a maintenance remeasurement schedule.

The Rocky Brook LOGS study was established in 1963 by the PNW Research Station on the Olympic National Forest, in collaboration with the Hoodsport Ranger District (since combined with the Quilcene District). Some limited information has been previously published by Williamson (1976) and Curtis and Marshall (1986). The report here presented is the final and only complete report on this installation.

Objectives

The LOGS cooperative study evolved from work in the late 1950s by George Staebler (1959, 1960). Staebler postulated that thinning would transfer increment to the remaining faster growing trees and increase growth percentage through reduction in growing stock, 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 at that time been tested for Douglas-fir. The objective of the LOGS study, as stated in the 1962 plan,[1] was "to determine how the amount of growing stock 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 so that results would show "how to produce any combination of factors deemed optimum from a management standpoint." The study was intended to define the quantitative relations between growth and growing stock (as expressed by basal area) for a closely controlled initial stand condition and kind of thinning.

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This report presents results of the Rocky Brook LOGS study, which is one of the two installations on low-productivity sites (site IV) (The other is Shawnigan Lake). The other seven LOGS installations are all on medium to excellent sites.

[1] Staebler, G.R.; Williamson, R.L. 1962. Plan for a level-of-growing-stock study in Douglas-fir. 15 p. Unpublished document. On file with: Silviculture Team, Forestry Sciences Laboratory, 3625 93rd Ave. SW, Olympia, WA 98512.

Methods

Description of Study Area

The Rocky Brook installation is located on the Quilcene Ranger District of the Olympic National Forest, in section 18, T. 26 N, R. 2 W., and section 13, T. 26 N., R. 3 W., Willamette Meridian. It is about 7.5 miles west of U.S. Highway 101, adjacent to the Rocky Brook Road.

The experimental area is situated on a glacial terrace along the steep side slopes of the Rocky Brook drainage. Elevation is about 2,400 ft. Soil materials consist of glacial outwash and drift of stratified and unstratified sands, gravels, and coarser materials overlying basalt bedrock. The soil was classified in 1965 as Hoodsport very gravelly sandy loam[2] underlain by strongly cemented till at depths ranging from 1 to 5 ft. A high, steep ridge to the south shades the area much of the year, and may significantly shorten the growing season.

Plots were classified by plant association[3] in 2007. There was considerable variation among plots, with a suggestion that the western group may be slightly better in average site than the eastern group, and that the amount of *Rhododendron macrophyllum* D. Don ex G. Don (RHMA) present is negatively associated with overstory density. The majority of plots were classified as associations including RHMA, usually considered to indicate site class IV.

The area had been clearcut and was broadcast burned in the fall of 1937. It was planted in 1938 with 2-year seedlings. There was abundant subsequent natural fill-in, predominantly Douglas-fir.

Experimental Design

The experiment is a completely randomized design having three replications of eight thinning treatments, plus an unthinned treatment. The 27 plots are each one-fifth acre in size, without buffers. The physical arrangement is shown in figure 2. Field work began in August, 1963.[4] Forty-five plots were laid out in the stand.

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[2] Herman, L.D. 1967. Soil investigations of the Rocky Brook experimental forest area, Olympic National Forest. 16 p. Unpublished report. On file with: Silviculture Team, Forestry Sciences Laboratory, 3625 93rd Ave. SW, Olympia, WA 98512.

[3] Peter, D. 2007. Plant associations of the Rocky Brook LOGS experimental forest area, Olympic National Forest. 7 p. Office report. On file with: Silviculture Team, Forestry Sciences Laboratory, 3625 93rd Ave. SW, Olympia, WA 98512.

[4] Williamson, R.L. 1964. Establishment report for Rocky Brook area Douglas-fir Level of Growing Stock Study. 15 p. Unpublished report. On file with: Silviculture Team, Forestry Sciences Laboratory, 3625 93rd Ave. SW, Olympia, WA 98512.

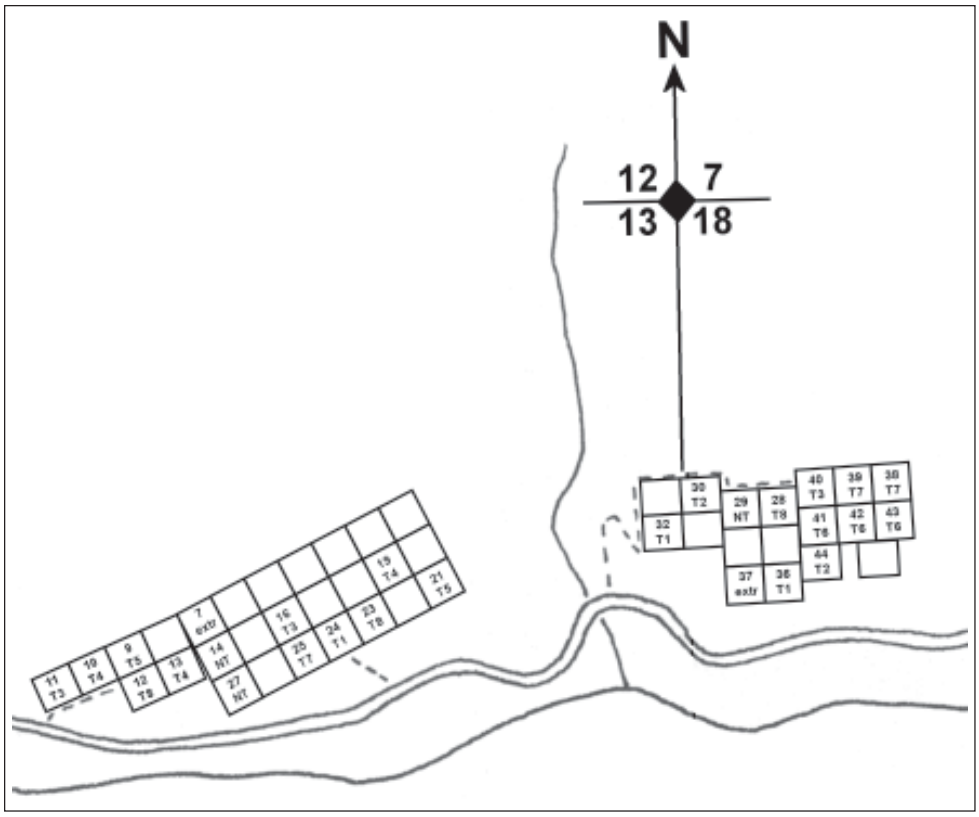

Figure 2—Plot arrangement in the Rocky Brook levels-of-growing-stock installation.

Treatments were closely controlled to provide comparability with installations at other locations.

Of these, 8 were rejected as unsuitable because of nonuniformity, and the 27 judged most comparable were selected for use in the study.

Six of the originally selected plots were replaced in 1965 because of severe snow breakage in the winter after the calibration thinning. Final assignment of plots to treatments is shown in table 1.

Stand Treatments

Treatments were closely controlled to provide comparability with installations at other locations.

Selection of crop trees—

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

Calibration thinning—

An initial calibration thinning was made in 1964 on the 24 plots assigned to thinning treatments, and also on the unused spare plots. This was intended to reduce

Table 1—Assignment of treatments by plot numbers[a]

Treatment	Plot numbers
Fixed:	
1	24, 32, 36
3	11, 16, 40
5	9, 21
7	25, 38, 39
Increasing:	
2	30, 44
4	10, 13, 19
Decreasing:	
6	41, 42, 43
8	12, 23, 28
Unthinned:	
	14, 27, 29
Extra plots:	
	7, 37

[a] Plot 20 in T-2 and 15 in T-5 were eliminated because of extensive stand damage.

plots to as nearly comparable 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 an initial spacing based on the equation

$$S = 0.6167 \times QMD + 8 , \quad (1)$$

where S is the average spacing in feet and QMD is the quadratic mean diameter of the leave trees on all plots combined. At Rocky Brook this produced a leave tree number of 400 stems per acre (average spacing 10.4 ft). 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 unthinned plots.

Eight thinning treatments differ in the amount of basal area allowed to accumulate in the growing stock.

Treatment thinnings—

The eight thinning treatments differ in the amount of basal area allowed to accumulate in the growing stock. The average residual basal area of thinned plots after the calibration thinning is the starting point for calculating future growing-stock accumulation. Thereafter, the basal area retained in any thinning is that retained in the previous thinning plus a predetermined percentage of the gross increase found in the unthinned plots since the previous thinning (table 2). Gross growth of unthinned plots was assumed to represent the productive potential of the site at full stocking and can be thought of as providing a local gross yield table for the study area.

Table 2—Treatments defined by percentage of gross basal area increment of unthinned treatment retained after thinning (calibration thinning excluded)

Treatment	Thinning				
	First	Second	Third	Fourth	Fifth
	Percentage retained				
Fixed:					
1	10	10	10	10	10
3	30	30	30	30	30
5	50	50	50	50	50
7	70	70	70	70	70
Increasing:					
2	10	20	30	40	50
4	30	40	50	60	70
Decreasing:					
6	50	40	30	20	10
8	70	60	50	40	30
Unthinned:					
	100	100	100	100	100

Following the initial calibration thinning, treatment thinnings were made at intervals of about 10 ft of growth in crop tree height (approximated in later years by H40, mean height of the largest 40 stems per acre [8 per plot]).[5] Treatment thinnings were made in 1969, 1976, 1982, 1988, and 1995 (total ages 33, 40, 46, 52, and 59, respectively). Basal areas to be left after thinning were calculated from the equation,

$$BA_n = BA_{(n-1)} + Pct \times GBAG , \quad (2)$$

where:

BA_n = basal area retained after thinning,

$BA_{(n-1)}$ = basal area at beginning of preceding treatment period,

Pct = prespecified percentage of gross basal area growth to be retained, and

GBAG = average gross basal area growth on unthinned plots in the given period.

The expected trends in basal area created by these specifications are shown schematically in figure 3. Treatments 1, 3, 5, and 7 are hereafter referred to as the "fixed" treatments and 2, 4, 6, and 8 as the "variable" treatments.

[5] The original intent was that the initially selected crop trees would be retained until all other trees had been removed; however, damage, decline in vigor, and death of some initially selected trees made numerous substitutions necessary. In effect, the crop tree list was revised at each thinning prior to marking trees to be cut.

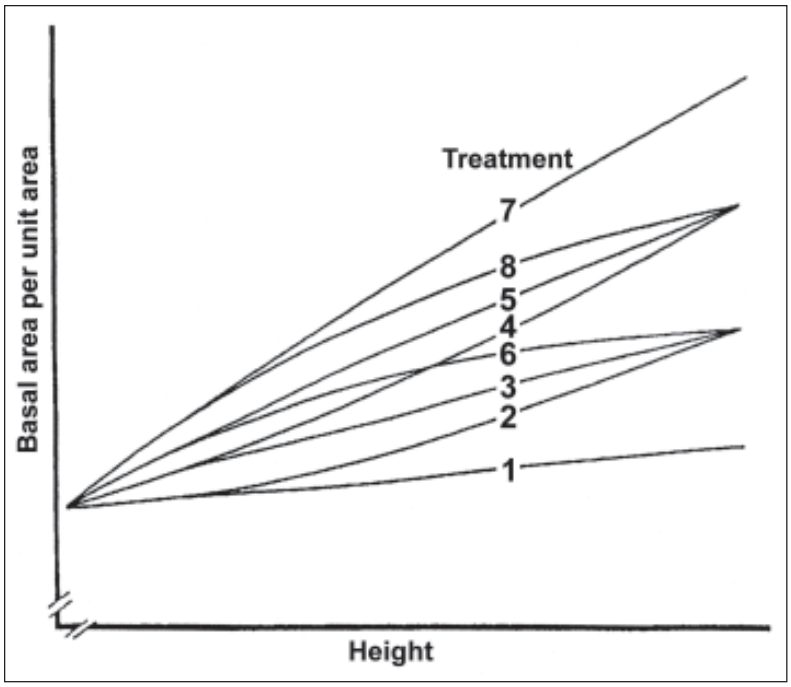

Figure 3—Idealized trends in basal area for the eight thinning regimes in the levels-of-growing-stock study.

Kind of thinning was further specified by the following requirements:

1. No crop trees were to be cut until all noncrop trees had been removed.
2. The QMD of trees removed in thinning should approximate the QMD of the noncrop trees until all noncrop trees had been removed. Because crop trees have a larger QMD than noncrop trees, this produces a d/D ratio (ratio of diameter of trees cut to diameter of stand before thinning) less than 1.0.
3. Trees removed in thinning were to be distributed across the range of diameters of trees available for thinning.

Extra Plots

Two of the original extra plots (plots 7 and 37) were resurrected in 1982 and were included in 1982 and subsequent measurements. These had received the original calibration thinning but no subsequent treatment. The intent was to provide a comparative example of stand development with no subsequent treatment following the initial precommercial thinning.

Data Collection and Summarization

After the calibration thinning and at all subsequent measurement dates, diameters of all tagged trees were measured to the nearest 0.1 in. Ingrowth was to be tagged and measured on the unthinned plots only (later deviations from this are discussed later). Heights were measured on a sample of trees at each occasion; sample size differed among measurement dates but was never less than 12 trees per plot and usually more, distributed across the range of diameters. Heights to base of live crown were measured from 1982 on.

Constrained height-diameter curves were fit to each measurement on each plot for height estimation (Flewelling and de Jong 1994). Total tree volumes in cubic feet inside bark (CVTS) were calculated by the Bruce and DeMars (1974) equation, from actual measured heights when available and from predicted heights for trees not having measured heights. These were converted to merchantable cubic volumes to a 6-in top (CV6, with no minimum log length) by equations from Brackett (1973). Scribner volumes for 32-ft logs (SV6), with a minimum top log of 16 ft, were calculated using diameter estimates from Flewelling's unpublished taper equations.[6]

Stand heights were characterized as H40 and as Hcrop, the mean height of designated crop trees. Although Hcrop was originally envisioned as the primary measure, initially designated crop trees often did not remain reasonable selections as the stand developed, and substitutions were often necessary. H40 is not much different, provides consistent values, and is the measure used in this report.

Stand Damage and Plot Rejection

The Rocky Brook LOGS installation has suffered substantial damage over the course of the experiment, introducing considerable variation not related to treatment. The principal types of damage have been (1) snowbreak in 1964, (2) continuing and developing mortality from root disease (*Phellinus weirii* (Murr.) Gilbertson), and (3) windfall, concentrated in 1994 and associated with root disease.

Severe snowbreak in 1964, shortly after study establishment in 1963, forced abandonment of several thinned plots and their replacement in 1965 by others from the extra plots. Because of this discrepancy in starting dates, we have begun our summaries with 1965. Although the calibration thinning left a target number of 400 stems per acre, those 1963 plots that were retained apparently lost a few trees

[6] Using the methodology of Flewelling and Raynes 1993.

to snowbreak, so there were minor differences in starting numbers of trees and in basal areas as of 1965.

In 1963, active centers of *Phellinus weirii* were reported on at least four plots. Although these specific centers were avoided in final plot selection, it became apparent in later years that *Phellinus* is widely distributed and a cause of major losses. There has also been considerable windfall, probably related to root disease.

Although a certain amount of damage from various causes is part of normal stand development, severe damage from causes unrelated to treatment makes a plot useless for determining the effect of planned growing stock on growth. Thus, the most extreme cases should be eliminated from analyses. In 1988 and again in 1995, a visual rating was made of root disease damage by plot, and sketch maps were made of major root rot centers. Based on the field notes plus graphs of basal area mortality over time, we decided to eliminate plot 15 (in treatment 5) and plot 20 (in treatment 2) from analyses. Several other plots with substantial but less severe root disease and windfall were retained.

The analyses in this report follow the general pattern established by previous reports on other LOGS installations.

Analyses

The analyses in this report follow the general pattern established by previous reports on other LOGS installations. Most comparisons are based on trees present and tagged at establishment. Ingrowth is not included unless this is specifically stated.

Gross increments (= survivor growth + cut + mortality) are considerably less influenced by the fluctuations introduced by sporadic mortality than are net increments. With the known presence of major mortality from root disease, we will emphasize relationships to gross increment and cumulative production as indicators of the effect of growing stock on growth.

Analysis of Variance

Differences among treatments in periodic gross volume (total stem) growth, gross basal area growth, survivor QMD growth, and volume growth percentage were tested by analysis of variance (ANOVA), as specified by the original study plan and shown in table 3. This is a repeated-measures experiment that is computationally similar to a split-plot design (Snedecor and Cochran 1980), in which the periodic remeasurements correspond to subplots and in which the seven degrees of freedom for treatments are used to test seven planned comparisons. Computations were done with the GLM procedure (SAS Institute 1990), accounting for the missing plots. Only the thinned treatments, which were controlled to achieve a range in growing

Table 3—Analysis of variance

Source of variation	Degrees of freedom (five treatment periods)
Treatments:	
(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 vs. decreasing percentage treatments	1
(D) Between levels of increasing percentage treatments	1
(E) Between levels of decreasing percentage treatments	1
Error (a) for testing treatments	14
Periods (P)	4
Treatment 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 interactions	56
Total	109

stock, were included. (For many, though not all, plots there is little difference between gross and net growth). The degrees of freedom reflect the two plots (15 and 20) that were dropped from the analysis. The results for the ANOVA are summarized in table 4 and discussed below. The specific trends discussed here will be shown graphically in later sections of this report. Results are generally consistent with those from other LOGS installations at the end of the five treatment periods (Beddows 2002, Curtis and Clendenen1994, Curtis and Marshall 2002, Hoyer and others 1996, King and others 2002, Marshall and others 1992).

All treatments—

Over the five treatment periods, growing stock (expressed as basal area) accumulated differently among the fixed percentage treatments (1, 3, 5, and 7) and among the variable percentage treatments (2, 4, 6, and 8), as expected (fig. 3). However, the mean growing stock (average of the initial values of the five treatment periods)

was nearly the same for the four fixed as for the mean of the four variable treatments (87.3 and 87.9 ft^2/ac, respectively). There was no significant difference (A in table 4) in overall average growth of the fixed versus variable treatments (alpha = 0.05).

Fixed treatments—
The ANOVA tested the fixed-percentage treatments (1, 3, 5, and 7) for linear, quadratic, and cubic trends across the range of growing stock (B in table 4). In all cases, growth could be adequately described as linearly related to growing stock for the five treatment periods since the quadratic and cubic terms were not significant. Basal area and volume growth increased linearly with growing stock, while diameter growth and volume growth percentage decreased with growing stock. This linear relationship also changed significantly between periods for basal area, volume, and diameter growth, but not for volume growth percentage, which stayed similar. One would not expect these trends to be linear over a wider range of growing stock, as growth would necessarily be zero for zero growing stock and the ANOVA does not include the much higher densities of the no thinning treatment.

Variable treatments—
The increasing treatments (2 and 4) accumulated more basal area in the later treatment periods and the decreasing treatments (6 and 8) accumulated more basal area in the earlier treatment periods, which resulted in mean growing stock (average of the initial values of the five treatment periods) of 79.4 and 96.2 ft^2/ac, respectively. Only basal area periodic growth showed a significant difference (C in table 4) between increasing and decreasing treatments over the five treatment periods with the decreasing treatments having slightly more average periodic growth. There were no significant differences in volume growth, diameter growth, or volume growth percentage. There were no significant differences between the two increasing treatments (D in table 4) and the two decreasing treatments (E in table 4) in basal area growth, volume growth, diameter growth, or volume growth percentage.

Trends in Stand Statistics

Experience with other LOGS installations has shown that many aspects of the experiment are more meaningfully presented and interpreted through simple graphic comparisons, and these are the principal means used in this report.

Table 4—Analysis of variance results for gross total cubic foot volume (CVTS) periodic annual increment (PAI), gross basal area PAI, survivor quadratic mean diameter PAI, and volume growth percentage

	P-values and mean square errors (in parentheses)[a]			
	Volume (CVTS)			
Source of variation	PAI	Growth percent	Basal area PAI	Diameter PAI
(A) Fixed vs. variable	0.420	0.335	0.740	0.841
(B) Fixed (linear)	<0.001	0.001	<0.001	0.002
(B) Fixed (quadratic)	0.503	0.061	0.972	0.111
(B) Fixed (cubic)	0.592	0.906	0.713	0.817
(C) Increasing vs. decreasing	0.076	0.309	0.031	0.152
(D) Between increasing	0.599	0.084	0.382	0.085
(E) Between decreasing	0.734	0.098	0.936	0.148
Error (a) mean square	(2,232.852)	(0.753)	(1.093)	(0.005)
Treatment x period interactions:				
P x A	0.756	0.626	0.413	0.699
P x B (linear)	<0.001**	0.060	0.002**	<0.001**
P x B (quadratic)	0.004**	<0.001**	0.045*	0.691
P x B (cubic)	0.515	0.045*	0.794	0.255
P x C	<0.001**	0.266	0.001**	0.004**
P x D	0.084	0.309	0.471	0.234
P x E	<0.001**	0.023**	0.013*	0.721
Error (b) mean square	(115.637)	(0.067)	(0.079)	(0.00014)

Significance levels: * = $0.01 < p \leq 0.05$ and ** = $p \leq 0.01$.

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

To avoid unduly cluttered graphs, we adopt the following conventions:

- Line graphs are given separately for fixed and variable treatments.
- Bar graphs have bars grouped from left to right as (1) fixed treatments (1, 3, 5, 7), (2) increasing treatments (2, 4), (3) decreasing treatments (6, 8), and (4) unthinned.

Site index—

Site indexes (King 1966, base age 50 years breast high) were calculated for each plot and as mean site index for each treatment, based on top height (H40) values and the assumption that total age of record (based on planting date) can be converted to an equivalent breast-high age by subtracting 9 years.

The range in plot site index values was 78.2 to 92.8; standard deviation was 4.66, overall mean 86.4, and coefficient of variation 5.39. Mean site index of

unthinned plots was 85.7, that of thinned plots was 86.5. Although there is considerable variation among treatment means, differences among treatments were not significant (ANOVA, p = 0.18). There is no evidence of a treatment effect on site index; differences among treatment mean site indices (fig. 4, app. 3) apparently arise from within-installation variation unrelated to treatment.

Figure 5 (app. 3) compares overall means of observed H40 values with the heights predicted by King (1966) for site index 86 (S86). This suggests that the Rocky Brook height growth curve is slightly steeper than King's.

Top height (H40)—

Mean increment in H40 over the 41-year period (age 29 to age 70) was 60.8 ft, which is very close to the 60 ft of height increment specified in the study plan as the intended duration of the experiment.

Tables 5a and 5b (app. 2) show considerable variability among plots and among treatments. The pattern closely resembles that for site index, and probably represents localized differences in site and in stand damage rather than any influence of treatment on height growth. Mean H40 increment of unthinned plots over the 41-year period was only slightly less (2.7 ft) than the overall mean of thinned plots, and H40 increments did not differ significantly among treatments (ANOVA, p = 0.12).

Number of trees—

Trends over time in number of live trees per acre (TPA) are shown for fixed treatments and for variable treatments in figures 6 and 7, and in tables 6a and 6b (app. 2). Diameter distributions at the start (1965) and end of the experiment (2006) are shown in table 7 (app. 2).

Basal area—

Live basal area—

Trends of live basal area over time for fixed treatments and for variable treatments are shown in figures 8 and 9, and in tables 8a and 8b (app. 2).

Basal area periodic annual increment—

Trends of net and gross periodic annual increment (PAI) in basal area for fixed and unthinned treatments are shown in figure 10, and for variable and unthinned treatments in figure 11.

Diameter

Quadratic mean diameter—

The QMDs at ages 29 and 70 are compared in fig. 12 and tables 9a and 9b (app. 2). The lower initial value on the unthinned plots reflects the presence of small trees that were removed in the calibration thinning on the other treatments. There are pronounced differences in increment and age-70 values, which correspond to differences in stocking levels. The removal of trees somewhat smaller than the mean in treatment thinnings probably accentuates the differences, although these are primarily due to differences in slope of the growth curves (figs. 13 and 14).

D40—

Initial D40 (mean diameter of the largest 40 trees per acre) of unthinned was slightly larger than in other treatments, possibly reflecting the removal of some potential crop trees in the calibration thinning.

D40 increments from age 29 to age 70 are compared in figure 15. Increment of the unthinned was the least of all treatments. Mean D40 increment of thinned plots was 9.76 in vs. 7.89 in for unthinned. The difference was significant (t-test, $p = 0.01$). Thinning has increased diameter increment of the largest 40 trees per acre, most obviously in the lowest growing-stock levels (treatments 1, 2, and 6).

D40 increments in the lowest stocking in each of the categories fixed, increasing, and decreasing (treatments 1, 2, and 6) appear somewhat larger than in the other stocking treatments. Increments in treatments 3, 5, 7, and 8 are virtually identical.

Live stand volumes

Trends in standing volume of entire stem (CVTS) are shown in figures 16 and 17 and tables 10a and 10b (app. 2). Corresponding trends in standing merchantable volume (CV6) are shown in figures 18 and 19 and tables 11a and 11b. Trends in board feet Scribner to a 6-in top (SV6) are shown in figures 20 and 21, and tables 12a and 12b (app. 2).

Mean annual increment (MAI) and periodic annual increment

CVTS—

MAI and PAI values in CVTS are compared in figure 22 for fixed treatments and figure 23 for variable treatments.

CV6—

Gross MAI values (black) and PAI values (red) in CV6 are compared in figure 24 for fixed treatments and in figure 25 for variable treatments. Corresponding trends in net CV6 are shown in figures 26 and 27. For thinned treatments, trends for net PAI are considerably more variable than those for gross PAI, mainly because of the effects of root disease and associated windfall. In contrast, the large differences between gross and net in the unthinned plots arise mainly from suppression mortality.

Corresponding trends for Scribner board feet, not shown here, are readily derivable from tables 12a and 12b (app. 2) and resemble those shown for CV6.

Thinning removals—

Number of trees, basal area, QMD, CVTS, CV6, and SV6 removed in thinnings are shown in tables 13 and 14 (app. 2). Thinning volumes as percentages of gross yield are shown in stand development tables 21 to 30 (app. 2).

A common method of expressing the type of thinning is by the d/D ratio, the ratio of average diameter of trees cut to the average diameter of trees present before cutting. The mean value of this ratio over all treatments and cutting dates was 0.88. It was somewhat lower (0.84) for the variable treatments than for the fixed treatments (0.93); we have no explanation for this difference.

Mortality—

Number of trees, basal area, QMD, CVTS, CV6, and SV6 recorded as dead are shown in tables 15 and 16 (app. 2). Mortality volumes are shown as percentages of gross yield in stand development tables 21 through 30 (app. 2).

Cumulative volume yield—

Cumulative net and gross yields to age 70 are shown in CVTS in figure 28, and in CV6 in figure 29. **Note** that the values shown for thinned treatments **do not** include volumes removed in the calibration thinning, which averaged 828 ft^3/ac in CVTS and 65 ft^3/ac in CV6.

Cumulative net yields in SV6 are compared in figure 30.

Volume Distribution by Log Size Classes

Volume distributions by log top diameters at age 70 are shown for merchantable cubic foot volume (CV6) in tables 17 and 18 (app. 2), and for Scribner board-foot volume (SV6) in tables 19 and 20. CV6 values are compared in figure 31, for fixed and unthinned treatments only. As expected, treatment 1 has a distribution that is

drastically different from the unthinned, with treatments 3, 5, and 7 in intermediate positions.

Stand Relative Density

Two measures of relative density that are often used in the region are Curtis RD (Curtis 1982) and Reineke Stand Density Index (SDI) (Reineke 1933). Trends in Curtis RD (fig. 32) and trends in Reineke's SDI (fig. 33) are shown for fixed and unthinned treatments only.

The observed basal area of the unthinned plots at age 59 (the maximum point for both RD and SDI) is 1.5 times the "normal" for the observed QMD, as given in table 25 of McArdle and others (1961).

It is evident that by any of these measures the unthinned plots are extremely dense, with maximum values somewhat greater than commonly accepted maxima. Both measures have declined in the most recent growth period, mainly because of suppression mortality. Values are probably somewhat inflated by inclusion of moribund understory Douglas-fir and scattered small hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and redcedar (*Thuja plicata* Donn ex D. Don.). They may also be influenced by possible edge effects on these unbuffered plots, which are generally bordered by thinned plots of markedly lower density. (Although a comparison of basal areas in 2006 of interior one-tenth-acre subplots with the surrounding one-tenth-acre suggests that such edge effects cannot be large).

Growth Percentage

Growth percentage is one method of expressing growth rates. The argument that one should seek maximum return on growing stock, one expression of which is growth percentage, was a part of the thinking that led to the LOGS study. Growth percentages used here are calculated as,

$$\text{Growth percent} = 100\ \{\text{PAI} / [(\text{X1} + \text{X2}) / 2]\}, \quad (3)$$

where X1 and X2 are growing stock at the beginning and end of the growth period, and PAI is in net volume.

Trends of net merchantable cubic-foot volume (CV6) growth percentage over time for fixed and unthinned treatments are shown in figure 34. Initial percentages are high because of the small values in the divisor. Trends for CVTS and SV6 are somewhat different from those shown for CV6, because ratios of merchantable to total cubic volume change with increase in diameter. Compared to CV6, growth percentages for SV6 are higher and those for CVTS are lower (fig. 35). Although

there is little difference among the CV6 curves for the fixed treatments, there are considerably larger differences among the corresponding CVTS curves, with treatment 1 having the highest growth percentage.

Little difference among the CV6 curves for the fixed treatments, there are considerably larger differences among the corresponding CVTS curves

Crown Dimensions

In the early years of the study no measurements were made on crown dimensions. Beginning in 1982, height to live crown was measured on those trees measured for total height. The following discussion is based on the measurements for 2006 (age 70) only.

Scatter diagrams indicated that the trend of height-to-crown base over diameter within each treatment was nearly horizontal over most of the diameter range, with a "tail" of smaller trees at the higher stocking levels.

Values of live crown length and live crown ratio for the sample trees were regressed on d.b.h., separately for each treatment. Regressions were significant in all cases except for live crown ratio in treatment 1. Regression estimates of live crown ratio corresponding to D40 and QMD, by treatments, are shown in figure 36. As would be expected, estimated crown lengths and live crown ratios are less for QMD than for D40. There is a clear progression: T1>T3>T5>T7; T2>T4; T6>T8; with unthinned less than any of the thinned treatments.

Ingrowth

Trees initially selected for retention on thinned plots were tagged, and all other trees were cut. On the unthinned plots no trees were cut, and all trees present 1.6-in d.b.h. or larger were tagged.

Ingrowth (trees of a younger age class later attaining the minimum measurement diameter of 1.6 in) were not recorded at the periodic measurements on thinned plots, had negligible effect on growth of tagged trees, and are not included in growth trends presented previously.

On unthinned plots, such trees were tagged and recorded as they passed the minimum 1.6-in diameter. These trees are in a suppressed or understory position within dense stands, make little contribution to overall growth, and have been excluded from the summary computations given previously.

As the study progressed, it became apparent that large numbers of ingrowth were appearing in some treatments, and that this could be of interest from the standpoints of wildlife habitat and prospective changes in stand composition and stand structure even though the volumes involved were small. Therefore, at the final measurement in 2006, ingrowth trees 1.6 in and larger d.b.h. then present on

the thinned plots were tallied by 1-in diameter class and species. These are compared in figure 37, for fixed treatments only. Species composition of the ingrowth is approximately one-third redcedar and two-thirds western hemlock.

Discussion

LOGS study was designed to determine relations between stocking level and increment.

Although the LOGS study is often referred to as a "thinning study," it is not and was not intended to be a comparative trial of operational thinning regimes. Rather, it was designed to determine relations between stocking level and increment.

Two basic ideas played a major role in conception and design of the LOGS study. The first of these was a concept sometimes termed the "Langsaeter hypothesis" (Langsaeter 1941 as cited by Braathe 1957; Staebler 1960), widely believed to have been demonstrated by European experience (Mar:Moller 1954), and stated or paraphrased in standard silviculture textbooks of the time. According to this hypothesis, the main effect of thinning, over a wide range of stocking, is to redistribute a near-constant gross increment among varying numbers of trees. If true, this would greatly simplify estimation of thinning effects and associated yields. This hypothesis had never been tested for young Douglas-fir and was somewhat controversial in Europe in the late 1950s.

A second related idea (Staebler 1959) was that, for financial efficiency, one should retain the minimum amount of growing stock feasible without major loss in growth. If the Langsaeter hypothesis is assumed to hold, then growth percentage should be in direct inverse relationship to growing stock over a considerable range of growing stock.

In these relatively young stands, volume increment is strongly related to growing-stock level High volume increment requires at least moderately high growing stock.

The LOGS study was designed to test these two concepts and to develop quantitative relations that could be used to design density control regimes, including specific additional comparisons between fixed, increasing, and decreasing trends in growing stock retained. It was also expected to provide much concomitant information.

Overall, the various LOGS installations have clearly demonstrated that in these relatively young stands, volume increment is strongly related to growing-stock level (here expressed as basal area). High volume increment requires at least moderately high growing stock. The general developmental trends and their ordering by treatments have been qualitatively consistent across installations, although the quantitative values necessarily differ with differences in site quality and in the age at which an installation was established.

Rocky Brook is of particular interest as one of the two installations on poor sites included in the LOGS series, and the first of these to complete the planned

course of the experiment. Although stand damage and localized site differences have introduced considerable variation unrelated to the treatments, overall the general trends are similar to those observed in the higher site installations that make up most of the LOGS series.

Volume Development at Rocky Brook

Patterns of stand development at Rocky Brook resemble those observed in the other LOGS installations, but there is considerably more variation than in most others and a number of apparent anomalies. These arise from two causes.

First, the area is considerably less uniform in site conditions than was thought when the installation was established. There is considerable variation in soil depth (see footnote 2) and perceptible associated differences in plant association (see footnote 3). There is also substantial variation in site index (fig. 4); the coefficient of variation of treatment mean site indexes at Rocky Brook is larger than that for any other installation, and roughly 50 percent greater than the mean of corresponding CVs of all other LOGS installations.

Second, the area has suffered extensive stand damage, primarily from *Phellinus weirii* root disease and *Phellinus*-related windfall. Although plots 15 and 20 were eliminated, a number of other plots have had substantial damage. The effects of *Phellinus* on the experiment have been greater than is suggested by the mortality statistics in tables 15 and 16 (app. 2), because living trees showing symptoms of disease were generally included in the cut. The effects can be illustrated by comparing gross and net values in figures 10 and 11. The patterns of gross increment are far more regular than those of net increment, which are strongly influenced by periodic mortality. Unthinned plot mortality has been primarily from suppression.

In figures 23 and 25, the relative positions of the MAI curves for treatments 6 and 8 are the reverse of that expected on the basis of experience at other LOGS installations, in which treatment 8 has consistently had higher production than treatment 6, and 4 higher than 2. Differences in standing volumes and basal areas are more or less as expected, but the volume removed in thinnings was considerably greater in treatment 6 (table 14, app. 2). A similar though less striking situation exists with treatments 2 and 4.

When cumulative gross CVTS production is plotted over H40 (fig. 38), the relative rankings at common values of H40 conform to the pattern observed in other LOGS installations; namely, T4>T2, and T8>T6. We conclude that the apparent reversal in rankings is the result of the considerable differences in mean site index of treatment 2 vs. 4, and treatment 6 vs. treatment 8 (fig. 4). The curves

also indicate that the decreasing treatments (T6 and T8) had greater production for a given H40 than the increasing treatments (T2 and T4).

Much smaller shifts in relative position exist in the fixed treatments, and are associated with the higher site indexes of treatments 1 and 7 relative to treatments 3 and 5.

With the above qualifications, general results are consistent with the conclusions from other LOGS installations.

The hypothesis of equal production over a wide range of stocking does not hold for young Douglas-fir.

Growth and growing stock—
Increment is strongly related to growing-stock level and increases through treatment 7 in the fixed treatments, which was thought to be about the maximum stocking level consistent with avoidance of suppression mortality and with stand stability. The hypothesis of equal production over a wide range of stocking does not hold for young Douglas-fir.

MAI trends and age of culmination—
As of the midpoint of the last measurement period (age 64.5), volume PAI values are roughly twice MAI values. These stands are still considerably short of culmination (the point at which MAI reaches a maximum). This will occur later for CV6 and still later for SV6 volumes than for CVTS, because of the effect of increasing diameter on merchantable to total volume ratios.

Increasing vs. decreasing treatments—
The basal area trends projected in the original study plan (fig. 3) were expected to converge at the end of 60 ft of height growth to one point for treatments 2, 3, and 6, and another for treatments 4, 5, and 8. The actual ending basal areas for treatments 2, 3, and 6 were 130.0, 127.7, and 124.7 ft^2/ac; those for treatments 4, 5, and 8 were 162.0, 166.8, and 170.5 ft^2/ac. This result was close to expectation.

Growth percentages—
Growth percentages decline with increasing age (and growing stock) as expected (fig. 34). Although there are substantial differences among treatments in CVTS growth percentages, the differences for merchantable volume growth percentages are small, contrary to expectations at the time the study was established (Staebler 1959). Although lesser growing stock means a smaller divisor (growth percent = 100(increment/growing stock) and therefore tends to increase growth percentage, this is largely offset by the lower increment associated with low growing stock. There are also substantial differences according to the unit of measure used (fig. 35).

Comparison with unthinned—
The primary purpose of the unthinned plots was to provide a site-related definition of growing-stock levels (table 1).

In this as in other LOGS installations, the unthinned plots have consistently produced more total volume (CVTS) than any of the thinning treatments. Merchantable volume (CV6 and SV6) production of unthinned plots was close to that of treatment 7, which had the highest growing-stock level among thinning treatments. (In some other LOGS installations production of treatments 7, and occasionally 5 and 8, have exceeded the unthinned). Diameters, both QMD and D40, were substantially less in unthinned than in thinned plots.

This result does not justify a conclusion that there were no gains from thinning, compared to no thinning. There are probable edge effects on the unthinned plots, which are very dense and bordered by thinned plots of much lower density. But it does strongly suggest that gains in volume production, if any, are small. The major gains from stocking control are not increased volume production, but larger and possibly more valuable trees, greater stand stability (generally true, though not attained at Rocky Brook because of root disease), and the ability to influence stand composition and structure.

Extra plots—
These had received the calibration thinning only, with no subsequent treatment. The two plots differ widely in volume production, diameters, and in site index. Site index of plot 7 is 83 with QMD in 2006 of 11.3 in, compared with plot 37 site index of 96 and QMD of 13.3 in. On this poor site, a 13-ft difference in site index represents a wide difference in productivity. The mean site index of these two plots (=H40 at age 59 in table 30, app. 2) is quite close to the overall mean of the installation. The mean number of trees present in 1965 (328 per acre) was substantially less than the calibration thinning target of 400 per acre, a difference that may be the result of 1964 snowbreak. These plots are not fully comparable to the thinned plots.

Their mean volume production was not very different from that of treatment 7; mean QMD was slightly greater, probably because of the lesser initial number of trees.

Crown lengths and live crown ratios are clearly inversely related to growing-stock level as expressed by basal area.

Crown Development

Crown lengths and live crown ratios differ among treatments, and are clearly inversely related to growing-stock level as expressed by basal area. Although not measured, there are presumably similar differences in crown width. The resulting

differences in canopy cover and shading must influence understory composition and development.

Ingrowth

Ingrowth, primarily western hemlock and western redcedar, is abundant in the understory of thinned plots, and increases in amount and dimensions at lower stocking (fig. 37). These stands are evolving toward a layered condition, with a younger age class of hemlock and redcedar under a Douglas-fir overstory. The occurrence of *Phellinus* root disease scattered over the area will doubtless accelerate this development.

Management Implications

The frequent thinnings and small volume removals in LOGS would not be feasible as operational regimes, and were not so intended. They were adopted to provide close control of growing stock in an experiment whose primary objective was to define the relations between growing stock and growth.

Similar results could probably be achieved with considerably longer thinning intervals. The extra plots suggest that, on this poor site, a precommercial thinning (earlier than that actually made) followed by one commercial thinning (perhaps at age 40 to 50) would have produced much the same volumes and similar diameters by age 70 as were obtained in LOGS with the higher stocking levels.

PAI in these stands still nearly twice MAI is an important point.

The fact that PAI in these stands at the midpoint of the last growth period (age 64.5) is still nearly twice MAI is an important point. This is particularly true for public ownerships, which include large amounts of relatively poor-site land and for which visual impacts, recreation, wildlife habitat, and carbon fixation are major considerations and often take precedence over timber production as management objectives. Rotations considerably longer than those indicated by conventional present net worth computations could reduce land use conflicts and increase carbon sequestration while maintaining or increasing timber output and timber-related revenues over the long run.

Rotations considerably longer could reduce land use conflicts increase carbon sequestration maintaining or increasing timber output.

Future Value of Rocky Brook

The principal future value of the Rocky Brook data (and data from the other LOGS installations) is as a part of the information needed to construct improved growth and yield models. The LOGS study provides high-quality data over a wide range of stocking and site combinations. Rocky Brook is of particular interest as one of

the only two LOGS installations on site IV. To facilitate such possible future use and because we expect this to be the only report for Rocky Brook, we have provided extensive data tables (probably more extensive than most readers will want), and the standard LOGS stand development tables (as used in other LOGS reports) as tables 21-30 in appendix 2.

Although growth trends at Rocky Brook are considerably more variable than at most other LOGS installations, much of the variation appears to be associated with within-installation differences in site index that are unrelated to treatment. Growth models that incorporate site index or height growth trends should be able to account for such differences.

Rocky Brook has now completed the originally planned course of the experiment. In view of the increasingly widespread occurrence of root disease and its impacts on these small plots, we see little purpose to continuing measurements in the future.

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Helpful reviews were provided by Tim Max and Richard Miller of Pacific Northwest Research Station, Douglas Maguire of Oregon State University, and Louise de Montigny of the British Columbia Ministry of Forests. Grace Haight and Joe Kraft provided assistance in manuscript preparation.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters
Feet (ft)	0.3048	Meters
Miles	1.609	Kilometers
Square feet (ft^2)	.0929	Square meters
Cubic feet (ft^3)	.028	Cubic meters
Acres (ac)	.4047	Hectares
Square feet per acre (ft^2/ac)	.2296	Square meters per hectare
Cubic feet per acre (ft^3/ac)	.06997	Cubic meters per hectare
Trees per acre (TPA)	2.47	Trees per hectare

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Williamson, R.L.; Staebler, G.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.

Appendix 1: Other LOGS (Levels-of-Growing-Stock) Reports

Williamson, R.L.; Staebler, G.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 thinning regimes. Main features of six study areas installed since 1961 in young stands are summarized.

Williamson, R.L.; Staebler, G.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.

Williamson, R.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 thinning regimes in young Douglas-fir stands and some characteristics of individual study areas established by cooperating public and private agencies are described.

Bell, J.F.; Berg, A.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.

Describes the calibration thinning and first treatment thinning in a 20-year-old Douglas-fir stand at Hoskins, Oregon. 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 establishment and installation of the two LOGS studies established on Vancouver Island at Shawnigan Lake and Sayward Forest.

Berg, A.B.; Bell, J.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.

Presents growth data for the first 12 years of management of young Douglas-fir growing at eight levels of growing stock.

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.

Tappeiner, J.C.; Bell, J.F.; Brodie, J.D. 1982. Response of young Douglas-fir to 16 years of intensive thinning. Res. Bull. 38. Corvallis, OR: Forest Research Laboratory, School of Forestry, Oregon State University. 17 p.

Williamson, R.L.; Curtis, R.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. Results are generally similar to those of two more advanced LOGS studies.

Curtis, R.O.; Marshall, D.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 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 index differences. The LOGS study design is evaluated.

Curtis, R.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, D.D.; Bell, J.F.; Tappeiner, J.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 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, R.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.

Presents results of the first 20 years of the Stampede Creek study in southwest Oregon. 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, R.O.; Clendenen, G.W. 1994. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 12—the Iron Creek study: 1966–89. Res. Pap. PNW-RP-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 in southern Washington are summarized through age 42 (completion of the 60 ft of height growth making up 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 size distributions and in crown dimensions. Periodic annual volume increment at age 42 is two to three times mean annual increment in all treatments.

Hoyer, G.E.; Andersen, N.A.; Marshall, D.D. 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 study, begun at stand age 15, are summarized together with results from additional first-thinning treatments started at age 25. To age 42, total volume growth on this mid-site II plantation has been strongly related to level of growing stock. 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.

Curtis, R.O.; Marshall, D.D.; Bell, J.F. 1997. LOGS: a pioneering example of silvicultural research in coast Douglas-fir. Journal of Forestry. 95(7): 19–25.

Provides a general overview of the LOGS cooperative and presents the major results to date.

Curtis, R.O.; Marshall, D.D. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 14—Stampede Creek. Res. Pap. PNW-RP-543. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 77 p.

Summarizes results of the Stampede Creek study from establishment at total age 33 through the final planned treatment period at age 63 in a site class III stand in southwest Oregon. Results are generally similar to the higher site LOGS installations, although development is slower. Volume growth is strongly related to growing stock, basal area growth less so. Thinning has produced marked differences in tree size distribution and periodic annual increment is still two to three times greater than mean annual increment.

Marshall, D.D.; Curtis, R.O. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 15—Hoskins: 1963–1998. Res. Pap. PNW-RP-537. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 80 p.

This report summarizes results from the Hoskins installation through age 55. Growing stock has been allowed to accumulate for 19 years since the last treatment thinning was applied in this high site class II natural stand. Volume and diameter growth were strongly related to growing stock, basal area growth less so. Culmination of mean annual increment has not occurred in any of the thinned treatments; the no-thinning treatment has culminated for total cubic volume and is near culmination for merchantable cubic volume. Differences in growth percentages between thinning treatments were small. Results demonstrate potential flexibility in managing Douglas-fir to reach a range of objectives.

Beddows, D. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 16—Sayward Forest and Shawnigan Lake. Victoria, BC: Canadian Forest Service, Pacific Forestry Centre. 67 p.

Presents results from the Sayward Forest and Shawnigan Lake installations. Volume growth at both the site III Sayward Forest installation to age 51 and the site IV Shawnigan Lake installation to age 52, has been strongly related to level of growing stock. Basal area growth followed a similar but weaker trend. Periodic annual volume increments at both installations are still two to three times mean annual volume increments, indicating the potential for productivity gains as treated stands age. Results are similar to those from other LOGS installations, differing from the more productive sites only in rate and degree of response, associated with lower site quality.

King, J.E.; Marshall, D.D.; Bell, J.F. 2002. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 17—the Skykomish study, 1961–93; the Clemons study, 1963–94. Res. Pap. PNW-RP-548. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 120 p.

This report presents results of the Skykomish and Clemons studies, which are generally similar to those from other installations. Some interpretations of the applicability of LOGS results to operational thinning regimes, and a history of the origins and early establishment of the LOGS cooperative are given.

Curtis, R.O. 2006. Volume growth trends in a Douglas-fir levels-of-growing-stock study. Western Journal of Applied Forestry. 21(2): 79–86.

Mean curves of increment and yield in gross total cubic volume and net merchantable volume were derived from seven installations of the cooperative LOGS study. To a top height of 100 ft and corresponding average age of 45 years, current annual increment is still far greater than mean annual increment. Volume growth and yield are strongly related to stocking level. Thinning has accelerated diameter growth of the largest 40 trees per acre as well as of the stand average. Maximum volume production would be obtained at stand densities approaching the zone of competition-related mortality; although, in practice, effects on diameter growth, feasibility of frequent entries, and wildlife and amenity considerations would make somewhat lower average levels necessary.

Table 5a—Mean heights of 40 largest (by diameter) trees per acre (H40) by plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Feet											
1	24	32.2	37.6	37.3	50.4	49.3	60.6	60.6	70.9	70.3	81.0	80.9	91.2
	32	35.7	42.6	42.6	54.9	54.9	66.9	66.1	76.1	75.6	87.9	86.5	100.8
	36	38.2	45.0	45.0	58.0	58.3	69.6	69.9	78.8	77.9	91.1	91.9	104.4
	Average	35.3	41.7	41.6	54.4	54.2	65.7	65.5	75.3	74.6	86.7	86.4	98.8
3	11	37.9	44.7	44.5	56.6	56.5	67.9	68.4	77.0	77.0	88.5	89.0	102.6
	16	36.0	43.1	43.1	54.8	53.3	62.2	62.2	71.2	71.2	80.5	80.3	90.3
	40	36.2	43.2	42.7	54.4	53.0	63.2	63.2	72.2	72.2	80.0	80.0	92.3
	Average	36.7	43.7	43.4	55.3	54.3	64.5	64.6	73.5	73.5	83.0	83.1	95.1
5	9	33.8	41.4	41.4	51.7	51.7	61.8	61.8	68.1	68.1	79.5	79.5	90.4
	15	Deleted											
	21	34.6	43.0	43.0	54.7	54.7	65.0	65.0	72.5	72.5	84.0	84.0	93.3
	Average	34.2	42.2	42.2	53.2	53.2	63.4	63.4	70.3	70.3	81.8	81.8	91.8
7	25	34.2	42.7	42.7	55.0	55.0	64.3	64.3	75.5	75.5	84.0	84.0	95.3
	38	35.4	46.5	46.5	59.8	59.8	72.1	72.6	81.9	81.9	91.3	91.3	100.7
	39	35.7	45.9	45.9	58.7	58.7	70.9	70.9	79.6	79.6	88.1	88.1	98.6
	Average	35.1	45.0	45.0	57.8	57.8	69.1	69.3	79.0	79.0	87.8	87.8	98.2

[a] Before cut.

[b] After cut.

Table 5b—Mean heights of 40 largest (by diameter) trees per acre (H40 by plot, measurement date, and age (in parentheses), for variable treatments

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Feet											
Increasing:													
2	20	Deleted											
	30	39.4	48.2	48.3	62.8	60.1	73.1	73.1	80.6	80.6	92.1	92.1	105.5
	44	37.7	49.5	49.5	64.0	63.0	72.8	72.8	83.1	83.1	91.1	91.1	103.2
	Average	38.6	48.8	48.9	63.4	61.6	73.0	73.0	81.8	81.8	91.6	91.6	104.4
4	10	37.3	46.4	46.4	57.7	57.7	69.2	69.2	76.5	76.5	86.1	86.1	97.4
	13	35.0	41.7	41.7	50.2	50.2	63.0	63.0	72.1	72.1	82.2	82.2	90.8
	19	38.9	47.2	47.2	59.0	58.9	68.3	68.6	79.0	79.0	88.9	88.9	98.3
	Average	37.1	45.1	45.1	55.6	55.6	66.8	66.9	75.9	75.9	85.8	85.8	95.5
Decreasing:													
6	41	37.8	47.9	47.9	63.1	63.3	76.5	75.4	82.6	82.2	92.8	92.8	100.7
	42	35.5	45.9	45.9	61.1	61.0	72.5	72.4	81.1	81.1	92.7	92.7	104.6
	43	35.7	45.5	45.5	60.2	59.6	70.9	70.9	76.7	75.9	88.2	88.2	96.7
	Average	36.3	46.4	46.4	61.4	61.3	73.3	72.9	80.1	79.8	91.2	91.2	100.7
8	12	36.6	44.8	44.8	54.6	54.6	64.1	64.1	71.4	71.4	80.4	80.4	89.8
	23	38.7	47.4	47.4	59.0	59.0	69.9	69.9	78.2	78.2	86.6	86.6	97.7
	28	37.0	44.8	44.8	56.5	56.5	67.4	67.4	76.4	76.4	85.7	85.7	98.0
	Average	37.4	45.7	45.7	56.7	56.7	67.1	67.1	75.3	75.3	84.3	84.3	95.1
Unthinned:													
	14	35.5	42.2	42.2	52.9	52.9	63.7	63.7	70.9	70.9	78.2	78.2	89.1
	27	43.2	50.2	50.2	64.2	64.2	74.1	74.1	83.4	83.4	92.3	92.3	105.3
	29	38.3	45.2	45.2	57.0	57.0	69.2	69.2	77.8	77.8	86.5	86.5	97.7
	Average	39.0	45.9	45.9	58.0	58.0	69.0	69.0	77.4	77.4	85.7	85.7	97.4

[a] Before cut

[b] After cut

Table 6a—Number of live trees per acre (excluding ingrowth), by plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Feet											
1	24	405	400	295	295	175	175	125	125	100	100	75	70
	32	330	320	205	200	120	120	85	85	60	60	55	55
	36	350	350	200	190	100	100	70	70	55	55	45	35
	Average	362	357	233	228	132	132	93	93	72	72	58	53
3	11	400	375	290	265	200	200	170	165	145	145	125	120
	16	385	375	355	350	260	255	230	230	215	210	180	170
	40	400	400	325	300	250	230	230	225	185	170	165	165
	Average	395	383	323	305	237	228	210	207	182	175	157	152
5	9	395	385	385	375	375	355	355	325	325	320	320	300
	15	Deleted											
	21	360	360	350	350	280	275	240	240	205	190	185	180
	Average	378	372	368	362	328	315	298	282	265	255	252	240
7	25	395	390	390	380	380	380	380	375	365	365	360	320
	38	400	380	380	370	370	370	355	355	315	290	290	265
	39	410	410	410	385	385	370	370	365	365	335	335	300
	Average	402	393	393	378	378	373	368	365	348	330	328	295

[a] Before cut.

[b] After cut.

Table 6b—Number of live trees per acre (excluding ingrowth), by plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Trees per acre											
Increasing:													
2	20	Deleted											
	30	340	340	210	200	135	135	110	105	105	105	100	100
	44	400	380	215	210	145	145	115	115	105	105	105	105
	Average	370	360	212	205	140	140	112	110	105	105	102	102
4	10	395	375	270	235	215	210	200	200	185	180	180	175
	13	400	400	330	320	290	280	275	270	270	265	265	245
	19	350	330	270	250	200	185	190	185	185	180	180	165
	Average	382	368	290	268	235	228	222	218	213	208	208	195
Decreasing:													
6	41	400	400	325	310	255	250	210	210	175	170	125	95
	42	400	380	370	345	270	270	220	220	175	175	120	120
	43	400	390	365	350	290	290	225	225	190	190	130	130
	Average	400	390	353	335	272	270	218	218	180	178	125	115
8	12	380	380	380	365	365	355	355	345	340	325	305	290
	23	360	355	355	345	340	340	290	285	220	220	195	185
	28	365	365	365	340	340	325	325	320	235	230	205	195
	Average	368	367	367	350	348	340	323	317	265	258	235	223
Unthinned:	14	1,510	1,490	1,490	1,435	1,435	1,345	1,345	1,210	1,210	1,045	1,045	740
	27	1,230	1,230	1,230	1,155	1,155	1,040	1,040	910	910	775	775	590
	29	1,500	1,465	1,465	1,330	1,330	1,180	1,180	1,055	1,055	890	890	665
	Average	1,413	1,395	1,395	1,307	1,307	1,188	1,188	1,058	1,058	903	903	665

[a] Before cut.

[b] After cut.

Table 7—Number of live trees per acre, by diameter class, treatment, and stand age, in 1965 and 2006 (ingrowth and plots 15 and 20 excluded)

Treatment	1		2		3		4		5		6		7		8		Unthinned	
Year	1965	2006	1965	2006	1965	2006	1965	2006	1965	2006	1965	2006	1965	2006	1965	2006	1965	2006
Age	29	70	29	70	29	70	29	70	29	70	29	70	29	70	29	70	29	70
	Trees per acre																	
Diameter class, inches																		
2	0	0	13	0	7	0	2	0	0	0	12	0	12	0	0	0	473	8
3	78	0	80	0	82	0	90	0	78	0	82	0	87	0	90	0	440	48
4	137	0	105	0	147	0	120	0	163	3	138	0	150	2	117	0	215	65
5	112	0	108	0	108	0	115	3	93	5	103	0	107	2	102	0	152	73
6	28	0	48	0	45	3	40	7	40	10	52	0	42	10	43	13	93	78
7	7	0	15	0	7	3	13	5	5	25	12	0	5	17	17	5	25	72
8	0	0	3	3	0	8	2	8	0	23	2	2	0	30	0	18	13	52
9	0	0	0	3	0	13	0	20	0	38	0	3	0	32	0	25	2	67
10	0	2	0	5	0	27	0	15	0	10	0	7	0	47	0	32	0	52
11	0	2	0	10	0	10	0	22	0	30	0	15	0	48	0	25	0	48
12	0	7	0	10	0	13	0	28	0	25	0	10	0	38	0	20	0	33
13	0	5	0	3	0	23	0	25	0	18	0	5	0	18	0	30	0	22
14	0	3	0	5	0	23	0	23	0	13	0	22	0	20	0	17	0	17
15	0	5	0	15	0	7	0	22	0	23	0	17	0	15	0	17	0	13
16	0	5	0	20	0	13	0	5	0	8	0	15	0	8	0	8	0	10
17	0	7	0	10	0	3	0	5	0	10	0	12	0	5	0	8	0	3
18	0	3	0	10	0	2	0	3	0	3	0	7	0	3	0	5	0	2
19	0	10	0	5	0	0	0	2	0	0	0	2	0	0	0	0	0	2
20	0	5	0	3	0	2	0	2	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	362	53	370	103	395	152	382	195	378	240	400	115	402	295	368	223	1,413	665

Table 8a—Basal area per acre of live trees (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Square feet per acre											
1	24	38.7	51.3	40.0	72.8	46.1	64.4	49.4	63.0	52.9	69.3	58.0	71.8
	32	39.1	51.7	35.8	65.5	44.2	66.5	50.3	69.7	52.9	71.9	66.1	92.7
	36	43.7	58.8	41.0	73.9	42.9	64.7	49.4	66.9	52.5	70.0	58.6	63.7
	Average	40.5	58.9	39.0	70.7	44.4	65.2	49.7	66.5	52.8	70.4	60.9	76.1
2	11	48.6	64.6	51.3	85.2	66.7	95.1	80.1	100.6	91.2	117.3	104.3	131.3
	16	39.0	51.4	48.6	81.9	64.6	83.7	77.6	96.4	90.6	111.4	100.0	118.0
	40	45.5	60.3	50.2	79.3	64.6	81.3	81.3	99.7	89.5	106.1	101.8	133.8
	Average	44.3	58.8	50.0	82.2	65.3	86.7	79.7	98.9	90.5	111.6	102.0	127.7
5	9	42.2	52.8	52.8	81.1	81.1	99.9	99.9	110.8	110.8	131.9	131.9	156.1
	15	Deleted											
	21	42.5	58.4	57.9	97.9	84.0	118.2	106.2	136.4	123.0	143.4	140.4	177.6
	Average	42.4	55.6	55.0	89.5	82.6	109.1	103.1	123.6	116.7	137.6	136.2	166.8
7	25	44.2	57.9	57.9	97.5	97.5	129.9	129.9	157.1	153.6	182.2	179.7	200.1
	38	41.5	56.2	56.2	100.8	100.8	139.7	133.1	166.7	154.4	174.9	174.9	205.8
	39	46.7	62.2	62.2	98.7	98.7	127.4	127.4	151.6	151.6	175.1	175.1	195.9
	Average	44.1	58.8	58.8	99.0	99.0	132.3	130.1	158.5	153.2	177.4	176.6	200.6

[a] Before cut.

[b] After cut.

Table 8b—Basal area per acre of live trees (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Square feet per acre											
Increasing:													
2	20	Deleted											
	30	43.7	58.6	40.7	71.7	51.0	74.0	63.2	77.1	77.1	101.1	98.8	131.1
	44	45.0	61.2	41.5	72.1	52.4	74.8	65.0	83.7	79.6	101.1	101.1	128.8
	Average	44.4	59.9	41.1	71.9	51.7	74.4	64.1	80.4	78.4	101.1	100.0	130.0
4	10	48.6	63.2	50.0	76.1	71.3	96.8	94.4	118.9	114.8	136.5	136.5	166.5
	13	44.0	55.9	48.0	75.9	70.3	92.0	91.2	110.5	110.5	131.7	131.7	154.8
	19	41.2	53.6	48.0	82.3	68.6	95.2	91.3	112.4	112.4	138.0	138.0	164.7
	Average	44.6	57.6	48.7	78.1	70.0	94.7	92.3	114.0	112.6	135.4	135.4	162.0
Decreasing:													
6	41	49.7	67.7	57.8	95.8	80.0	112.2	93.0	120.9	105.8	131.2	105.5	102.3
	42	43.7	58.2	56.9	96.3	80.0	112.7	92.1	118.8	101.1	131.4	106.5	140.5
	43	45.6	61.2	57.8	93.8	79.9	110.8	91.9	114.7	101.3	126.6	102.0	131.2
	Average	46.3	62.3	57.5	95.3	80.0	111.9	92.4	118.1	102.7	129.8	104.7	124.7
8	12	41.6	54.2	54.2	83.3	83.3	106.5	106.5	127.2	126.2	146.1	138.2	166.5
	23	46.1	61.1	61.1	100.8	100.0	133.9	120.4	143.7	121.2	147.4	139.2	171.4
	28	42.7	55.8	88.8	88.8	119.1	119.1	151.5	120.8	150.8	150.8	139.0	173.6
	Average	43.4	57.0	57.0	90.9	90.7	119.8	115.3	140.8	122.7	148.1	138.8	170.5
Unthinned:	14	94.6	116.2	116.2	164.3	164.3	199.1	199.1	227.8	227.8	246.0	246.0	242.0
	27	02.5	128.0	128.0	179.7	179.7	210.7	210.7	234.2	234.2	261.1	261.1	282.5
	29	23.4	142.0	142.0	195.4	195.4	233.3	233.3	264.4	264.4	284.1	284.1	284.1
	Average	106.8	128.7	128.7	179.8	179.8	214.4	214.4	242.1	242.1	263.7	263.7	269.5

[a] Before cut.

[b] After cut.

Table 9a—Quadratic mean diameter of live trees (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration		Treatment									
		period		Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Quadratic mean diameter (in)											
1	24	4.2	4.8	5.0	6.7	6.9	8.2	8.5	9.6	9.8	11.3	11.9	13.7
	32	4.7	5.4	5.7	7.7	8.2	10.1	10.4	12.3	12.7	14.8	14.8	17.6
	36	4.8	5.5	6.1	8.4	8.9	10.9	11.4	13.2	13.2	15.3	15.4	18.3
	Average	4.5	5.3	5.6	7.6	8.0	9.7	10.1	11.7	11.9	13.8	14.1	16.5
3	11	4.7	5.6	5.7	7.7	7.8	9.3	9.3	10.6	10.7	12.2	12.4	14.2
	16	4.3	5.0	5.0	6.6	6.7	7.8	7.9	8.8	8.8	9.9	10.1	11.3
	40	4.6	5.3	5.3	7.0	6.9	8.0	8.0	9.0	9.4	10.7	10.6	12.2
	Average	4.5	5.3	5.3	7.1	7.2	8.4	8.4	9.5	9.6	10.9	11.0	12.5
5	9	4.4	5.0	5.0	6.3	6.3	7.2	7.2	7.9	7.9	8.7	8.7	9.8
	15	Deleted											
	21	4.7	5.5	5.5	7.2	7.4	8.9	9.0	10.2	10.5	11.8	11.8	13.5
	Average	4.6	5.2	5.2	6.8	6.8	8.0	8.1	9.0	9.2	10.2	10.2	11.6
7	25	4.5	5.2	5.2	6.9	6.9	7.9	7.9	8.8	8.8	9.6	9.6	10.7
	38	4.4	5.2	5.2	7.1	7.1	8.3	8.3	9.3	9.5	10.5	10.5	11.9
	39	4.6	5.3	5.3	6.9	6.9	7.9	7.9	8.7	8.7	9.8	9.8	10.9
	Average	4.5	5.2	5.2	6.9	6.9	8.1	8.1	8.9	9.0	10.0	10.0	11.2

[a] Before cut.

[b] After cut.

Table 9b—Quadratic mean diameter of live trees (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration		Treatment									
		period		Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Quadratic mean diameter (in)											
Increasing:													
2	20	Deleted											
	30	4.9	5.6	6.0	8.1	8.3	10.0	10.3	11.6	11.6	13.3	13.5	15.5
	44	4.5	5.4	5.9	7.9	8.1	9.7	10.2	11.6	11.8	13.3	13.3	15.0
	Average	4.7	5.5	6.0	8.0	8.2	9.8	10.2	11.6	11.7	13.3	13.4	15.2
4	10	4.8	5.6	5.8	7.7	7.8	9.2	9.3	10.4	10.7	11.8	11.8	13.2
	13	4.5	5.1	5.2	6.6	6.7	7.8	7.8	8.7	8.7	9.5	9.5	10.8
	19	4.6	5.5	5.7	7.8	7.9	9.5	9.4	10.6	10.6	11.9	11.9	13.5
	Average	4.6	5.4	5.6	7.4	7.5	8.8	8.8	9.9	10.0	11.1	11.1	12.5
Decreasing:													
6	41	4.8	5.6	5.7	7.5	7.6	9.1	9.0	10.3	10.5	11.9	12.4	14.0
	42	4.5	5.3	5.3	7.2	7.4	8.7	8.8	9.9	10.3	11.7	12.8	14.6
	43	4.6	5.4	5.4	7.0	7.1	8.4	8.7	9.7	9.9	11.1	12.0	13.6
	Average	4.6	5.4	5.5	7.2	7.4	8.7	8.8	10.0	10.2	11.6	12.4	14.1
8	12	4.5	5.1	5.1	6.5	6.5	7.4	7.4	8.2	8.3	9.1	9.1	10.3
	23	4.8	5.6	5.6	7.3	7.3	8.5	8.7	9.6	10.1	11.1	11.4	13.0
	28	4.6	5.3	5.3	6.9	6.9	8.2	8.2	9.3	9.7	11.0	11.2	12.8
	Average	4.6	5.3	5.3	6.9	6.9	8.0	8.1	9.1	9.3	10.4	10.6	12.0
Unthinned:	14	3.4	3.8	3.8	4.6	4.6	5.2	5.2	5.9	5.9	6.6	6.6	7.7
	27	3.9	4.4	4.4	5.3	5.3	6.1	6.1	6.9	6.9	7.9	7.9	9.4
	29	3.9	4.2	4.2	5.2	5.2	6.0	6.0	6.8	6.8	7.6	7.6	8.8
	Average	3.7	4.1	4.1	5.0	5.0	5.8	5.8	6.5	6.5	7.4	7.4	8.7

[a] Before cut.

[b] After cut.

Table 10a—Live cubic-foot volume of total stem, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration		Treatment									
		period		Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Cubic volume of total stem (ft^3/ac)											
1	24	483	740	584	1,368	879	1,472	1,146	1,705	1,444	2,122	1,798	2,480
	32	524	811	573	1,335	922	1,677	1,285	2,029	1,546	2,368	2,162	3,449
	36	612	964	712	1,631	964	1,723	1,330	2,003	1,567	2,426	2,046	2,479
	Average	540	838	623	1,445	922	1,624	1,253	1,912	1,519	2,305	2,002	2,803
3	11	664	1,058	849	1,815	1,435	2,471	2,087	2,881	2,634	3,857	3,447	4,842
	16	494	774	732	1,581	1,259	1,938	1,811	2,493	2,353	3,195	2,887	3,830
	40	589	936	789	1,576	1,272	1,908	1,908	2,627	2,395	3,126	2,992	4,439
	Average	582	922	790	1,657	1,322	2,106	1,935	2,667	2,461	3,393	3,109	4,370
5	9	534	787	787	1,497	1,497	2,212	2,212	2,672	2,672	3,641	3,641	4,836
	15	Deleted											
	21	557	928	907	1,937	1,722	2,926	2,640	3,718	3,377	4,541	4,448	6,176
	Average	546	858	847	1,735	1,610	2,569	2,426	3,195	3,024	4,091	4,044	5,506
7	25	568	911	911	1,985	1,985	3,164	3,164	4,384	4,289	5,610	5,532	6,871
	38	534	922	922	2,158	2,158	3,628	3,454	4,921	4,594	5,725	5,725	7,415
	39	615	1,025	1,025	2,071	2,071	3,226	3,226	4,303	4,303	5,529	5,529	6,828
	Average	572	953	953	2,071	2,071	3,339	3,281	4,536	4,395	5,621	5,595	7,038

[a] Before cut.

[b] After cut

Table 10b—Live cubic-foot volume of total stem, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Cubic volume of total stem (ft^3/ac)											
Increasing:													
2	20	Deleted											
	30	317	998	715	1,627	1,173	2,036	1,762	2,345	2,345	3,507	3,444	5,064
	44	606	1,043	740	1,623	1,204	2,012	1,767	2,538	2,435	3,427	3,427	4,816
	Average	612	1,020	728	1,625	1,188	2,024	1,764	2,442	2,390	3,467	3,436	4,940
4	10	670	1,047	842	1,583	1,484	2,438	2,384	3,315	3,215	4,301	4,301	5,780
	13	585	869	755	1,448	1,343	2,142	2,128	2,884	2,884	3,869	3,869	4,970
	19	586	920	842	1,802	1,521	2,513	2,406	3,345	3,345	4,647	4,647	6,034
	Average	614	946	813	1,611	1,449	2,365	2,306	3,181	3,148	4,272	4,272	5,594
Decreasing:													
6	41	696	1,190	1,026	2,202	1,846	3,133	2,592	3,646	3,220	4,479	3,660	3,813
	42	584	990	970	2,157	1,815	3,074	2,507	3,546	3,066	4,452	3,705	5,377
	43	616	1,044	989	2,062	1,765	2,472	2,462	3,314	2,942	4,144	3,405	4,717
	Average	632	1,075	995	2,141	1,809	3,047	2,520	3,502	3,076	4,358	3,590	4,636
8	12	552	851	851	1,609	1,609	2,472	2,472	3,260	3,239	4,196	3,987	5,243
	23	657	1,055	1,055	2,158	2,145	3,417	3,088	4,119	3,530	4,712	4,472	6,058
	28	585	911	911	1,831	1,831	2,974	2,974	4,258	3,451	4,805	4,458	6,159
	Average	598	939	939	1,866	1,862	2,954	2,845	3,879	3,406	4,571	4,306	5,820
Unthinned:	14	1,172	1,677	1,677	2,974	2,974	4,346	4,346	5,541	5,541	6,651	6,651	7,346
	27	1,419	2,085	2,085	3,676	3,676	5,125	5,125	6,398	6,398	7,951	7,951	9,721
	29	1,655	2,212	2,212	3,820	3,820	5,527	5,527	7,010	7,010	8,408	8,408	9,316
	Average	1,415	1,991	1,991	3,490	3,490	4,999	4,999	6,316	6,316	7,670	7,670	8,794

[a] Before cut.

[b] After cut.

Table 11a—Live merchantable cubic-foot volume to 6-in top (CV6) per acre, ingrowth excluded, by treatment plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		CV6 (ft^3/ac)											
1	24	2	16	16	465	322	871	728	1,283	1,115	1,810	1,579	2,282
	32	6	72	59	695	532	1,318	1,041	1,808	1,398	2,219	2,026	3,283
	36	23	153	153	1,022	656	1,439	1,143	1,831	1,432	2,280	1,925	2,363
	Average	10	80	76	727	504	1,209	970	1,641	1,315	2,103	1,843	2,643
3	11	7	120	96	890	734	1,777	1,492	2,353	2,178	3,417	3,074	4,481
	16	9	57	57	503	441	1,039	994	1,674	1,590	2,470	2,279	3,269
	40	21	117	108	682	523	1,125	1,125	1,843	1,760	2,578	2,456	3,911
	Average	12	98	87	691	566	1,314	1,203	1,957	1,842	2,821	2,603	3,887
5	9	9	55	55	427	427	1,001	1,001	1,542	1,542	2,475	2,475	3,722
	15	Deleted											
	21	17	111	111	857	805	1,963	1,808	2,938	2,731	3,947	3,871	5,636
	Average	13	83	83	642	616	1,482	1,404	2,240	2,136	3,211	3,173	4,679
7	25	17	67	67	695	695	1,727	1,727	2,916	2,864	4,195	4,137	5,656
	38	7	93	93	907	907	2,135	2,135	3,595	3,411	4,658	4,658	6,467
	39	14	132	132	875	875	1,918	1,918	2,970	2,970	4,279	4,279	5,708
	Average	13	97	97	826	826	1,967	1,927	3,160	3,082	4,377	4,358	5,943

[a] Before cut.

[b] After cut.

Table 11b—Live merchantable cubic-foot volume to 6-in top (CV6) per acre, ingrowth excluded, by treatment plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		CV6 (ft^3/ac)											
Increasing:													
2	20	Deleted											
	30	46	186	158	953	706	1,589	1,404	2,030	2,030	3,190	3,146	4,744
	44	34	215	197	972	740	1,526	1,397	2,185	2,119	3,114	3,114	4,491
	Average	40	200	178	962	723	1,558	1,400	2,108	2,074	3,152	3,130	4,618
4	10	45	184	182	851	816	1,735	1,719	2,666	2,630	3,731	3,731	5,235
	13	8	59	59	505	483	1,181	1,181	1,933	1,933	2,926	2,926	4,124
	19	32	153	153	929	815	1,826	1,731	2,720	2,720	4,063	4,063	5,525
	Average	28	132	132	761	704	1,580	1,544	2,440	2,428	3,574	3,574	4,962
Decreasing:													
6	41	41	201	200	1,117	954	2,204	1,815	2,920	2,618	3,917	3,260	3,523
	42	20	138	138	960	851	2,041	1,675	2,759	2,443	3,855	3,330	4,996
	43	15	140	140	894	801	1,879	1,664	2,550	2,308	3,528	2,993	4,322
	Average	25	160	159	990	869	2,041	1,718	2,743	2,457	3,767	3,194	4,280
8	12	18	83	83	510	510	1,196	1,196	1,969	1,969	2,938	2,806	4,167
	23	40	196	196	1,068	1,068	2,244	2,079	3,123	2,786	3,974	3,840	5,463
	28	18	112	112	745	745	1,803	1,803	3,108	2,629	4,023	3,775	5,550
	Average	25	131	131	774	774	1,748	1,692	2,733	2,462	3,645	3,474	5,060
Unthinned:	14	11	79	79	502	502	1,244	1,244	2,134	2,134	3,243	3,243	4,632
	27	195	479	479	1,531	1,531	2,677	2,677	3,879	3,879	5,490	5,490	7,637
	29	82	255	255	1,223	1,223	2,541	2,541	3,937	3,937	5,544	5,544	7,012
	Average	96	271	271	1,085	1,085	2,154	2,154	3,317	3,317	4,759	4,759	6,427

[a] Before cut.

[b] After cut.

Table 12a—Live board foot volume per acre to 6-in top (SV6), ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration		Treatment									
		period		Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Scribner board feet (SV6) per acre											
1	24	0	0	0	443	331	3,161	2,712	4,761	4,198	6,535	5,802	8,978
	32	0	0	0	1,705	1,349	4,569	3,569	5,773	4,471	8,535	7,737	12,823
	36	0	0	0	3,249	2,356	4,604	3,600	5,960	4,704	8,849	7,463	9,703
	Average	0	0	0	1,799	1,345	4,112	3,293	5,498	4,458	7,973	7,001	10,501
3	11	0	0	0	2,535	2,180	6,775	5,728	8,649	7,930	13,045	11,762	18,443
	16	0	0	0	1,012	893	3,595	3,495	6,185	5,891	8,944	8,298	13,063
	40	0	106	106	1,799	1,349	3,843	3,843	6,009	5,847	9,212	8,760	15,706
	Average	0	35	35	1,782	1,474	4,738	4,355	6,948	6,556	10,400	9,607	15,737
5	9	0	0	0	656	656	3,170	3,170	4,842	4,842	9,225	9,225	14,422
	15	Deleted											
	21	0	0	0	2,005	2,005	6,974	6,429	9,985	9,159	14,796	14,508	22,728
	Average	0	0	0	1,330	1,330	5,072	4,800	7,414	7,000	12,012	11,866	18,575
7	25	0	119	119	1,338	1,338	6,094	6,094	11,814	11,558	16,817	16,566	23,493
	38	0	0	0	2,312	2,312	8,220	7,776	13,606	12,887	18,537	18,537	26,426
	39	0	0	0	2,673	2,673	6,753	6,753	11,139	11,139	16,798	16,798	23,724
	Average	0	40	40	2,108	2,108	7,022	6,874	12,186	11,861	17,384	17,301	24,548

[a] Before cut.

[b] After cut.

Table 12b—Live board foot volume per acre to 6-in top (SV6), ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration period		Treatment									
				Period 1		Period 2		Period 3		Period 4		Period 5	
Treatment	Plot	1965 (29)	1969 (33)[a]	1969 (33)[b]	1976 (40)	1976 (40)	1982 (46)	1982 (46)	1988 (52)	1988 (52)	1995 (59)	1995 (59)	2006 (70)
		Scribner board feet (SV6) per acre											
Increasing:													
2	20	Deleted											
	30	0	212	212	2,907	2,202	5,731	5,024	7,264	7,264	12,819	12,637	19,342
	44	0	356	356	3,333	2,546	5,279	4,865	7,843	7,549	12,100	12,100	18,201
	Average	0	284	284	3,120	2,374	5,505	4,944	7,554	7,406	12,460	12,368	18,772
4	10	0	244	244	2,281	2,143	5,857	5,857	9,058	8,908	13,826	13,826	21,125
	13	0	0	0	837	837	3,976	3,976	6,887	6,887	10,908	10,908	16,425
	19	0	144	144	2,718	2,456	6,531	6,243	10,145	10,145	15,879	15,879	23,347
	Average	0	129	129	1,945	1,812	5,455	5,359	8,696	8,646	13,538	13,538	20,299
Decreasing:													
6	41	0	343	343	3,621	3,107	8,343	6,908	11,082	9,911	15,894	13,193	14,474
	42	0	106	106	2,835	2,535	7,035	5,706	10,456	9,239	15,759	13,673	20,229
	43	0	106	106	2,925	2,663	6,990	5,946	9,212	8,353	14,095	11,983	17,818
	Average	0	185	185	3,127	2,769	7,356	6,187	10,250	9,167	15,250	12,950	17,507
8	12	0	100	100	1,062	1,062	3,819	3,819	7,018	7,018	11,055	10,529	16,494
	23	0	0	0	3,236	3,236	8,004	7,504	10,748	9,554	15,443	14,824	22,349
	28	0	0	0	2,017	2,017	6,108	6,108	11,614	9,978	15,787	14,785	22,789
	Average	0	33	33	2,105	2,105	5,977	5,810	9,794	8,850	14,095	13,379	20,544
Unthinned:	14	0	0	0	1,174	1,174	3,993	3,993	6,877	3,877	11,902	11,902	18,177
	27	112	1,012	1,012	4,316	4,316	9,586	9,586	14,441	14,441	21,905	21,905	31,751
	29	0	0	0	3,060	3,060	8,836	8,836	14,398	14,398	21,574	21,574	28,969
	Average	37	337	337	2,850	2,850	7,472	7,472	11,905	11,905	18,460	18,460	26,299

[a] Before cut.

[b] After cut.

Table 13—Number, quadratic mean diameter, and basal area of live trees cut, excluding plots 15 (in treatment 5) and 20 (in treatment 2)

	Year (age)						
Treatment	1965 (29)	1969 (33)	1976 (40)	1982 (46)	1988 (52)	1995 (59)	Total
			Trees per acre				
1	0	123	97	38	22	13	293
2	0	148	65	28	5	3	249
3	0	60	68	18	25	18	189
4	0	78	33	7	5	0	123
5	0	5	35	18	18	3	79
6	0	37	63	52	38	53	243
7	0	0	0	5	17	2	24
8	0	0	2	17	52	23	94
			Quadratic mean diameter (in)				
1	0	4.7	7.1	8.6	10.7	11.6	7.1
2	0	4.8	7.5	8.2	8.7	8.3	6.2
3	0	5.2	6.7	8.5	7.9	9.9	7.0
4	0	4.6	6.7	7.9	7.1	0.0	5.6
5	0	5.0	6.0	7.8	8.3	9.7	7.1
6	0	4.9	6.7	8.3	8.6	9.3	7.8
7	0	0.0	0.0	8.9	7.5	8.8	8.0
8	0	0.0	4.9	7.0	8.0	8.6	7.9
			Basal area (ft^2/ac)				
1	0	15.0	26.3	15.5	13.7	9.5	80.0
2	0	18.8	20.2	10.4	2.1	1.1	52.6
3	0	8.7	16.9	7.0	8.4	9.6	50.6
4	0	8.9	8.1	2.4	1.4	0.0	20.7
5	0	0.7	7.0	6.0	6.7	1.5	21.9
6	0	4.8	15.4	19.5	15.4	25.1	80.2
7	0	0.0	0.0	2.2	5.3	0.8	8.3
8	0	0.0	0.3	4.5	18.1	9.3	32.1

Table 14—Total cubic-foot, merchantable cubic-foot, and Scribner (SV6) volumes of live trees cut, excluding plots 15 (in treatment 5) and 20 (in treatment 2)

	Year (age)						
Treatment	1965 (29)	1969 (33)	1976 (40)	1982 (46)	1988 (52)	1995 (59)	Total
	Cubic volume of total stem (ft^3/ac)						
1	0	216	523	371	393	303	1,806
2	0	293	436	260	52	31	1,072
3	0	132	335	170	206	284	1,128
4	0	132	161	59	33	0	386
5	0	10	126	143	171	46	496
6	0	80	332	527	426	768	2,133
7	0	0	0	58	141	26	225
8	0	0	4	109	472	265	851
	Merchantable cubic volume (ft^3 to 6-in top/ac)						
1	0	4	224	239	326	260	1,052
2	0	23	239	157	33	22	475
3	0	11	125	110	114	218	579
4	0	0	57	37	12	0	107
5	0	0	26	78	103	38	245
6	0	0	122	323	287	572	1,305
7	0	0	0	40	78	19	138
8	0	0	0	55	272	171	498
	Scribner volume (Scribner board ft to 6-inch top/ac)						
1	0	0	454	818	1,041	972	3,285
2	0	0	746	560	147	91	1,544
3	0	0	308	382	392	794	1,876
4	0	0	133	96	50	0	279
5	0	0	0	272	413	144	829
6	0	0	359	1,169	1,082	2,300	4,910
7	0	0	0	148	325	84	557
8	0	0	0	167	944	715	1,826

Table 15—Number, quadratic mean diameter, and basal area of dead trees recorded at end of period, by treatment[a]

Treatment	Year (age)							Total
	1965 (29)	1969 (33)	1976 (40)	1982 (46)	1988 (52)	1995 (59)	2006 (70)	
	Trees per acre							
1	40	5	5	0	0	0	5	55
2	30	10	8	0	3	0	0	51
3	5	12	18	8	3	7	7	60
4	17	13	22	7	3	5	13	80
5	23	5	5	13	15	10	13	84
6	0	10	18	2	0	2	10	42
7	2	8	15	5	3	18	33	84
8	32	2	17	8	7	7	12	85
Unthinned	12	18	88	118	130	157	238	781
	Quadratic mean diameter (in)							
1	3.58	4.00	4.81	0.00	0.00	0.00	13.94	5.53
2	3.48	4.64	4.68	.00	13.32	0.00	0.00	5.02
3	3.41	3.49	4.76	7.64	11.07	9.22	11.63	7.06
4	3.48	3.87	4.92	5.77	10.37	9.85	9.29	6.22
5	3.22	3.85	5.21	6.15	7.26	10.61	6.40	6.35
6	0.00	3.35	4.42	4.21	0.00	10.04	13.06	7.57
7	3.10	3.47	4.58	6.57	9.87	8.62	8.11	7.27
8	3.56	3.67	4.81	5.25	6.27	7.10	7.76	5.31
Unthinned	2.92	2.51	3.02	2.96	3.23	4.21	5.45	4.15
	Basal area (ft^2/ac)							
1	2.80	0.44	0.63	0.00	0.00	0.00	5.30	9.17
2	1.98	1.17	0.95	0.00	2.90	0.00	0.00	7.02
3	0.32	0.80	2.23	2.55	2.00	3.24	5.16	16.29
4	1.12	1.06	2.90	1.27	1.76	2.64	6.12	16.88
5	1.30	0.41	0.74	2.68	4.32	6.14	2.90	18.48
6	0.00	0.61	1.92	0.19	0.00	1.10	9.30	13.13
7	0.11	0.53	1.72	1.18	1.59	7.30	11.83	24.25
8	2.21	0.15	2.14	1.20	1.50	1.93	3.94	13.07
Unthinned	1.49	0.62	4.38	5.64	7.41	15.20	38.58	73.32

[a] Plots 15 (in treatment 5) and 20 (in treatment 2) excluded, ingrowth excluded, calibration period included.

Table 16—Total cubic-foot, merchantable cubic-foot, and Scribner volumes per acre of dead trees recorded at end of period, by treatment[a]

	Years (age)							
Year	**1965**	**1969**	**1976**	**1982**	**1988**	**1995**	**2006**	
age	**(29)**	**(33)**	**(40)**	**(46)**	**(52)**	**(59)**	**(70)**	**Total**
				CVTS (ft^3/ac)				
Treatment								
1	32.7	5.5	9.4	0.0	0.0	0.0	187.1	234.7
2	22.5	18.1	14.9	0.0	96.9	0.0	0.0	152.5
3	3.4	9.5	35.0	58.2	49.8	95.9	170.3	422.2
4	13.2	14.2	48.8	26.6	50.5	80.0	185.0	418.4
5	14.7	4.9	12.0	57.2	96.8	187.8	68.1	441.6
6	0.0	8.1	32.7	3.6	0.0	36.3	348.6	429.3
7	1.2	6.4	28.4	25.5	45.0	219.6	354.2	680.5
8	26.9	1.9	35.4	23.6	38.4	53.8	112.8	292.8
Unthinned	17.9	7.3	62.3	92.3	131.6	329.8	991.6	1,632.5
				Merchantable cubic volume ($ft^3$to 6-in top/ac)				
1	0.0	0.0	0.0	0.0	0.0	0.0	173.7	173.7
2	.0	1.3	.0	.0	90.8	.0	.0	92.0
3	.0	.0	.0	25.4	39.6	77.4	149.9	292.2
4	.0	.0	2.4	3.0	39.0	60.8	136.0	241.2
5	.0	.0	.0	25.6	38.3	158.4	21.7	244.0
6	.0	.0	1.0	.0	.0	30.9	316.1	347.8
7	.0	.0	.7	9.6	33.2	161.2	232.8	437.5
8	.0	.0	2.6	9.5	25.2	37.3	69.5	144.1
Unthinned	.0	.0	.2	.2	8.8	37.6	337.8	384.5
				Board-foot volume to 6-in top (Scribner bd ft/ac)				
1	0	0	0	0	0	0	734	734
2	0	0	0	0	383	0	0	383
3	0	0	0	81	134	288	550	1,053
4	0	0	0	0	117	248	499	865
5	0	0	0	91	106	523	84	804
6	0	0	0	0	0	96	1,354	1,450
7	0	0	0	40	96	579	947	1,661
8	0	0	0	42	96	117	267	522
Unthinned	0	0	0	0	44	84	1,355	1,483

[a] Plots 15 (in treatment 5) and 20 (in treatment 2) and ingrowth excluded, calibration period included.

Table 17—Percentage of merchantable cubic-foot volume (CV6) of live trees present in 2006 in logs with scaling diameter larger than indicated value

Treatment	Scaling diameter (in)						Total live CV6
	6	8	10	12	14	16	
	Percent						*Ft^3/ac*
Fixed:							
1	100	85.4	60.4	39.0	3.2	0	2,643
3	100	64.2	32.9	8.7	2.1	0	3,887
5	100	69.7	44.4	10.3	0	0	4,679
7	100	72.3	51.3	19.3	0	0	5,943
Increasing:							
2	100	79.5	60.2	35.8	6.6	3.5	4,618
4	100	63.9	33.5	9.7	1.6	0	4,962
Decreasing:							
6	100	72.3	51.3	19.3	0	0	4,280
8	100	60.3	31.0	9.7	0	0	5,060
Unthinned:							
	100	43.5	18.7	4.9	0	0	6,427

Table 18—Percentage of merchantable cubic-foot volume (CV6) of trees removed in thinning in logs with scaling diameter larger than indicated value

Treatment	Scaling diameter (in)						Total live CV6
	6	8	10	12	14	16	
	Percent						*Ft^3/ac*
Fixed:							
1	100	48.4	29.4	8.7	0	0	1,053
3	100	33.7	10.9	4.3	0	0	579
5	100	40.3	27.2	4.7	0	0	245
7	100	0	0	0	0	0	138
Increasing:							
2	100	53.3	35.5	20.0	3.0	1.6	475
4	100	46.5	21.2	5.1	0	0	107
Decreasing:							
6	100	39.4	12.9	7.2	0	0	1,305
8	100	16.7	8.0	0	0	0	498
Unthinned:							
	0	0	0	0	0	0	0

Table 19—Percentage of merchantable board-foot volume (SV6) of live trees present in 2006 in logs with scaling diameter larger than indicated value and minimum log length 16 ft

Treatment	Scaling diameter (in)						Total live SV6
	6	8	10	12	14	16	
	Percent						*Board ft/ac*
Fixed:							
1	100	86.1	61.9	38.5	3.4	0	10,501
3	100	65.3	65.2	9.0	2.3	0	15,737
5	100	70.4	46.4	10.3	0	0	18,575
7	100	53.1	25.9	5.1	0	0	24,548
Increasing:							
2	100	80.8	62.4	36.7	8.1	4.3	18,772
4	100	63.9	35.2	9.7	1.7	0	20,229
Decreasing:							
6	100	73.6	53.1	19.5	0	0	17,507
8	100	61.4	33.1	10.7	0	0	20,544
Unthinned:							
	100	0	0	0	0	0	26,299

Table 20—Percentage of merchantable board-foot volume (SV6) in trees removed in thinning, in logs with scaling diameter larger than indicated value and minimum log length 16 ft

Treatment	Scaling diameter (in)						Total live SV6
	6	8	10	12	14	16	
	Percent						*Board ft/ac*
Fixed:							
1	100	63.5	48.3	15.9	0	0	3,285
3	100	47.4	49.7	7.6	0	0	1,876
5	100	63.1	46.3	7.0	0	0	829
7	100	0	0	0	0	0	557
Increasing:							
2	100	69.3	54.8	33.5	6.4	3.4	1,544
4	100	63.4	33.2	7.7	0	0	279
Decreasing:							
6	100	50.4	23.7	13.1	0	0	4,910
8	100	27.0	16.5	0	0	0	1,826
Unthinned:							
	0	0	0	0	0	0	0

Table 21a—Stand development table for treatment 1 (plots 24, 32, and 36) per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – Ft³ – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	35	6.0	362	4.5	40.5	540	10	0	0.0	0.0	0	0	0.0	0.0	0.00	40	3.6	2.8	33	0
1969	33	42	6.9	233	5.6	39.0	623	76	123	4.7	15.0	216	4	1.8	1.3	.90	5	4.0	.4	5	0
1976	40	54	9.3	132	8.0	44.4	922	504	97	7.1	26.3	523	224	5.4	3.6	.94	5	4.8	.6	9	0
1982	46	66	11.2	93	10.1	49.7	1,253	970	38	8.6	15.5	371	239	9.8	6.8	.90	0	.0	.0	0	0
1988	52	75	12.9	72	11.9	52.8	1,519	1,315	22	10.8	13.7	393	326	17.9	16.3	.95	0	.0	.0	0	0
1995	59	87	14.8	58	14.1	60.9	2,002	1,843	13	11.4	9.5	303	260	23.3	21.7	.85	0	.0	.0	0	0
2006	70	99	17.2	53	16.5	76.1	2,803	2,643	0	.0	.0	0	0	.0	.0	.00	5	13.9	5.3	187	174

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – In – – –*		*– – – Ft²– – –*		*– Ft³ –*							
1965	29	540	572	10	10	0.00	0.00	0.0	0.0	0	19	0	0	0	20	0	0
1969	33	838	877	80	80	.18	.18	3.4	3.5	75	25	17	2	76	27	17	2
1976	40	1,660	1,708	732	732	.29	.29	4.5	4.6	117	42	93	18	119	43	93	18
1982	46	2,363	2,411	1,437	1,437	.29	.29	3.5	3.5	117	51	118	31	117	52	118	31
1988	52	3,022	3,069	2,107	2,107	.27	.27	2.8	2.8	110	58	112	41	110	59	112	41
1995	59	3,808	3,856	2,895	2,895	.27	.27	2.5	2.5	112	65	113	49	112	65	113	49
2006	70	4,609	4,843	3,695	3,869	.22	.22	1.4	1.9	73	66	73	53	90	69	89	55

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

[b] Quadratic mean diameter at breast height (QMD).

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,806 ft^3 (37 percent of total gross yield to age 70); volume (CVTS) in mortality = 235 ft^3 (5 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 21b—Metric stand development table for treatment 1 (plots 24, 32, and 36), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		m^3	*No.*	*Cm*	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	10.8	15.2	893	11.5	9.3	37.8	0.7	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	99	9.1	0.6	2.3	0.0
1969	33	12.7	17.6	576	14.2	8.9	43.6	5.3	305	12.0	3.4	15.1	.3	.0	.0	.90	12	10.2	.1	.4	.0
1976	40	16.6	23.5	325	20.4	10.2	64.5	35.2	239	18.0	6.0	36.6	15.6	.2	.1	.94	12	12.2	.1	.7	.0
1982	46	20.0	28.3	231	25.7	11.4	87.7	67.9	95	21.9	3.6	26.0	16.7	.3	.2	.90	0	.0	.0	.0	.0
1988	52	23.0	32.7	177	30.3	12.1	106.3	92.0	54	27.4	3.2	27.5	22.8	.5	.5	.94	0	.0	.0	.0	.0
1995	59	26.4	37.7	144	35.7	14.0	140.1	129.0	33	29.1	2.2	21.2	18.2	.6	.6	.85	0	.0	.0	.0	.0
2006	70	30.1	43.6	132	42.0	17.5	196.1	184.9	0	.0	.0	.0	.0	.0	.0	.00	12	35.4	1.2	13.1	12.2

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	37.8	40.0	0.7	0.7	0.00	0.00	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.4	0.0	0.0
1969	33	58.7	61.3	5.6	5.6	.47	.46	.8	.8	5.2	1.8	1.2	.2	5.3	1.9	1.2	.2
1976	40	116.2	119.5	51.2	51.2	.74	.73	1.0	1.1	8.2	2.9	6.5	1.3	8.3	3.0	6.5	1.3
1982	46	165.3	168.7	100.6	100.6	.73	.73	.8	.8	8.2	3.6	8.2	2.2	8.2	3.7	8.2	2.2
1988	52	211.4	214.8	147.5	147.5	.68	.68	.6	.6	7.7	4.1	7.8	2.8	7.7	4.1	7.8	2.8
1995	59	266.5	269.8	202.6	202.6	.68	.68	.6	.6	7.9	4.5	7.9	3.4	7.9	4.6	7.9	3.4
2006	70	322.5	338.9	258.6	270.7	.57	.55	.3	.4	5.1	4.6	5.1	3.7	6.3	4.8	6.2	3.9

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

[b] Quadratic mean diameter at breast height (QMD).

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 126.4 m^3 (37 percent of total gross yield at age 70; volume (CVTS) in mortality = 13.1 m^3 (5 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period.

[g] MAI = mean annual increment.

Table 22a—Stand development table for treatment 2 (plots 30 and 44) per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 Largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	HT	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – – Ft³ – – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	39	6.8	370	4.7	44.3	612	40	0	0.0	0.0	0	0	0.0	0.0	.00	30	3.5	2.0	23	0
1969	33	49	8.0	213	6.0	41.1	727	177	148	4.8	18.8	293	23	2.0	1.1	.88	10	4.6	1.2	18	1
1976	40	63	10.5	140	8.2	51.7	1,189	723	65	7.5	20.2	436	239	6.7	6.8	.94	8	4.8	1.0	15	0
1982	46	73	12.1	113	10.2	64.1	1,764	1,401	28	8.3	10.4	260	157	9.3	6.8	.85	0	.0	.0	0	0
1988	52	82	13.6	105	11.7	78.3	2,390	2,074	5	8.7	2.1	52	33	10.4	6.6	.75	3	14.6	2.9	97	91
1995	59	92	15.5	103	13.4	99.9	3,435	3,130	3	9.1	1.1	31	22	10.3	7.3	.69	0	.0	.0	0	0
2006	70	104	17.9	103	15.3	130.0	4,940	4,618	0	.0	.0	0	0	.0	.0	.00	0	.0	.0	0	0

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft²– – –*		*– Ft³ –*							
1965	29	612	634	40	40	0.00	0.00	0.0	0.0	0	21	0	1	0	22	0	1
1969	33	1,020	1,061	201	202	.21	.21	3.9	4.2	102	31	40	6	107	32	40	6
1976	40	1,918	1,974	985	987	.30	.29	4.4	4.5	128	48	112	25	130	49	112	25
1982	46	2,754	2,809	1,820	1,821	.27	.27	3.8	3.8	139	60	139	40	139	61	139	40
1988	52	3,431	3,584	2,527	2,619	.23	.25	2.7	3.2	113	66	118	49	129	69	133	50
1995	59	4,508	4,660	3,605	3,697	.23	.23	3.2	3.2	154	76	154	61	154	79	154	63
2006	70	6,012	6,165	5,092	5,184	.17	.17	2.7	2.7	137	86	135	73	137	88	135	74

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

[b] Quadratic mean diameter at breast height (QMD).

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark(CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,072 ft^3 (17 percent of total gross yield to age 70); volume (CVTS) in mortality = 153 ft^3 (2 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 22b—Metric stand development table for treatment 2 (plots 30 and 44), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^2		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	11.8	17.1	914	11.9	10.2	42.8	2.8	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	74	8.8	0.5	1.6	0.0
1969	33	14.9	20.3	525	15.1	9.4	50.9	12.4	364	12.3	4.3	20.5	1.6	.1	.0	.88	25	11.8	.3	1.3	.1
1976	40	19.3	26.6	346	20.9	11.9	83.2	50.6	161	19.2	4.6	30.5	16.7	.2	.2	.94	19	12.3	.2	1.0	.0
1982	46	22.2	30.7	278	26.0	14.7	123.4	98.0	68	21.1	2.4	18.2	11.0	.3	.2	.84	0	.0	.0	.0	.0
1988	52	24.9	34.7	259	29.7	18.0	167.3	145.1	12	22.1	.5	3.6	2.3	.3	.2	.75	6	37.1	.7	6.8	6.4
1995	59	27.9	39.4	253	34.0	22.9	240.4	219.0	6	23.1	.3	2.2	1.5	.3	.3	.68	0	.0	.0	.0	.0
2006	70	31.8	45.5	253	38.7	29.8	345.7	323.1	0	.0	.0	.0	.0	.0	.0	.00	0	.0	.0	.0	.0

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	42.8	44.4	2.8	2.8	0.00	0.00	0.0	0.0	0.0	1.5	0.0	.1	0.0	1.5	0.0	.1
1969	33	71.4	74.2	14.0	14.1	.53	.53	.9	1.0	7.1	2.2	2.8	.4	7.5	2.2	2.8	.4
1976	40	134.2	138.1	68.9	69.0	.75	.74	1.0	1.0	9.0	3.4	7.8	1.7	9.1	3.5	7.8	1.7
1982	46	192.7	196.6	127.4	127.5	.70	.70	.9	.9	9.7	4.2	9.7	2.8	9.7	4.3	9.7	2.8
1988	52	240.1	250.8	176.8	183.3	.58	.63	.6	.7	7.9	4.6	8.2	3.4	9.0	4.8	9.3	3.5
1995	59	315.4	326.1	252.2	258.7	.58	.58	.7	.7	10.8	5.3	10.8	4.3	10.8	5.5	10.8	4.4
2006	70	420.7	431.4	356.3	362.8	.43	.43	.6	.6	9.6	6.0	9.5	5.1	9.6	6.2	9.5	5.2

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

[b] Quadratic mean diameter at breast height (QMD).

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 75.0 m^3 (17 percent of total gross yield at age 70; volume (CVTS) in mortality = 10.7 m^3 (2 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period.

[g] MAI = mean annual increment.

Table 23a—Stand development table for treatment 3 (plots 11, 16, and 40), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	37	6.2	395	4.5	44.3	582	12	0	0.0	0.0	0	0	0.0	0.0	0.00	5	3.4	0.3	3	0
1969	33	44	7.2	323	5.3	50.0	790	87	60	5.2	8.7	132	11	2.2	1.6	.97	12	3.5	.8	9	0
1976	40	55	9.2	237	7.2	65.3	1,322	566	68	6.7	16.9	335	125	4.9	2.9	.96	18	4.7	2.2	35	0
1982	46	64	10.6	210	8.4	79.7	1,935	1,203	18	8.4	7.0	170	110	9.4	7.3	1.00	8	7.5	2.5	58	25
1988	52	73	11.8	182	9.6	90.5	2,461	1,842	25	7.9	8.4	206	114	8.2	5.2	.84	3	10.5	2.0	50	40
1995	59	83	13.4	157	11.0	102.0	3,109	2,603	18	9.8	9.6	284	218	15.8	12.1	.91	7	9.4	3.2	96	77
2006	70	95	15.5	152	12.5	127.7	4,370	3,887	0	.0	.0	0	0	.0	.0	.00	7	11.9	5.2	170	150

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – – In – – – – –*		*– – – Ft³ – – –*		*– Ft³ –*							
1965	29	582	586	12	12	0.00	0.00	0.0	0.0	0	20	0	0	0	20	0	0
1969	33	922	935	98	98	.19	.18	3.6	3.8	85	28	21	3	87	28	21	3
1976	40	1,790	1,837	702	702	.25	.24	4.6	4.9	124	45	86	18	129	46	86	18
1982	46	2,573	2,679	1,450	1,475	.20	.21	3.6	4.0	131	56	125	32	140	58	129	32
1988	52	3,305	4,489	3,182	3,324	.18	.18	3.0	3.5	133	72	140	54	147	76	151	56
2006	70	5,498	5,921	4,466	4,758	.14	.14	2.3	2.8	115	79	117	64	130	85	130	68

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

[b] Quadratic mean diameter (QAD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,127 ft^3 (19 percent of total gross yield to age 70); volume (CVTS) in mortality = 421 ft^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 23b—Metric stand development table for treatment 3 (plots 11, 16, and 40), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	11.2	15.8	976	11.5	10.2	40.8	0.9	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	12	8.7	0.1	0.2	0.0
1969	33	13.3	18.2	799	13.6	11.5	55.3	6.1	148	13.1	2.0	9.3	.8	.1	.1	.97	29	9.0	.2	.7	.0
1976	40	16.9	23.2	585	18.2	15.0	92.5	39.6	169	17.1	3.9	23.4	8.8	.1	.1	.96	45	12.0	.5	2.4	.0
1982	46	19.6	26.8	519	21.3	18.3	135.4	84.2	45	21.3	1.6	11.9	7.7	.3	.2	1.00	21	19.0	.6	4.1	1.8
1988	52	22.4	30.0	449	24.5	20.8	172.2	128.9	62	20.0	1.9	14.4	8.0	.2	.1	.84	8	26.7	.5	3.5	2.8
1995	59	25.3	34.1	387	28.0	23.4	217.5	182.2	45	24.9	2.2	19.9	15.3	.4	.3	.91	16	24.0	.7	6.7	5.4
2006	70	29.0	39.3	375	31.9	29.3	305.8	272.0	0	.0	.0	.0	.0	.0	.0	.00	16	30.3	1.2	11.9	10.5

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	40.8	41.0	.9	.9	0.00	0.00	0.0	0.0	0.0	1.4	0.0	0.0	0.0	1.4	0.0	0.0
1969	33	64.5	65.4	6.8	6.8	.49	.47	.8	.9	5.9	2.0	1.5	.2	6.1	2.0	1.5	.2
1976	40	125.2	128.6	49.1	49.1	.62	.61	1.1	1.1	8.7	3.1	6.0	1.2	9.0	3.2	6.0	1.2
1982	46	180.0	187.5	101.4	103.2	.52	.53	.8	.9	9.1	3.9	8.7	2.2	9.8	4.1	9.0	2.2
1988	52	231.2	242.2	154.1	158.7	.44	.46	.7	.8	8.5	4.4	8.8	3.0	9.1	4.7	9.2	3.1
1995	59	296.5	314.1	222.6	232.6	.46	.46	.7	.8	9.3	5.0	9.8	3.8	10.3	5.3	10.6	3.9
2006	70	384.7	414.3	312.5	332.9	.35	.36	.5	.6	8.0	5.5	8.2	4.5	9.1	5.9	9.1	4.8

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 78.9 m^3 (19 percent of total gross yield at age 70; volume (CVTS) in mortality = 29.5 m^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period.

[g] MAI = mean annual increment.

Table 24a—Stand development table for treatment 4 (plots 10, 13, and 19), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	37	6.5	382	4.6	44.6	614	28	0	0.0	0.0	0	0	0.0	0.0	0.00	17	3.5	1.1	13	0
1969	33	45	7.5	290	5.6	48.7	813	132	78	4.6	8.9	132	0	1.7	.0	.85	13	3.8	1.1	14	0
1976	40	56	9.7	235	7.5	70.0	1,449	704	33	6.7	8.1	161	57	4.9	2.8	.91	22	5.0	2.9	49	2
1982	46	67	11.3	222	8.8	92.3	2,306	1,544	7	8.1	2.4	59	37	8.4	12.3	.93	7	5.9	1.3	27	3
1988	52	76	12.6	213	10.0	112.6	3,148	2,428	5	7.1	1.4	33	12	6.6	4.0	.72	3	9.8	1.8	51	39
1995	59	86	13.9	208	11.1	135.4	4,272	3,574	0	.0	.0	0	0	.0	.0	.00	5	9.8	2.6	80	61
2006	70	96	15.8	195	12.5	162.0	5,594	4,962	0	.0	.0	0	0	.0	.0	.00	13	9.2	6.1	185	136

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– Ft³ –*							
1965	29	614	627	28	28	0.00	0.00	0.0	0.0	0	21	0	1	0	22	0	1
1969	33	946	973	132	132	.18	.18	3.2	3.5	83	29	26	4	86	29	26	4
1976	40	1,743	1,819	762	764	.26	.25	4.2	4.6	114	44	90	19	121	45	90	19
1982	46	2,658	2,761	1,638	1,644	.22	.22	4.1	4.3	153	58	146	36	157	60	147	36
1988	52	3,534	3,687	2,534	2,579	.18	.18	3.6	3.9	146	68	149	49	154	71	156	50
1995	59	4,658	4,891	3,680	3,785	.16	.16	3.3	3.6	161	79	164	62	172	83	172	64
2006	70	5,980	6,399	5,068	5,309	.13	.12	2.4	3.0	120	85	126	72	137	91	139	76

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 385 ft^3 (6 percent of total gross yield to age 70); volume (CVTS) in mortality = 419 ft^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 24b—Metric stand development table for treatment 4 (plots 10, 13, and 19), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^2		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	11.3	16.6	943	11.8	10.2	43.0	2.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	41	8.9	0.3	0.9	0.0
1969	33	13.7	19.1	716	14.1	11.2	56.9	9.2	193	11.6	2.0	9.3	.0	.0	.0	.85	33	9.7	.2	1.0	.0
1976	40	17.0	24.5	580	19.0	16.1	101.4	49.3	82	16.9	1.9	11.3	4.0	.1	.1	.91	54	12.6	.7	3.4	.2
1982	46	20.4	28.8	548	22.4	21.2	161.4	108.0	16	20.6	.5	4.1	2.6	.3	.4	.93	16	15.0	.3	1.9	.2
1988	52	23.1	31.9	527	25.3	25.9	220.3	169.9	12	17.9	.3	2.3	.8	.2	.1	.72	8	25.0	.4	3.5	2.7
1995	59	26.1	35.4	515	28.1	31.1	299.0	250.0	0	.0	.0	.0	.0	.0	.0	.00	12	25.0	.6	5.6	4.3
2006	70	29.1	40.2	482	31.8	37.2	391.5	347.2	0	.0	.0	.0	.0	.0	.0	.00	33	23.3	1.4	12.9	9.5

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	43.0	43.9	2.0	2.0	0.00	0.00	0.0	0.0	0.0	1.5	0.0	0.1	0.0	1.5	0.0	0.1
1969	33	66.2	68.1	9.2	9.2	.46	.45	.7	.8	5.8	2.0	1.8	.3	6.1	2.1	1.8	.3
1976	40	122.0	127.3	53.3	53.5	.65	.63	1.0	1.1	8.0	3.0	6.3	1.3	8.5	3.2	6.3	1.3
1982	46	186.0	193.2	114.6	115.0	.57	.55	.9	1.0	10.7	4.0	10.2	2.5	11.0	4.2	10.3	2.5
1988	52	247.2	258.0	177.3	180.4	.45	.46	.8	.9	10.2	4.8	10.4	3.4	10.8	5.0	10.9	3.5
1995	59	325.9	342.3	257.5	264.9	.40	.40	.7	.8	11.2	5.5	11.5	4.4	12.0	5.8	12.1	4.5
2006	70	418.4	447.7	354.6	371.5	.33	.31	.6	.7	8.4	6.0	8.8	5.1	9.6	6.4	9.7	5.3

[a] Average height (ht) and diameter at breast height (d.b.h.) of the 100 largest trees per acre (estimated from d.b.h. and ht-d.b.h. curves).

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 27 m^3 (6 percent of total gross yield to age 70); volume (CVTS) in mortality = 29.2 m^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 25a—Stand development table for treatment 5 (plots 9 and 21), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	34	6.3	378	4.5	42.3	545	13	0	0.0	0.0	0	0	0.0	0.0	0.00	23	3.3	1.3	15	0
1969	33	42	7.1	368	5.2	54.9	847	83	5	5.0	.7	10	0	2.0	.0	.96	5	3.9	.4	5	0
1976	40	53	9.1	328	6.9	82.6	1,609	616	35	6.0	7.0	126	26	3.6	1.4	.90	5	5.2	.7	12	0
1982	46	63	10.6	298	8.1	103.0	2,426	1,404	18	7.9	6.0	143	78	7.9	5.2	1.00	13	6.3	2.7	57	26
1988	52	70	11.9	265	9.2	116.9	3,024	2,136	18	8.4	6.7	171	103	9.5	6.9	.94	15	7.3	4.3	97	38
1995	59	82	13.4	253	10.2	136.1	4,045	3,173	3	10.6	1.5	46	38	15.3	12.7	1.07	10	10.6	6.1	188	158
2006	70	92	15.3	240	11.6	166.8	5,506	4,679	0	.0	.0	0	0	.0	.0	.00	13	6.5	2.9	68	22

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– Ft³ –*							
1965	29	545	560	13	13	0.00	0.00	0.0	0.0	0	19	0	0	0	19	0	0
1969	33	857	877	83	83	.17	.17	3.3	3.4	78	26	17	3	79	27	17	3
1976	40	1,745	1,777	642	642	.21	.21	4.9	5.0	127	44	80	16	129	44	80	16
1982	46	2,705	2,793	1,508	1,534	.20	.19	4.4	4.9	160	59	144	33	169	61	149	33
1988	52	3,474	3,660	2,344	2,407	.16	.16	3.4	4.2	128	67	139	45	144	70	146	46
1995	59	4,541	4,914	3,418	3,640	.15	.15	3.0	3.8	152	77	154	58	179	83	176	62
2006	70	6,002	6,443	4,924	5,168	.12	.11	2.8	3.1	133	86	137	70	139	92	139	74

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 496 ft^3 (8 percent of total gross yield to age 70); volume (CVTS) in mortality = 442 ft^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 25b—Metric stand development table for treatment 5 (plots 9 and 21), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	10.4	15.9	932	11.5	9.7	38.2	0.9	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	56	8.3	0.3	1.0	0.0
1969	33	12.9	18.1	908	13.3	12.6	59.3	5.8	12	12.8	.2	.7	.0	.1	.0	.96	12	9.8	.1	.3	.0
1976	40	16.2	23.2	809	17.4	19.0	112.6	43.1	86	15.3	1.6	8.8	1.8	.1	.0	.90	12	13.2	.2	.8	.0
1982	46	19.3	26.8	735	20.6	23.7	169.7	98.3	43	20.1	1.4	10.0	5.4	.2	.1	.99	31	15.9	.6	4.0	1.8
1988	52	21.4	30.2	655	23.4	26.8	211.6	149.5	43	21.3	1.5	11.9	7.2	.3	.2	.94	37	18.5	1.0	6.8	2.7
1995	59	24.9	34.0	624	26.0	31.3	283.0	222.0	6	26.9	.4	3.2	2.7	.5	.5	1.06	25	27.0	1.4	13.1	11.1
2006	70	28.0	38.9	593	29.5	38.3	385.3	327.4	0	.0	.0	.0	.0	.0	.0	.00	31	16.6	.7	4.8	1.5

		Cumulative yield[e]				QMD growth[f]		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	38.2	39.2	0.9	0.9	0.00	0.00	0.0	0.0	0.0	1.3	0.0	0.0	0.0	1.4	0.0	0.0
1969	33	60.0	61.4	5.8	5.8	.44	.44	.8	.8	5.5	1.8	1.2	.2	5.5	1.9	1.2	.2
1976	40	122.1	124.3	44.9	44.9	.54	.54	1.1	1.2	8.9	3.1	5.6	1.1	9.0	3.1	5.6	1.1
1982	46	189.2	195.5	105.5	107.3	.50	.49	1.0	1.1	11.2	4.1	10.1	2.3	11.9	4.2	10.4	2.3
1988	52	243.1	256.1	164.0	168.5	.41	.41	.8	1.0	9.0	4.7	9.7	3.2	10.1	4.9	10.2	3.2
1995	59	317.7	343.9	239.2	254.7	.37	.39	.7	.9	10.7	5.4	10.7	4.1	12.5	5.8	12.3	4.3
2006	70	420.0	450.9	344.5	361.6	.32	.29	.6	.7	9.3	6.0	9.6	4.9	9.7	6.4	9.7	5.2

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 34.6 m^3 (8 percent of total gross yield to age 70); volume (CVTS) in mortality = 30.8 m^3 (7 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 26a—Stand development table for treatment 6 (plots 41, 42, and 43), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD[b]	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	36	6.5	400	4.6	46.3	632	25	0	0.0	0.0	0	0	0.0	0.0	0.00	0	0.0	0.0	0	0
1969	33	46	7.6	353	5.5	57.5	995	159	37	4.9	4.8	80	0	2.2	.0	.91	10	3.4	.6	8	0
1976	40	61	9.9	272	7.4	80.0	1,809	869	63	6.7	15.4	332	122	5.3	3.7	.92	18	4.4	1.9	33	1
1982	46	73	11.7	218	8.8	92.4	2,520	1,718	52	8.3	19.5	527	323	10.1	6.9	.96	2	4.6	.2	4	0
1988	52	80	13.1	180	10.2	102.7	3,076	2,457	38	8.6	15.4	426	287	11.2	9.0	.86	0	.0	.0	0	0
1995	59	91	14.6	125	12.4	104.7	3,590	3,194	53	9.3	25.1	768	572	14.5	12.2	.80	2	11.0	1.1	36	31
2006	70	101	16.5	115	14.1	124.7	4,636	4,280	0	.0	.0	0	0	.0	.0	.00	10	13.1	9.3	349	316

		Cumulative yield[e]				QMD growth[f]		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– Ft³ –*							
1965	29	632	632	25	25	0.00	0.00	0.0	0.0	0	22	0	1	0	22	0	1
1969	33	1,075	1,083	160	160	.20	.19	4.0	4.2	111	33	34	5	113	33	34	5
1976	40	2,220	2,261	991	992	.25	.24	5.4	5.7	164	56	119	25	168	57	119	25
1982	46	3,458	3,503	2,164	2,165	.23	.23	5.3	5.4	206	75	195	47	207	76	195	47
1988	52	4,440	4,485	3,189	3,190	.19	.19	4.3	4.3	164	85	171	61	164	86	171	61
1995	59	5,723	5,803	4,499	4,531	.19	.19	3.9	4.0	183	97	187	76	188	98	192	77
2006	70	6,768	7,198	5,585	5,933	.16	.16	1.8	2.7	95	97	99	80	127	103	127	85

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

[b] Quadratic mean diameter at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 2,133 ft^3 (30 percent of total gross yield to age 70); volume (CVTS) in mortality = 430 ft^3 (6 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 26b—Metric stand development table for treatment 6 (plots 41, 42, and 43), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	11.1	16.6	988	11.7	10.6	44.2	1.8	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0	0.0	0.0	0.0	0.0
1969	33	14.2	19.4	873	13.9	13.2	69.6	11.1	91	12.5	1.1	5.6	.0	.1	.0	.91	25	8.5	.1	.6	.0
1976	40	18.7	25.1	671	18.7	18.4	126.6	60.8	156	16.9	3.5	23.2	8.5	.1	.1	.92	45	11.1	.4	2.3	.1
1982	46	22.3	29.7	539	22.4	21.2	176.3	120.2	128	21.2	4.5	36.9	22.6	.3	.2	.96	4	11.7	.0	.3	.0
1988	52	24.4	33.1	445	26.0	23.6	215.2	171.9	95	21.8	3.5	29.8	20.0	.3	.3	.86	0	.0	.0	.0	.0
1995	59	27.8	37.0	309	31.5	24.0	251.2	223.5	132	23.6	5.8	53.8	40.0	.4	.3	.80	4	27.9	.3	2.5	2.2
2006	70	30.7	41.9	284	35.8	28.6	324.4	299.5	0	.0	.0	.0	.0	.0	.0	.00	25	33.2	2.1	24.4	22.1

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	44.2	44.2	1.8	1.8	0.00	0.00	0.0	0.0	0.0	1.5	0.0	0.1	0.0	1.5	0.0	0.1
1969	33	75.2	75.8	11.2	11.2	.51	.49	.9	1.0	7.7	2.3	2.3	.3	7.9	2.3	2.3	.3
1976	40	155.4	158.2	69.3	69.4	.64	.62	1.2	1.3	11.5	3.9	8.3	1.7	11.8	4.0	8.3	1.7
1982	46	242.0	245.1	151.4	151.5	.58	.58	1.2	1.2	14.4	5.3	13.7	3.3	14.5	5.3	13.7	3.3
1988	52	310.7	313.8	223.1	223.2	.49	.49	1.0	1.0	11.5	6.0	12.0	4.3	11.5	6.0	12.0	4.3
1995	59	400.4	406.1	314.8	317.0	.48	.48	.9	.9	12.8	6.8	13.1	5.3	13.2	6.9	13.4	5.4
2006	70	473.6	503.6	390.8	415.1	.39	.41	.4	.6	6.7	6.8	6.9	5.6	8.9	7.2	8.9	5.9

[a] Average height (ht) and diameter at breast height (d.b.h.) of the 100 largest trees per acre (estimated from d.b.h. and ht-d.b.h. curves).

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 149.3 m^3 (30 percent of total gross yield to age 70); volume (CVTS) in mortality = 30.1 m^3 (6 percent of total gross yield).

[f] Net perodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 27a—Stand development table for treatment 7 (plots 25, 38, and 39), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	35	6.2	402	4.5	44.1	572	13	0	0.0	0.0	0	0	0.0	0.0	0.00	2	3.5	0.1	1	0
1969	33	45	7.2	393	5.2	58.8	953	97	0	.0	.0	0	0	.0	.0	.00	8	3.4	.5	6	0
1976	40	58	9.5	378	6.9	99.0	2,071	826	0	.0	.0	0	0	.0	.0	.00	15	4.6	1.7	28	1
1982	46	69	11.1	368	8.1	130.1	3,281	1,927	5	8.9	2.2	58	40	11.6	13.3	1.11	5	6.6	1.2	26	10
1988	52	79	12.4	348	9.0	153.2	4,395	3,082	17	7.6	5.3	141	78	8.3	6.0	.85	3	9.4	1.6	45	33
1995	59	88	13.8	328	10.0	176.6	5,595	4,358	2	9.6	.8	26	19	13.0	9.5	.97	18	8.5	7.3	220	161
2006	70	98	15.4	295	11.2	200.6	7,038	5,943	0	.0	.0	0	0	.0	.0	.00	33	8.1	11.8	354	233

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft²– – –*		*– Ft³ –*							
1965	29	572	573	13	13	0.00	0.00	0.0	0.0	0	20	0	0	0	20	0	0
1969	33	953	960	97	97	.19	.18	3.7	3.8	95	29	21	3	97	29	21	3
1976	40	2,071	2,107	826	826	.24	.24	5.7	6.0	160	52	104	21	164	53	104	21
1982	46	3,339	3,401	1,967	1,977	.19	.19	5.6	5.7	211	73	190	43	216	74	192	43
1988	52	4,594	4,701	3,201	3,244	.15	.15	4.7	5.0	209	88	206	62	217	90	211	62
1995	59	5,820	6,146	4,496	4,701	.14	.13	3.5	4.5	175	99	185	76	207	104	208	80
2006	70	7,263	7,943	6,082	6,519	.11	.10	2.2	3.3	131	104	144	87	163	113	165	93

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic (CVTS) or merchantable cubic to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 149.3 m^3 (30 percent of total gross yield to age 70); volume (CVTS) in mortality = 30.1 m^3 (6 percent of total gross yield).

[f] Net perodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 27b—Metric stand development table for treatment 7 (plots 25, 38, and 39), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	10.7	15.8	992	11.4	10.1	40.0	0.9	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	4	8.8	0.0	0.1	0.0
1969	33	13.7	18.3	972	13.3	13.5	66.7	6.8	0	.0	.0	.0	.0	.0	.0	.00	21	8.6	.1	.5	.0
1976	40	17.6	24.1	934	17.6	22.7	144.9	57.8	0	.0	.0	.0	.0	.0	.0	.00	37	11.6	.4	2.0	.0
1982	46	21.1	28.3	910	20.5	29.9	229.6	134.8	12	22.7	.5	4.1	2.8	.3	.4	1.11	12	16.7	.3	1.8	.7
1988	52	24.1	31.4	860	22.9	35.2	307.5	215.6	41	19.4	1.2	9.9	5.5	.2	.2	.85	8	23.8	.4	3.2	2.3
1995	59	26.8	35.0	811	25.3	40.5	391.5	304.9	4	24.4	.2	1.8	1.4	.5	.3	.97	45	21.7	1.7	15.4	11.3
2006	70	29.9	39.2	729	28.4	46.1	492.5	415.9	0	.0	.0	.0	.0	.0	.0	.00	82	20.5	2.7	24.8	16.3

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^3							
1965	29	40.0	40.1	0.9	0.9	0.00	0.00	0.0	0.0	0.0	1.4	0.0	0.0	0.0	1.4	0.0	0.0
1969	33	66.7	67.2	6.8	6.8	.47	.46	.8	.9	6.7	2.0	1.5	.2	6.8	2.0	1.5	.2
1976	40	144.9	147.4	57.8	57.8	.62	.61	1.3	1.4	11.2	3.6	7.3	1.4	11.5	3.7	7.3	1.4
1982	46	233.7	238.0	137.6	138.4	.48	.48	1.3	1.3	14.8	5.1	13.3	3.0	15.1	5.2	13.4	3.0
1988	52	321.5	328.9	224.0	227.0	.37	.38	1.1	1.1	14.6	6.2	14.4	4.3	15.2	6.3	14.8	4.4
1995	59	407.2	430.1	314.6	328.9	.35	.34	.8	1.0	12.3	6.9	12.9	5.3	14.5	7.3	14.6	5.6
2006	70	508.2	555.8	425.5	456.2	.29	.24	.5	.7	9.2	7.3	10.1	6.1	11.4	7.9	11.6	6.5

[a] Average height (ht) and diameter at breast height (d.b.h.) of the 100 largest trees per acre (estimated from d.b.h. and ht-d.b.h. (curves).

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic to a 15.25-cm top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 15.8 m^3 (3 percent of total gross yield to age 70); volume (CVTS) in mortality = 47.8 m^3 (9 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 28a—Stand development table for treatment 8 (plots 12, 23, and 28), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – Ft³ – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	37	6.5	368	4.6	43.4	598	25	0	0.0	0.0	0	0	0.0	0.0	0.00	32	3.6	2.2	27	0
1969	33	46	7.4	367	5.3	57.0	939	131	0	.0	.0	0	0	.0	.0	.00	2	4.0	.1	2	0
1976	40	57	9.4	348	6.9	90.7	1,862	774	2	5.3	.3	4	0	2.0	.0	.77	17	4.9	2.1	35	3
1982	46	67	11.0	323	8.1	115.3	2,845	1,692	17	7.0	4.5	109	55	6.4	5.5	.87	8	5.1	1.2	24	9
1988	52	75	12.4	265	9.3	122.7	3,406	2,462	52	8.0	18.1	472	272	9.1	6.0	.89	7	6.4	1.5	38	25
1995	59	84	13.8	235	10.6	138.8	4,306	3,474	23	8.6	9.3	265	171	11.5	7.8	.83	7	7.3	1.9	54	37
2006	70	95	15.8	223	12.0	170.5	5,820	5,060	0	.0	.0	0	0	.0	.0	.00	12	7.9	3.9	113	70

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI[g]	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– – – – – – – – – – – – – – – – Ft³ – – – – – – – – – – – – – – – –*							
1965	29	598	625	25	25	0.00	0.00	0.0	0.0	0	21	0	1	0	22	0	1
1969	33	939	968	131	131	.17	.17	3.4	3.4	85	28	26	4	86	29	26	4
1976	40	1,866	1,930	774	777	.22	.22	4.8	5.2	132	47	92	19	137	48	92	19
1982	46	2,959	3,046	1,748	1,760	.19	.18	4.9	5.1	182	64	162	38	186	66	164	38
1988	52	3,992	4,119	2,789	2,826	.16	.15	4.2	4.5	172	77	174	54	179	79	178	54
1995	59	5,157	5,337	3,972	4,047	.15	.14	3.6	3.9	166	87	169	67	174	90	174	69
2006	70	6,671	6,964	5,558	5,703	.13	.12	2.9	3.2	138	95	144	79	148	99	151	81

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 851 ft^3 (12 percent of total gross yield to age 70).

Volume (CVTS) in mortality = 293 ft^3 (4 percent of the gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 28b—Metric stand development table for treatment 8 (plots 12, 23, and 28), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	11.4	16.4	910	11.8	10.0	41.8	1.8	0	.0	0.0	0.0	0.0	0.0	0.0	.00	78	9.1	0.5	1.9	0.0
1969	33	13.9	18.7	906	13.6	13.1	65.7	9.1	0	.0	.0	.0	.0	.0	.0	.00	4	10.2	.0	.1	.0
1976	40	17.3	23.9	860	17.6	20.8	130.3	54.2	4	13.5	.1	.3	.0	.0	.0	.77	41	12.3	.5	2.5	.2
1982	46	20.5	27.9	799	20.6	26.5	199.1	118.4	41	17.9	1.0	7.7	3.9	.2	.2	.88	21	13.1	.3	1.7	.7
1988	52	23.0	31.4	655	23.7	28.2	238.4	172.2	128	20.4	4.2	33.1	19.0	.3	.2	.89	16	16.3	.3	2.7	1.8
1995	59	25.7	35.0	580	26.9	31.9	301.3	243.1	58	21.7	2.1	18.5	12.0	.3	.2	.83	16	18.5	.4	3.8	2.6
2006	70	29.0	40.0	552	30.5	39.1	407.2	354.1	0	.0	.0	.0	.0	.0	.0	.00	29	20.0	.9	7.9	4.9

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^2		m^2							
1965	29	41.8	43.7	1.8	1.8	0.00	0.00	0.0	0.0	0.0	1.4	0.0	0.1	0.0	1.5	0.0	0.1
1969	33	65.7	67.7	9.1	9.1	.44	.44	.8	.8	6.0	2.0	1.8	.3	6.0	2.1	1.8	.3
1976	40	130.6	135.1	54.2	54.4	.57	.56	1.1	1.2	9.3	3.3	6.4	1.4	9.6	3.4	6.5	1.4
1982	46	207.0	213.2	122.3	123.1	.48	.46	1.1	1.2	12.7	4.5	11.4	2.7	13.0	4.6	11.5	2.7
1988	52	279.4	288.2	195.1	197.7	.40	.39	1.0	1.0	12.1	5.4	12.1	3.8	12.5	5.5	12.4	3.8
1995	59	360.8	373.4	277.9	283.2	.38	.37	.8	.9	11.6	6.1	11.8	4.7	12.2	6.3	12.2	4.8
2006	70	466.8	487.3	388.9	399.0	.34	.31	.7	.7	9.6	6.7	10.1	5.6	10.4	7.0	10.5	5.7

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic (CVTS) or merchantable cubic to a 15.25-cm diameter inside bark (CV6).

[d] QMD cut/QMD before thinning.

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; yield does not include any volume removed in the calibration cut; volume (CVTS) removed in thinnings = 59.5 m^3 (12 percent of the total gross yield at the time of the last thinning); volume (CVTS) in mortality = 20.5 m^3 (4 percent of the total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 29a—Stand development table for unthinned (plots 14, 27, and 29), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*					*No.*	*In*	*Ft²*	*– – – Ft³ – – –*	
1965	29	39	7.2	1,413	3.7	106.8	1,415	96	0	0.0	0.0	0	0	0.0	0.0	.00	32	2.9	1.5	18	0
1969	33	46	8.0	1,395	4.1	128.7	1,991	271	0	.0	.0	0	0	.0	.0	.00	18	2.5	.6	7	0
1976	40	58	9.9	1,307	5.0	179.8	3,490	1,085	0	.0	.0	0	0	.0	.0	.00	88	3.0	4.4	62	0
1982	46	69	11.2	1,188	5.8	214.4	4,999	2,154	0	.0	.0	0	0	.0	.0	.00	118	3.0	5.6	92	0
1988	52	77	12.4	1,058	6.5	242.1	6,316	3,317	0	.0	.0	0	0	.0	.0	.00	130	3.2	7.4	132	9
1995	59	86	13.6	903	7.4	263.7	7,670	4,759	0	.0	.0	0	0	.0	.0	.00	157	4.2	15.2	330	37
2006	70	97	15.0	665	8.7	269.5	8,794	6,427	0	.0	.0	0	0	.0	.0	.00	238	5.4	38.6	992	338

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– Ft³ –*							
1965	29	1,415	1,433	96	96	0.00	0.00	0.0	0.0	0	49	0	3	0	49	0	3
1969	33	1,991	2,016	271	271	.10	.10	5.5	5.6	144	60	44	8	146	61	44	8
1976	40	3,490	3,577	1,085	1,085	.13	.12	7.3	7.9	214	87	116	27	223	89	116	27
1982	46	4,999	5,179	2,154	2,154	.12	.09	5.8	6.7	252	109	178	47	267	113	178	47
1988	52	6,316	6,628	3,317	3,326	.12	.08	4.6	5.9	220	121	194	64	241	127	195	64
1995	59	7,670	8,311	4,759	4,806	.12	.08	3.1	5.3	193	130	206	81	240	141	211	81
2006	70	8,794	10,427	6,427	6,812	.12	.07	.5	4.0	102	126	152	92	192	149	182	97

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

[b] Quadratic mean diameter (QMD) at breast height.

[C] All volumes are total stem cubic (CVTS) or merchantable cubic to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing; gross = standing + mortality; volume (CVTS) in mortality = 1,633 ft^3 (16 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 29b—Metric stand development table for unthinned (plots 14, 27, and 29), per-hectare basis (ingrowth excluded)

Year	Stand age	After thinning: 100 largest[a] Ht	After thinning: 100 largest[a] D.b.h.	After thinning: Trees	After thinning: QMD[b]	After thinning: Basal area	After thinning: Volume[c] CVTS	After thinning: Volume[c] CV6	Removed in thinning: Trees	Removed in thinning: QMD	Removed in thinning: Basal area	Removed in thinning: Volume CVTS	Removed in thinning: Volume CV6	Removed in thinning: Avg. volume CVTS	Removed in thinning: Avg. volume CV6	Removed in thinning: d/D[d]	Mortality: Trees	Mortality: QMD	Mortality: Basal area	Mortality: Volume CVTS	Mortality: Volume CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3	m^3	*No.*	*Cm*	m^2	m^3	m^3	m^3	m^3		*No.*	*Cm*	m^2	m^3	m^3
1965	29	11.9	18.2	3,491	9.5	24.5	99.0	6.7	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	78	7.5	0.3	1.2	0.0
1969	33	14.0	20.4	3,446	10.5	29.6	139.3	19.0	0	.0	.0	.0	.0	.0	.0	.00	45	6.3	.1	.5	.0
1976	40	17.7	25.2	3,227	12.8	41.3	244.2	75.9	0	.0	.0	.0	.0	.0	.0	.00	218	7.7	1.0	4.4	.0
1982	46	21.0	28.5	2,935	14.7	49.2	349.8	150.7	0	.0	.0	.0	.0	.0	.0	.00	292	7.5	1.3	6.5	.0
1988	52	23.6	31.4	2,614	16.5	55.6	442.0	232.1	0	.0	.0	.0	.0	.0	.0	.00	321	8.2	1.7	9.2	.6
1995	59	26.1	34.6	2,231	18.7	60.5	536.7	333.0	0	.0	.0	.0	.0	.0	.0	.00	387	10.7	3.5	23.1	2.6
2006	70	29.7	38.2	1,643	22.0	61.9	615.4	449.7	0	.0	.0	.0	.0	.0	.0	.00	589	13.8	8.9	69.4	23.6

Year	Stand age	Cumulative yield: Net CVTS	Cumulative yield: Gross CVTS	Cumulative yield: Net CV6	Cumulative yield: Gross CV6	QMD growth: Net PAI[f]	QMD growth: Survivor PAI	Basal area growth: Net PAI	Basal area growth: Gross PAI	Net volume growth: CVTS PAI	Net volume growth: CVTS MAI[g]	Net volume growth: CV6 PAI	Net volume growth: CV6 MAI	Gross volume growth: CVTS PAI	Gross volume growth: CVTS MAI	Gross volume growth: CV6 PAI	Gross volume growth: CV6 MAI
	Years	m^3	m^3	m^3	m^3	*Cm*	*Cm*	m^2	m^2	m^3	m^3	m^3	m^3	m^3	m^3	m^3	m^3
1965	29	99.0	100.3	6.7	6.7	0.00	0.00	0.0	0.0	0.0	3.4	0.0	0.2	0.0	3.5	0.0	0.2
1969	33	139.3	141.1	19.0	19.0	.25	.24	1.3	1.3	10.1	4.2	3.1	.6	10.2	4.3	3.1	.6
1976	40	244.2	250.3	75.9	75.9	.33	.31	1.7	1.8	15.0	6.1	8.1	1.9	15.6	6.3	8.1	1.9
1982	46	349.8	362.4	150.7	150.7	.31	.24	1.3	1.5	17.6	7.6	12.5	3.3	18.7	7.9	12.5	3.3
1988	52	442.0	463.8	232.1	232.7	.31	.21	1.1	1.3	15.4	8.5	13.6	4.5	16.9	8.9	13.7	4.5
1995	59	536.7	581.5	333.0	336.3	.31	.19	.7	1.2	13.5	9.1	14.4	5.6	16.8	9.9	14.8	5.7
2006	70	615.4	729.6	449.7	476.6	.30	.17	.1	.9	7.2	8.8	10.6	6.4	13.5	10.4	12.8	6.8

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

[d] QMD cut/QMD before thinning.

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; volume (CVTS) in mortality = 114.2 m^3 (16 percent of the total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 30a—Stand development table for extra plots (plots 7 and 37), per-acre basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		40 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*Ft*	*In*	*No.*	*In*	*Ft²*	*– – – Ft³ – – –*		*No.*	*In*	*Ft²*	*– – – – – – – – – Ft³ – – – – – – – – –*						*No.*	*In*	*– – – Ft² – – –*	
1965	29	39	6.4	328	4.7	39.4	543	28	0	0.0	0.0	0	0	0.0	0.0	0.00	73	3.8	5.8	67	0
1969	33	48	7.4	323	5.4	51.1	829	132	0	.0	.0	0	0	.0	.0	.00	5	4.9	.7	9	0
1988	52	77	12.7	268	9.4	130.3	3,628	2,743	0	.0	.0	0	0	.0	.0	.00	55	5.2	8.1	151	43
1995	59	88	14.3	258	10.6	160.2	5,090	4,220	0	.0	.0	0	0	.0	.0	.00	10	5.6	1.7	32	2
2006	70	99	16.4	235	12.3	196.4	6,906	6,153	0	.0	.0	0	0	.0	.0	.00	23	8.0	7.9	213	136

		Cumulative yield[a]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	*– – – – – – – – – – Ft³ – – – – – – – – – –*				*– – – – In – – – –*		*– – – Ft² – – –*		*– Ft³ –*							
1965	29	543	610	28	28	0.00	0.00	0.0	0.0	0	19	0	1	0	21	0	1
1969	33	829	905	132	132	.17	.17	2.9	3.1	71	25	26	4	74	27	26	4
1988	52	3,628	3,856	2,743	2,787	.21	.21	4.2	4.6	147	70	137	53	155	74	140	54
1995	59	5,090	5,350	4,220	4,266	.17	.16	4.3	4.5	209	86	211	72	213	91	211	72
2006	70	6,906	7,378	6,153	6,334	.15	.14	3.3	4.0	165	99	176	88	184	105	188	90

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic feet (CVTS) or merchantable cubic feet to a 6-in top diameter inside bark (CV6).

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

[e] Cumulative yield: net = standing; gross = standing + mortality; volume (CVTS) in mortality = 472 ft^3 (6 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Table 30b—Metric stand development table for extra plots (plots 7 and 37), per-hectare basis (ingrowth excluded)

		After thinning							Removed in thinning								Mortality				
		100 largest[a]					Volume[c]					Volume		Avg. volume						Volume	
Year	Stand age	Ht	D.b.h.	Trees	QMD[b]	Basal area	CVTS	CV6	Trees	QMD	Basal area	CVTS	CV6	CVTS	CV6	d/D[d]	Trees	QMD	Basal area	CVTS	CV6
	Years	*m*	*Cm*	*No.*	*Cm*	m^2	m^3		*No.*	*Cm*	m^2	m^3					*No.*	*Cm*	m^2	m^3	
1965	29	12.0	16.4	809	12.0	9.1	38.0	1.9	0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	179	9.7	1.3	4.7	0.0
1969	33	14.8	18.7	797	13.7	11.7	58.0	9.2	0	.0	.0	.0	.0	.0	.0	.00	12	12.5	.2	.7	.0
1988	52	23.4	32.2	661	23.8	29.9	253.9	191.9	0	.0	.0	.0	.0	.0	.0	.00	136	13.2	1.9	10.6	3.0
1995	59	26.9	36.3	636	26.9	36.8	356.2	295.3	0	.0	.0	.0	.0	.0	.0	.00	25	14.3	.4	2.3	.1
2006	70	30.3	41.6	580	31.2	45.1	483.2	430.5	0	.0	.0	.0	.0	.0	.0	.00	56	20.4	1.8	14.9	9.5

		Cumulative yield[e]				QMD growth		Basal area growth		Net volume growth				Gross volume growth			
Year	Stand age	Net CVTS	Gross CVTS	Net CV6	Gross CV6	Net PAI[f]	Survivor PAI	Net PAI	Gross PAI	CVTS PAI	CVTS MAI[g]	CV6 PAI	CV6 MAI	CVTS PAI	CVTS MAI	CV6 PAI	CV6 MAI
	Years	m^3				*Cm*		m^m		m^3							
1965	29	38.0	42.7	1.9	1.9	0.00	0.00	0.0	0.0	0.0	1.3	0.0	0.1	0.0	1.5	0.0	0.1
1969	33	58.0	63.3	9.2	9.2	.43	.44	.7	.7	5.0	1.8	1.8	.3	5.2	1.9	1.8	.3
1988	52	253.9	269.8	191.9	195.0	.53	.53	1.0	1.1	10.3	4.9	9.6	3.7	10.9	5.2	9.8	3.7
1995	59	356.2	374.3	295.3	298.5	.44	.41	1.0	1.0	14.6	6.0	14.8	5.0	14.9	6.3	14.8	5.1
2006	70	483.2	516.3	430.5	443.2	.39	.35	.8	.9	11.5	6.9	12.3	6.2	12.9	7.4	13.2	6.3

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

[b] Quadratic mean diameter (QMD) at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.25-cm top diameter inside bark (CV6).

[d] QMD cut/QMD before thinning.

[e] Cumulative yield: net = standing + thinning; gross = standing + thinning + mortality; volume (CVTS) in mortality = 33.1 m^3 (6 percent of total gross yield).

[f] Net periodic annual increment (PAI) is based on difference between QMDs at start and end of period; survivor PAI is growth of those trees present at both start and end of period (and thus is unaffected by mortality).

[g] MAI = mean annual increment.

Appendix 3

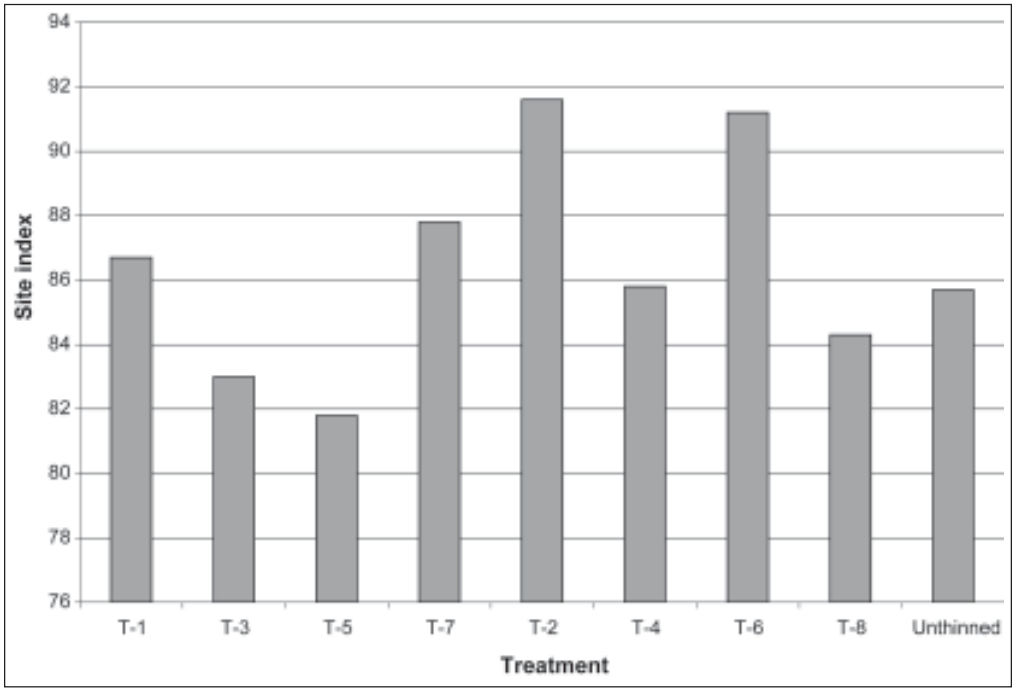

Figure 4—Mean site indexes by treatments (Source: King 1966).

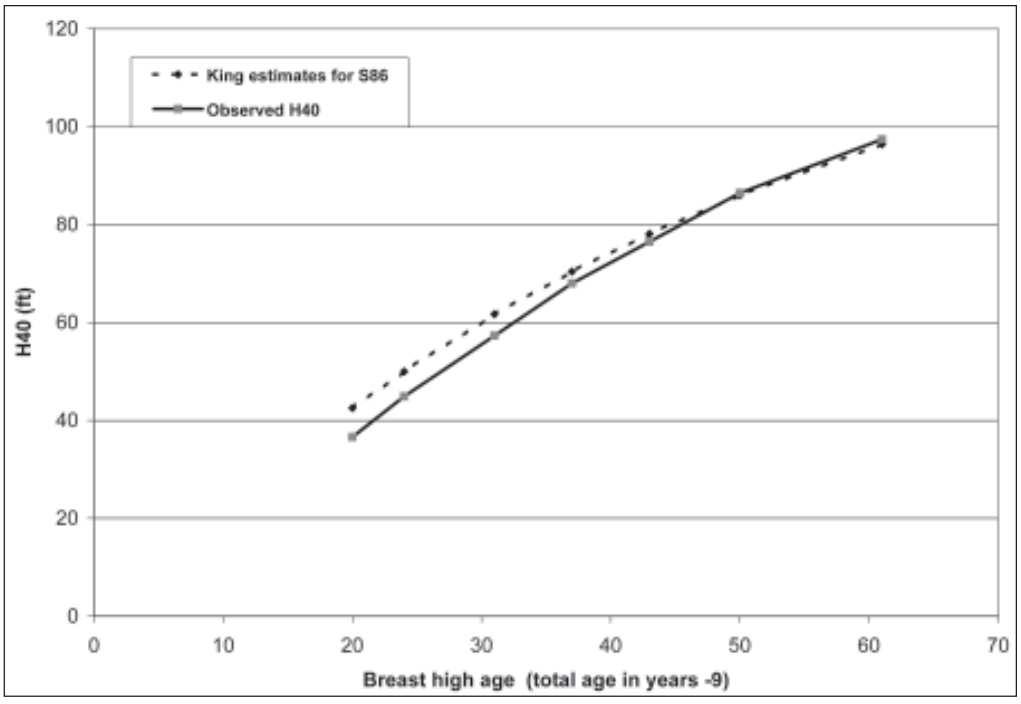

Figure 5—Comparison of King estimates for site index 86 with observed H40.

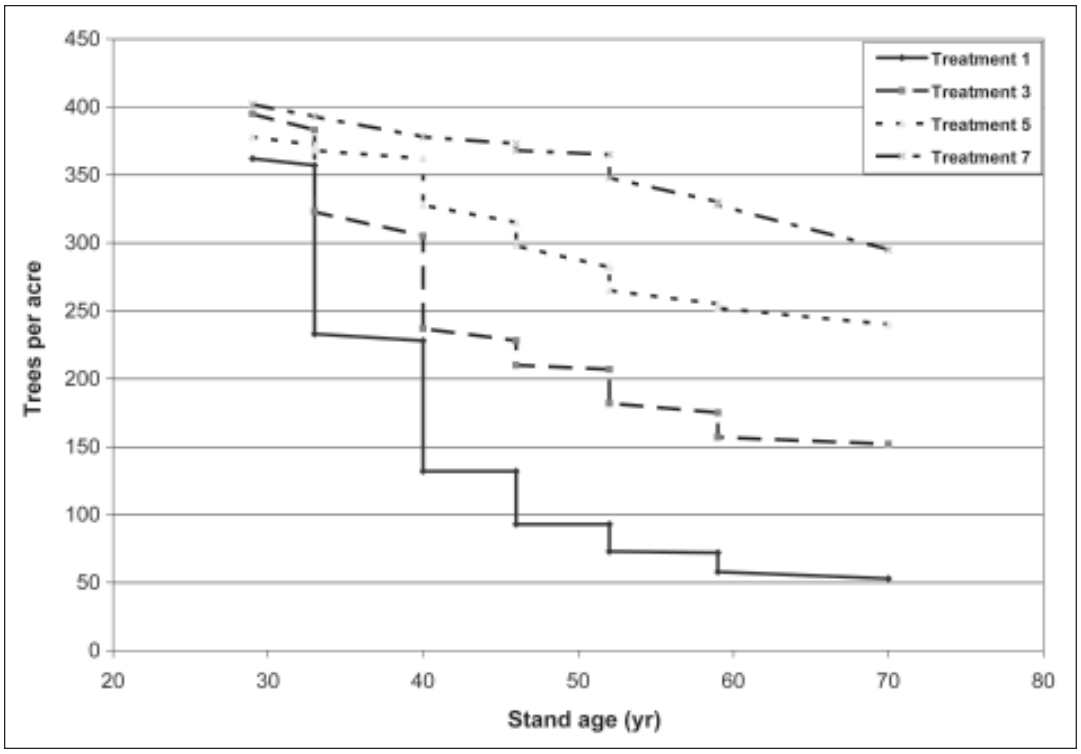

Figure 6—Number of live trees per acre, fixed treatments.

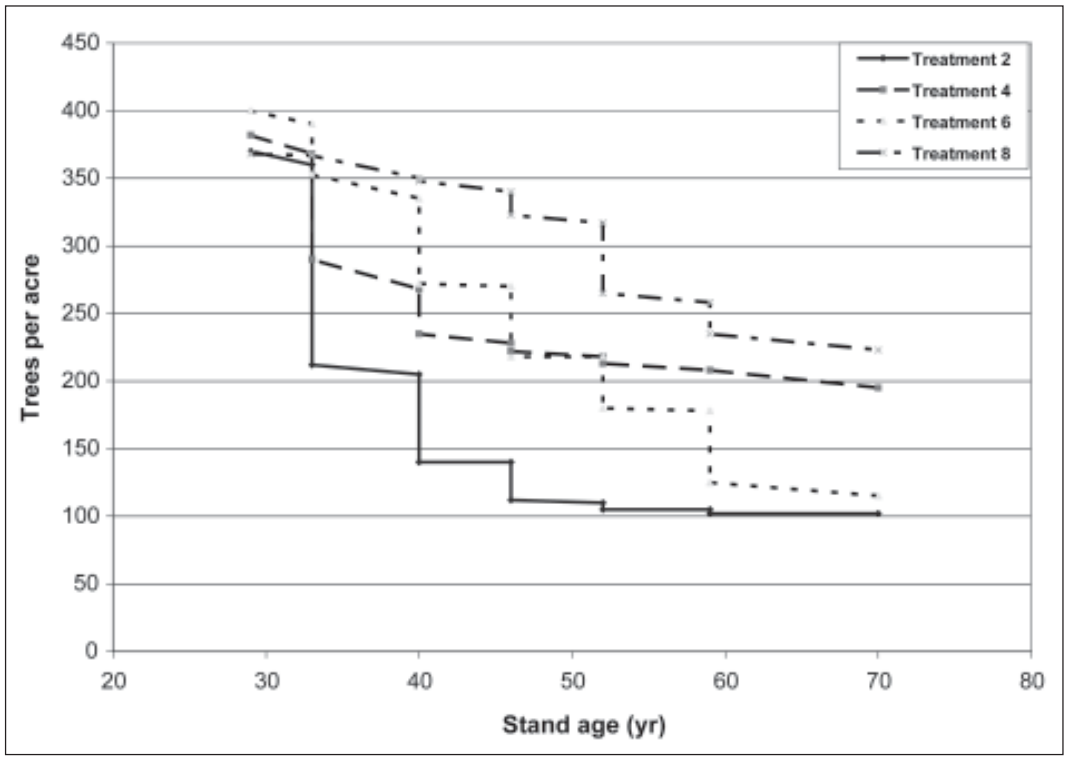

Figure 7—Number of live trees per acre, variable treatments.

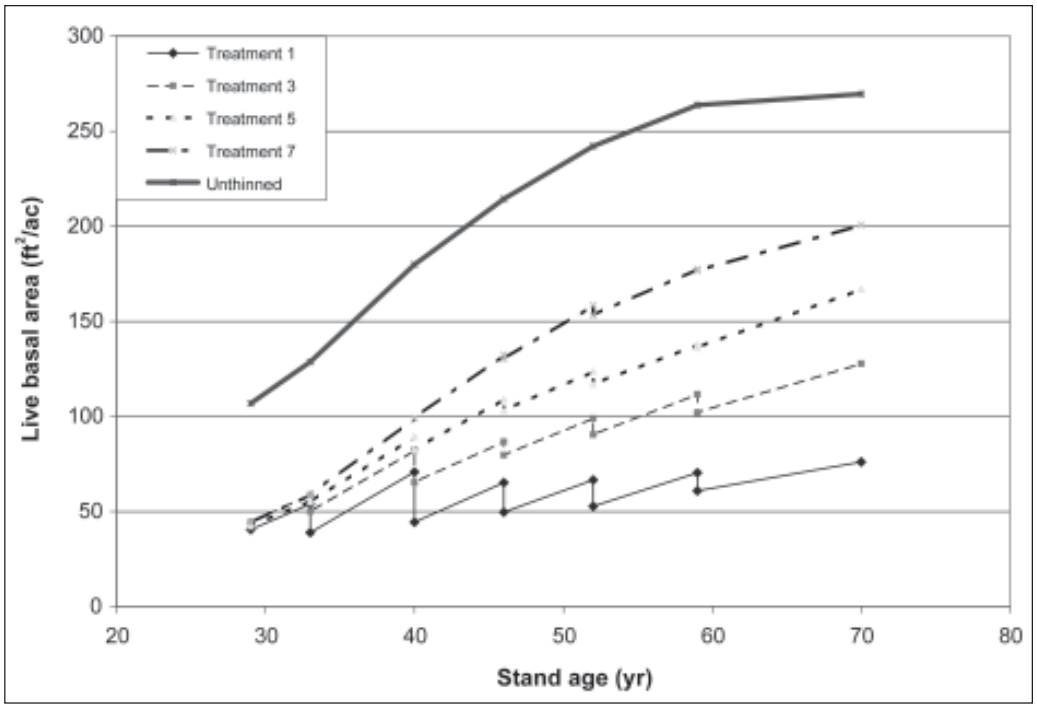

Figure 8—Live basal area over time, fixed treatments.

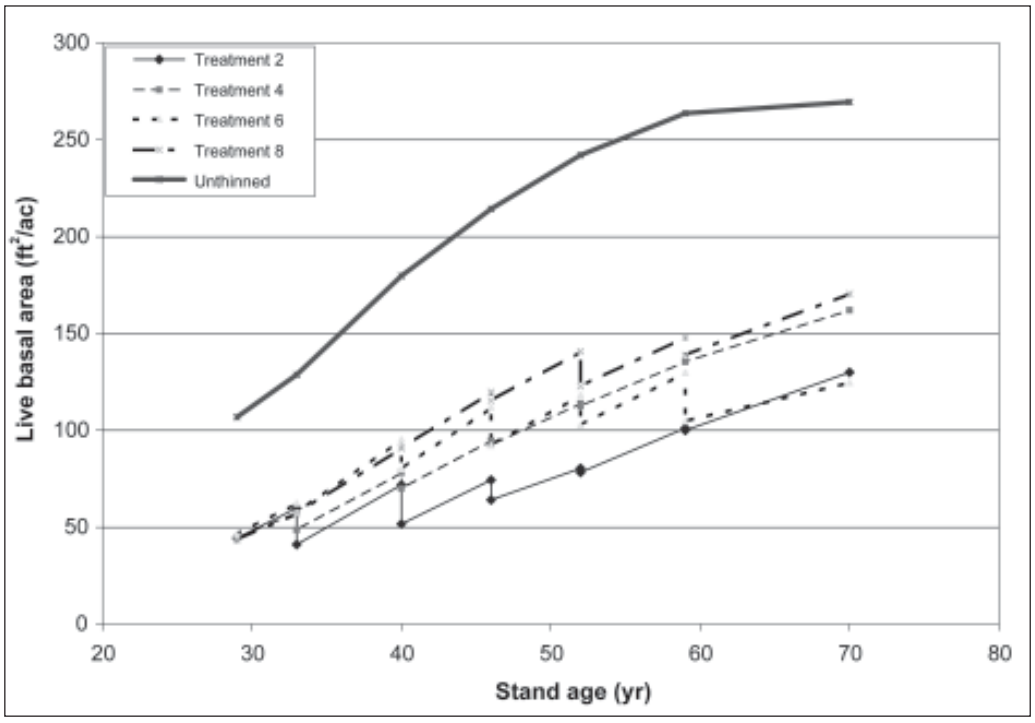

Figure 9—Live basal area over time, variable treatments.

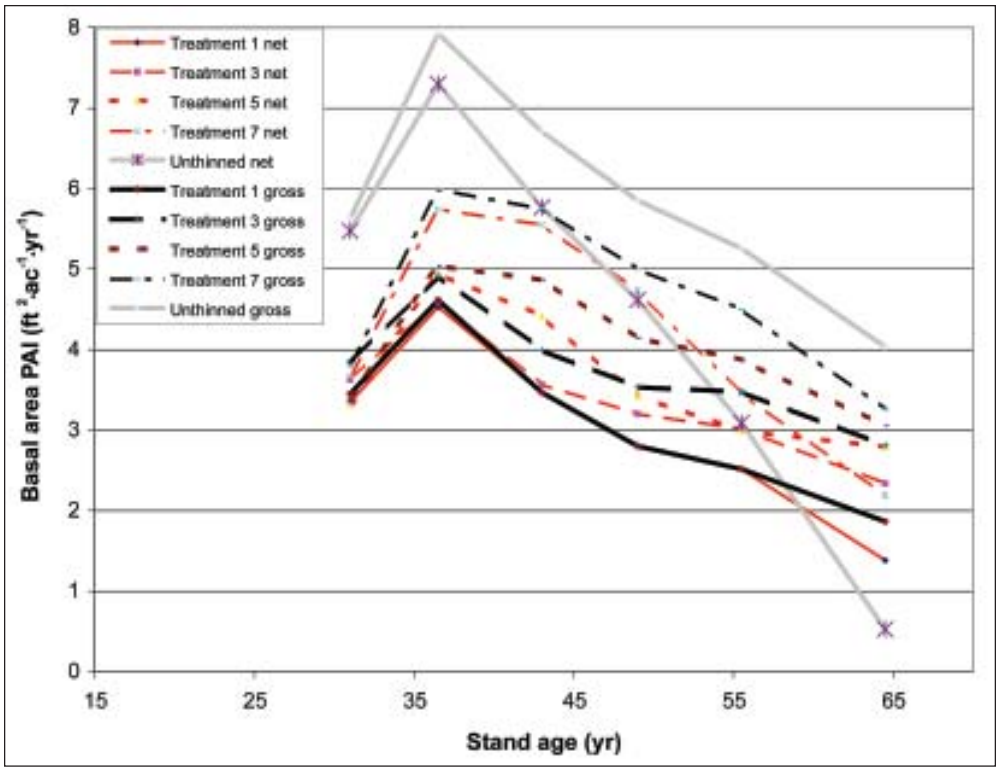

Figure 10—Net (red) and gross (black) basal area periodic annual increment (PAI) per acre, fixed treatments.

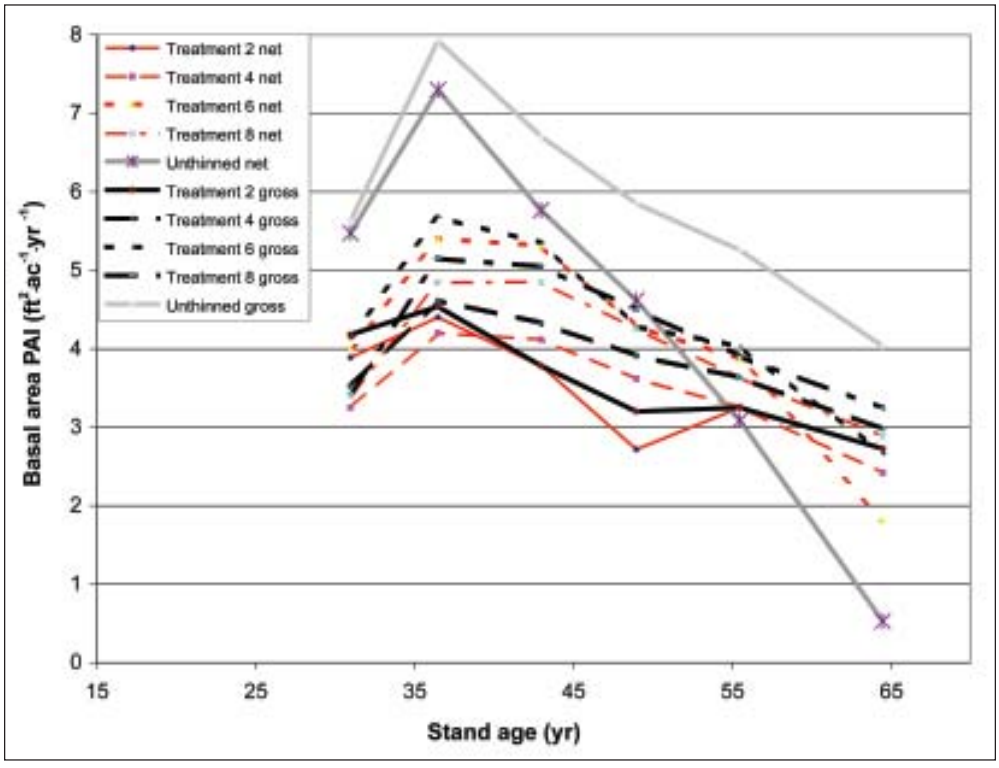

Figure 11—Net (red) and gross (black) basal area periodic annual increment (PAI) per acre, variable treatments.

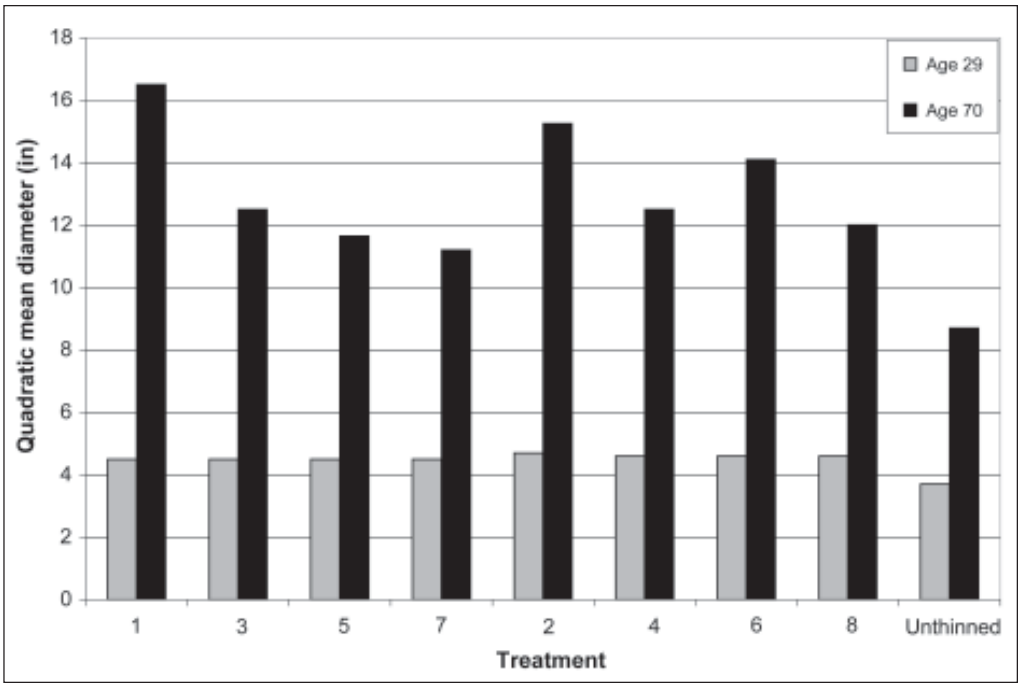

Figure 12—Quadratic mean diameters at ages 29 and 70, by treatments.

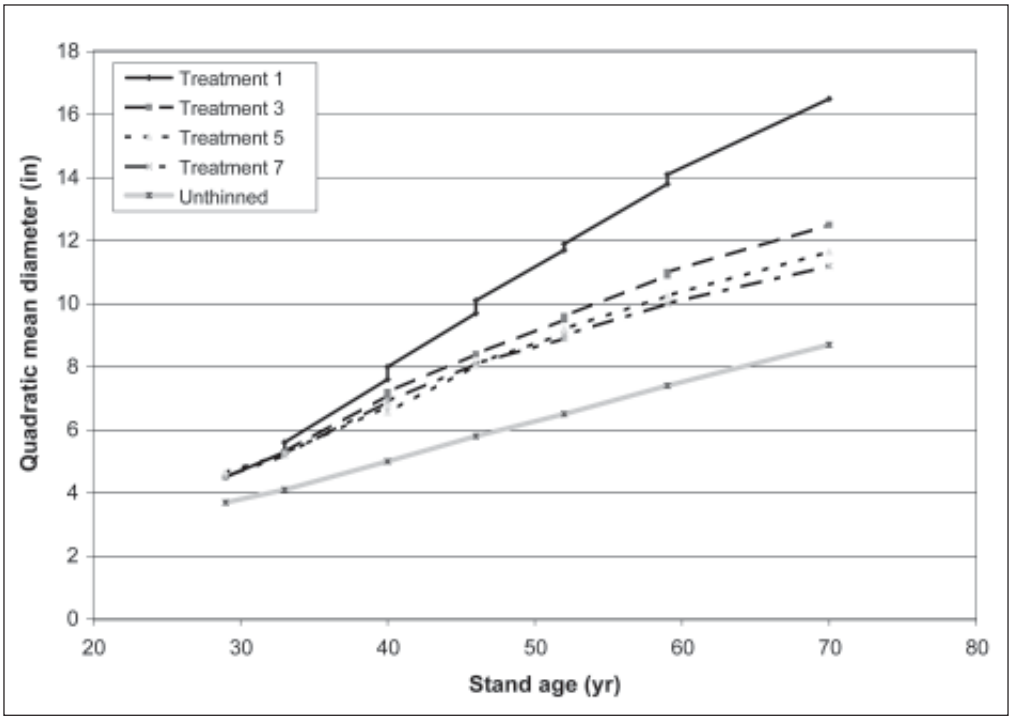

Figure 13—Quadratic mean diameter over age, fixed treatments.

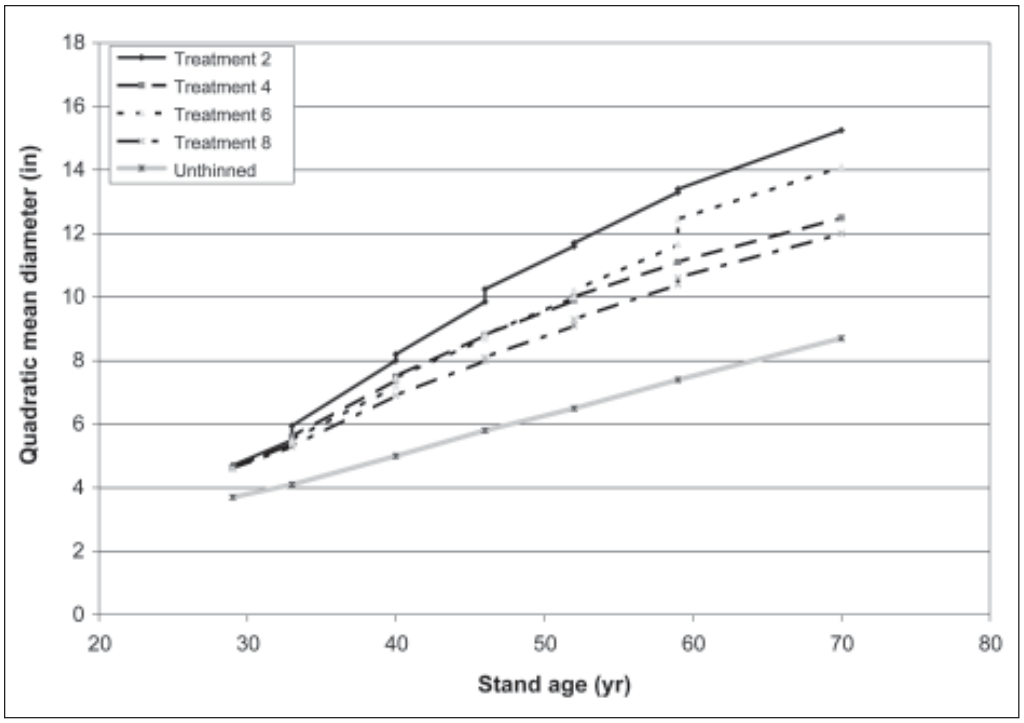

Figure 14—Quadratic mean diameter over age, variable treatments.

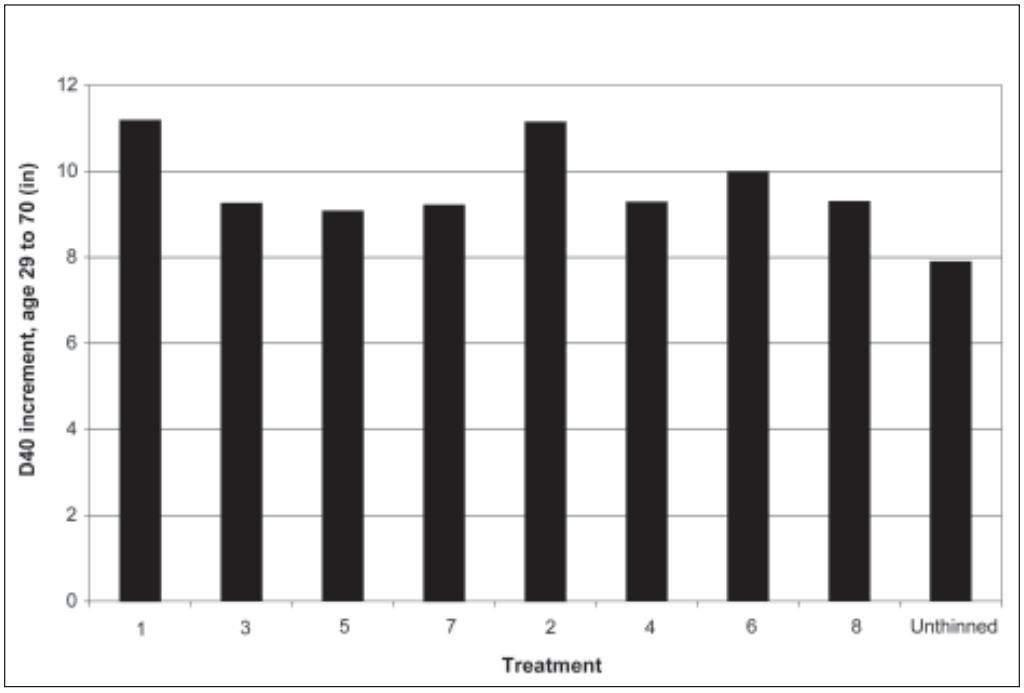

Figure 15—Mean diameter increment of the 40 largest trees per acre (D40) from age 29 to 70, by treatments.

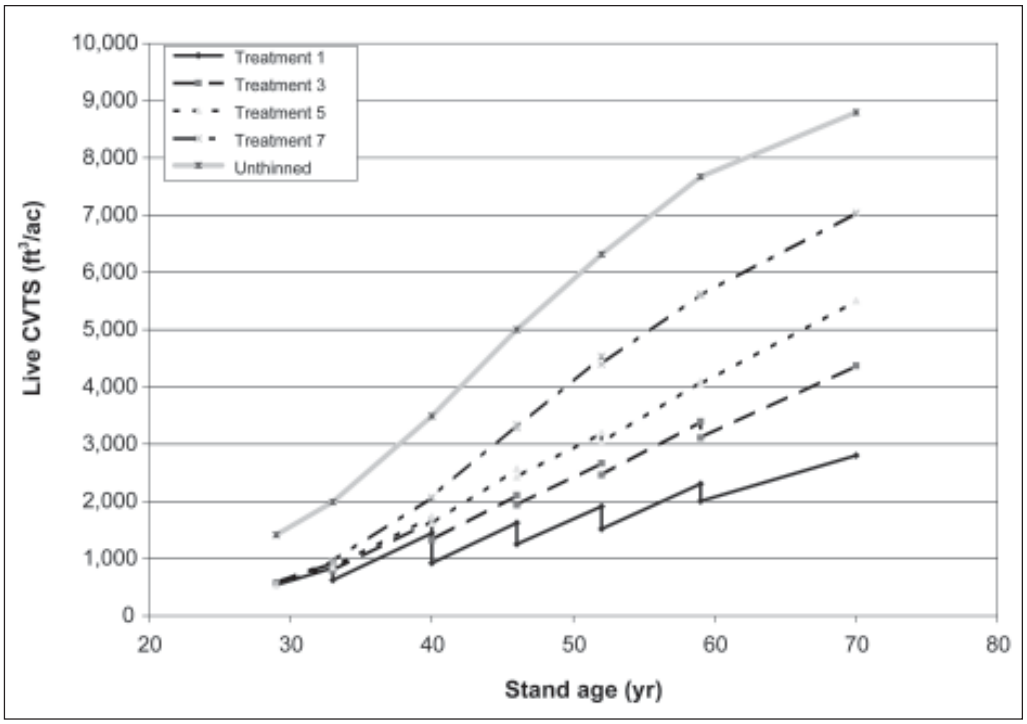

Figure 16—Live total cubic volume per acre (CVTS) over time, fixed treatments.

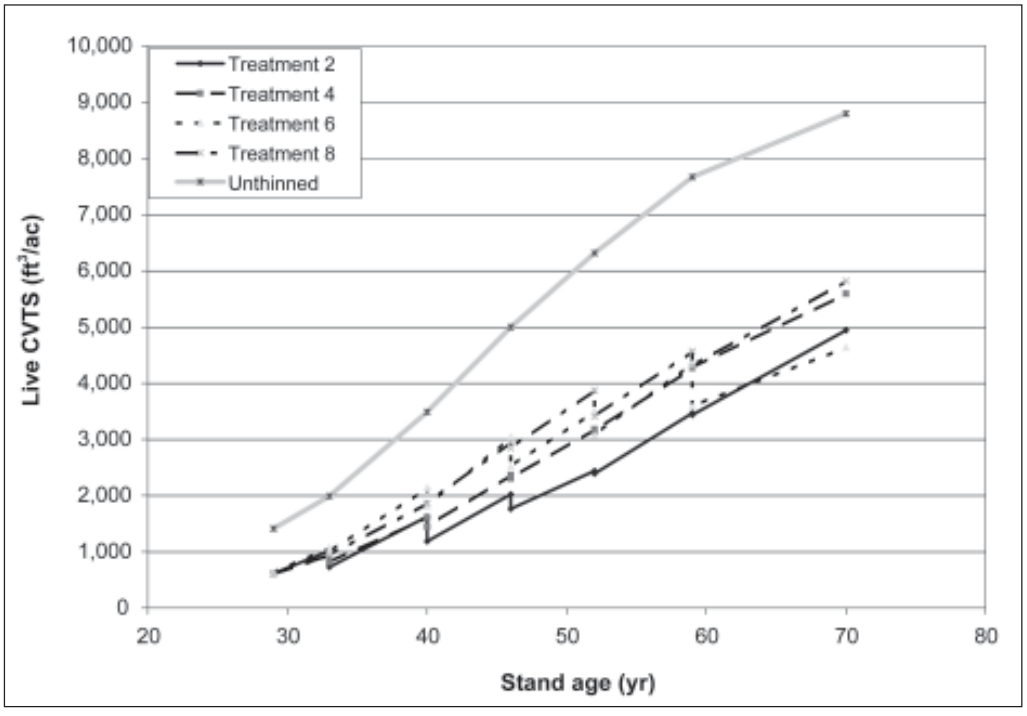

Figure 17—Live total cubic volume per acre (CVTS) over time, variable treatments.

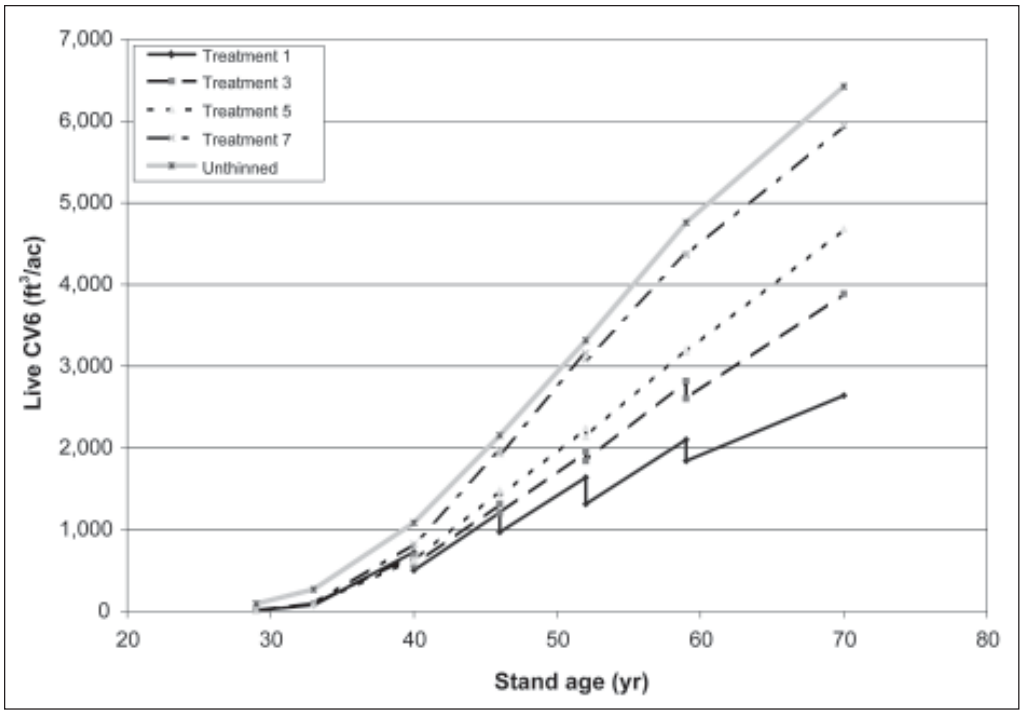

Figure 18—Live merchantable cubic volume per acre (CV6) over time, fixed treatments.

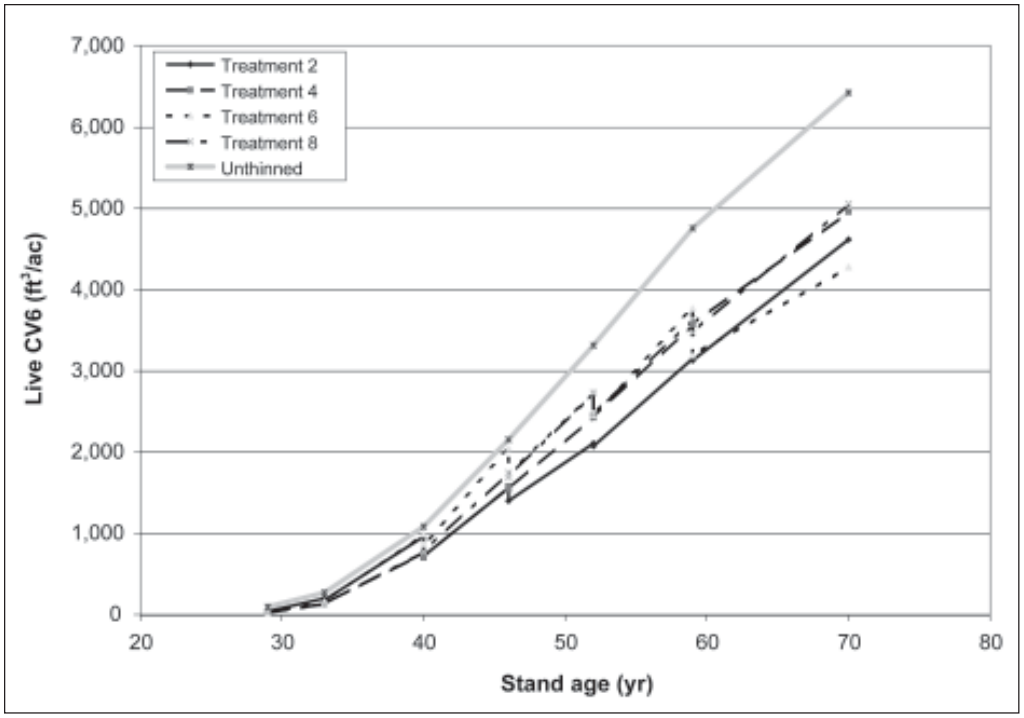

Figure 19—Live merchantable cubic volume per acre (CV6) over time, variable treatments.

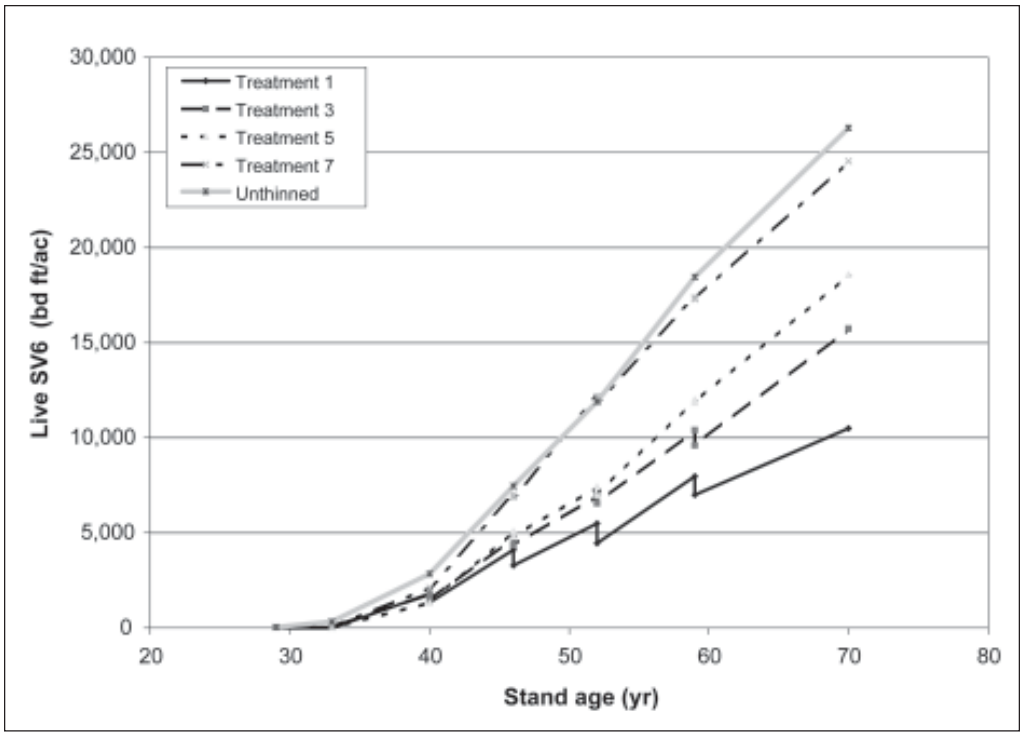

Figure 20—Live Scribner board foot volume per acre (SV6) over time, fixed treatments.

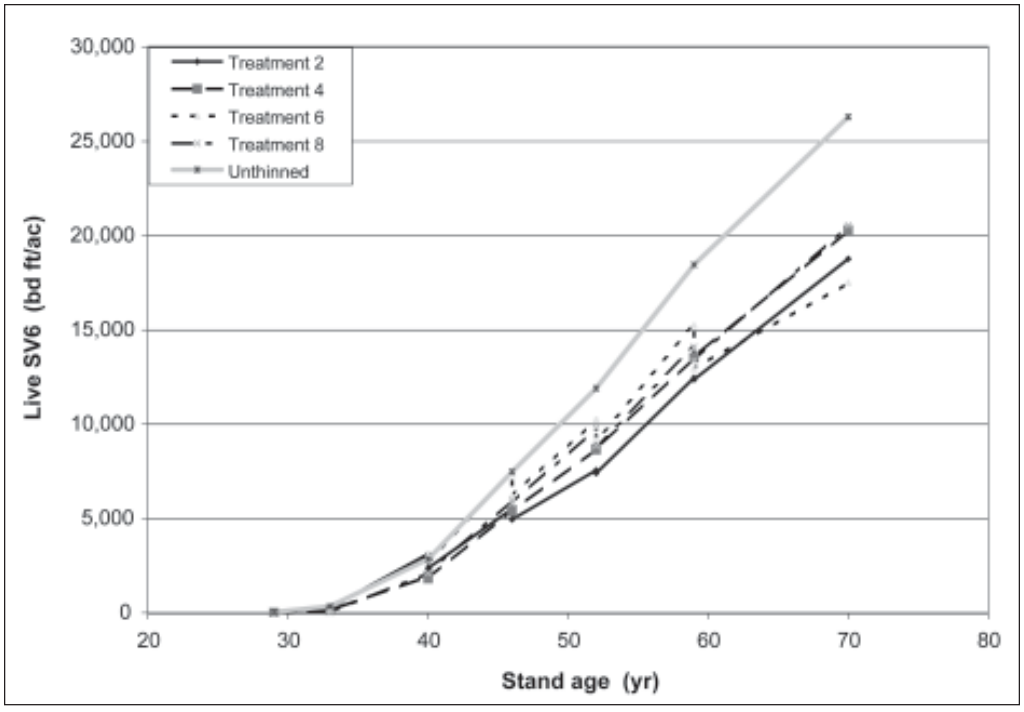

Figure 21—Live Scribner board foot volume per acre (SV6) over time, variable treatments.

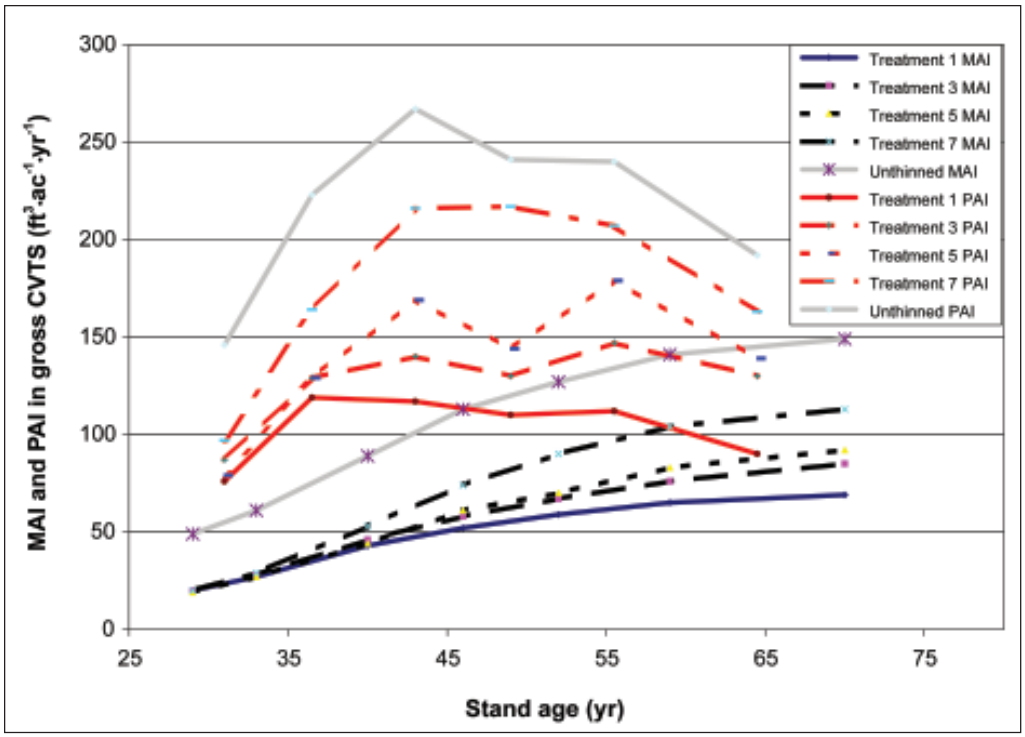

Figure 22—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in gross CVTS, fixed treatments.

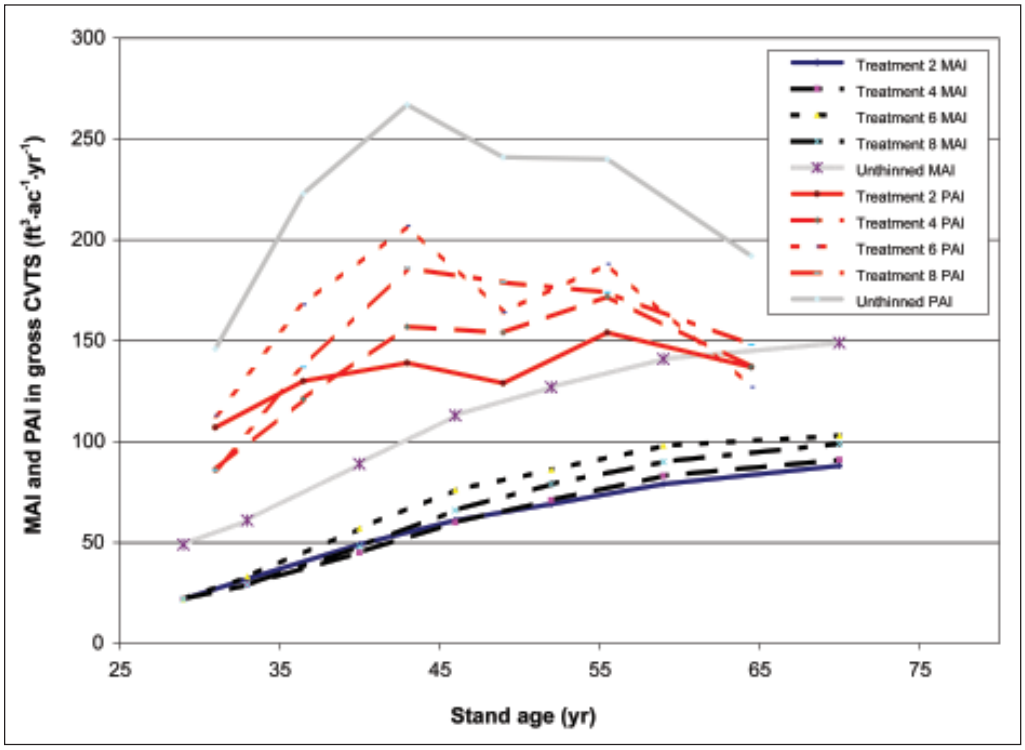

Figure 23—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in gross total cubic volumes CVTS, variable treatments.

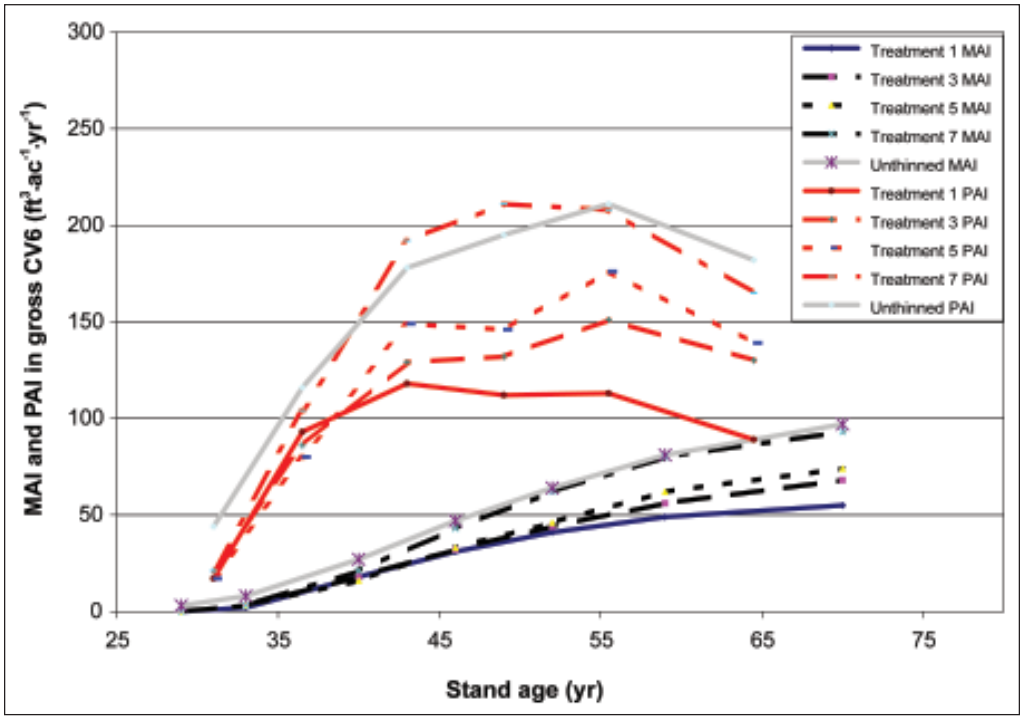

Figure 24—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in gross CV6 per acre, fixed treatments.

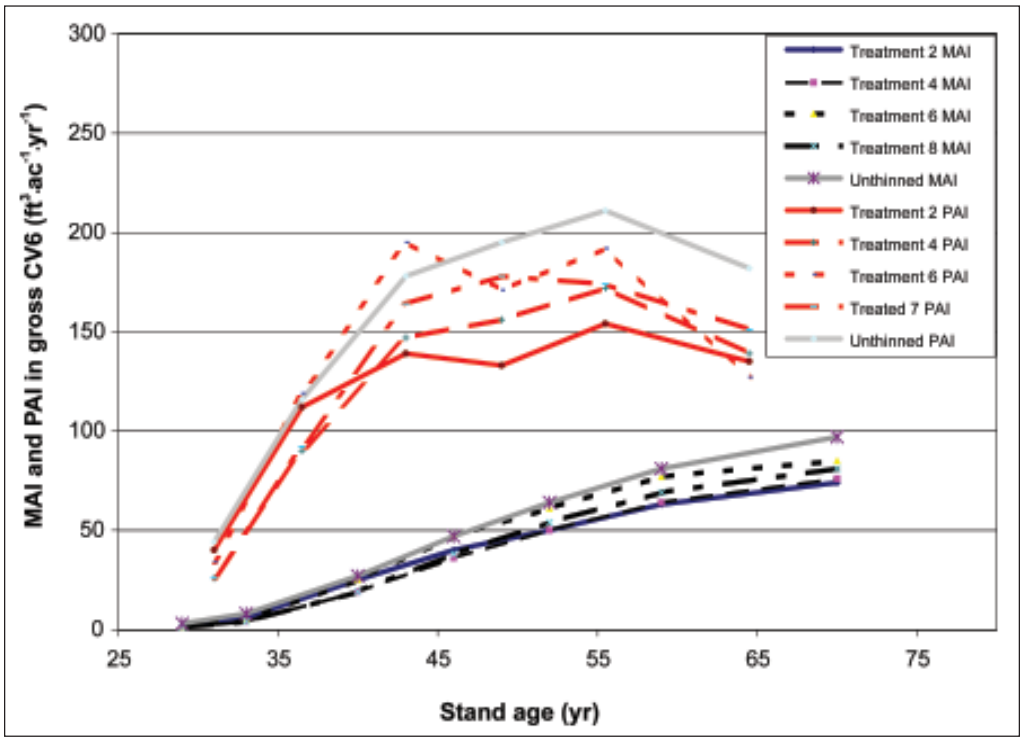

Figure 25—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in gross CV6 per acre, variable treatments.

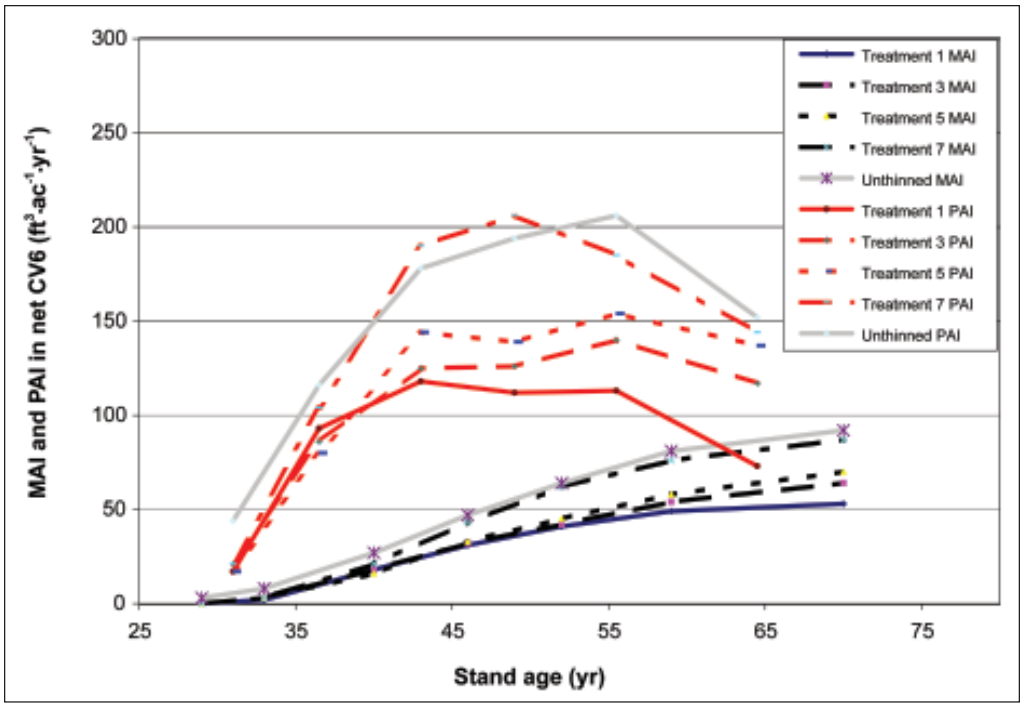

Figure 26—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in net CV6 per acre, fixed treatments.

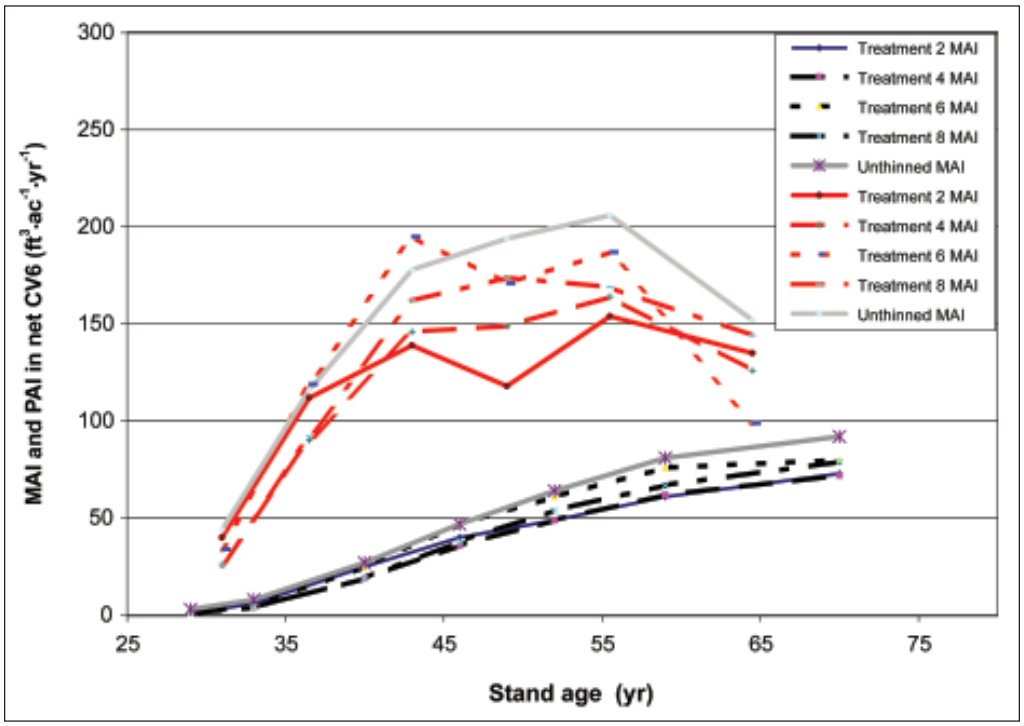

Figure 27—Mean annual increment (MAI, in black) and periodic annual increment (PAI, in red) per acre in net CV6 per acre, variable treatments.

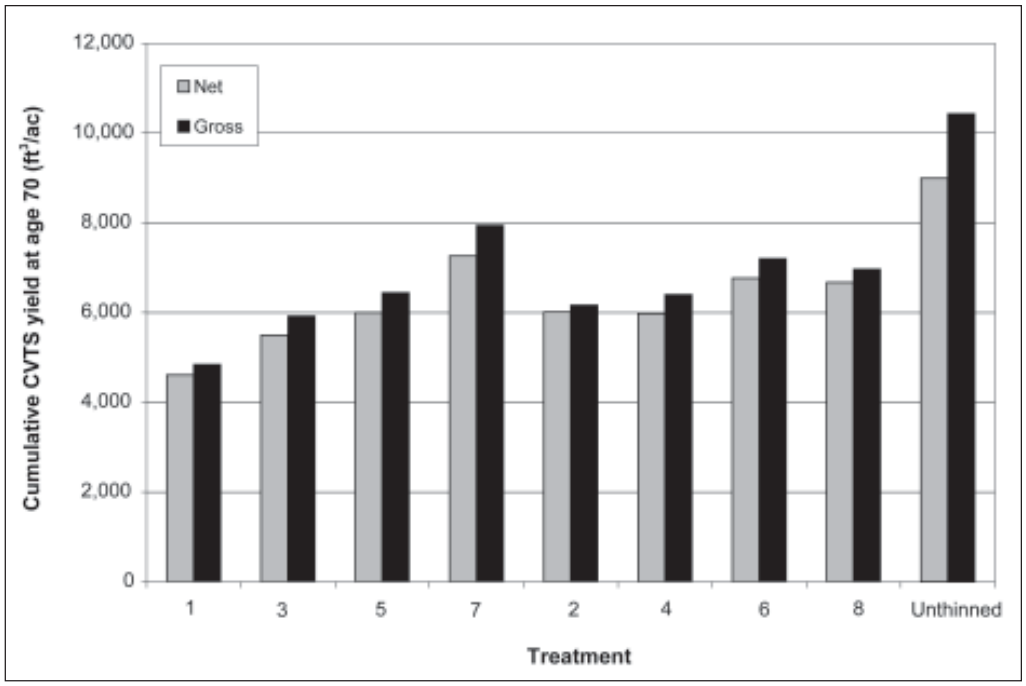

Figure 28—Cumulative net and gross yield in total cubic volume (CVTS) at age 70 (volume removed in calibration thinning not included).

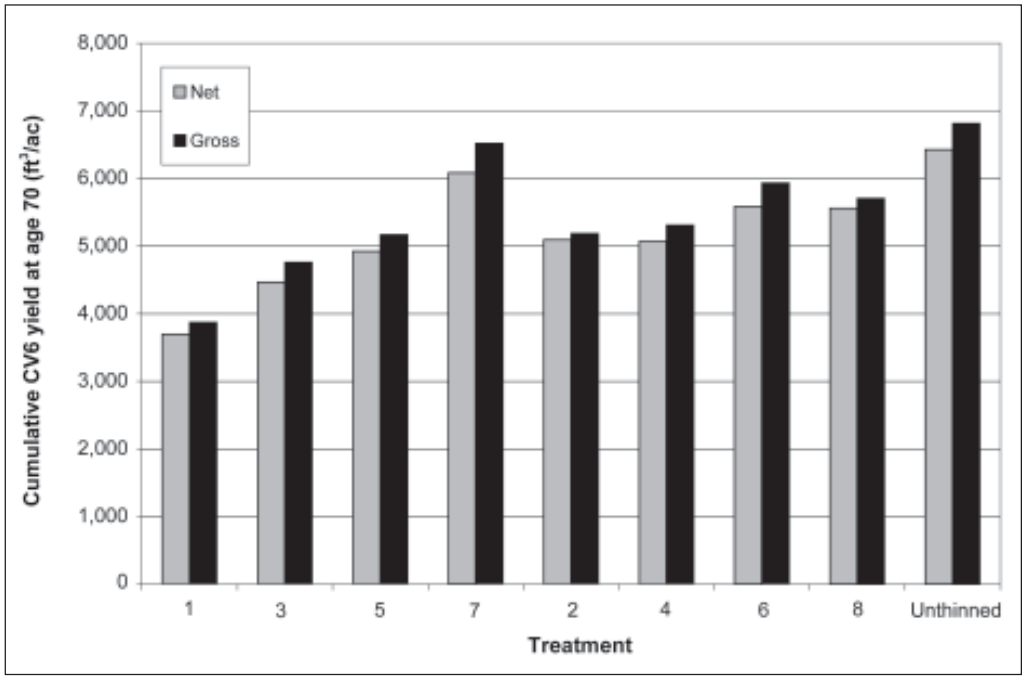

Figure 29—Cumulative net and gross yield in merchantable cubic volume (CV6) at age 70.

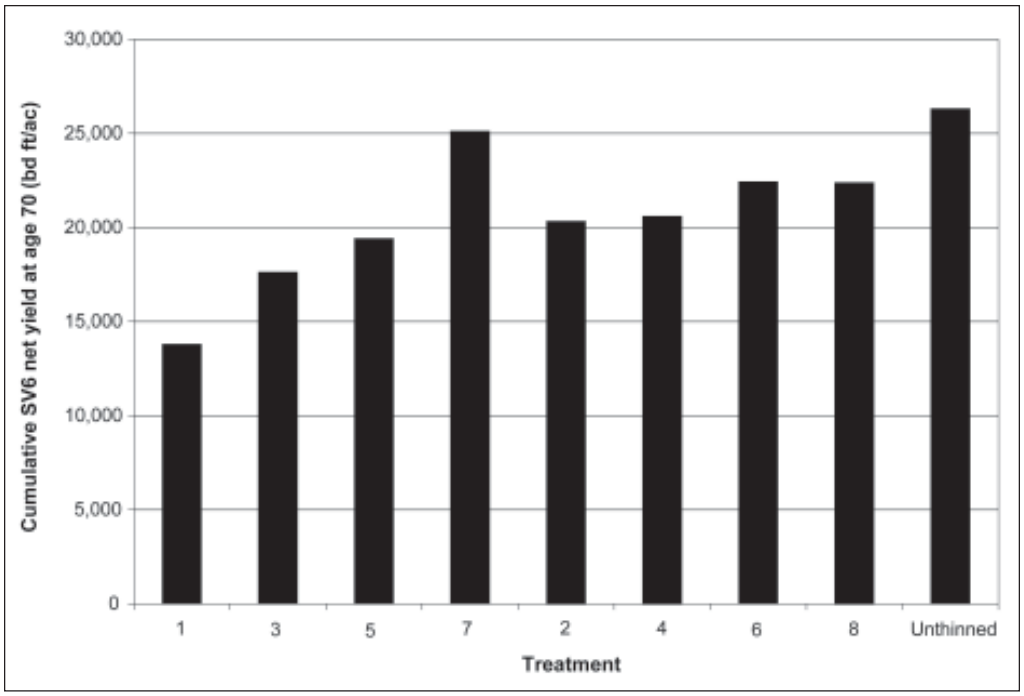

Figure 30—Cumulative net yield in Scribner board feet (SV6) per acre at age 70.

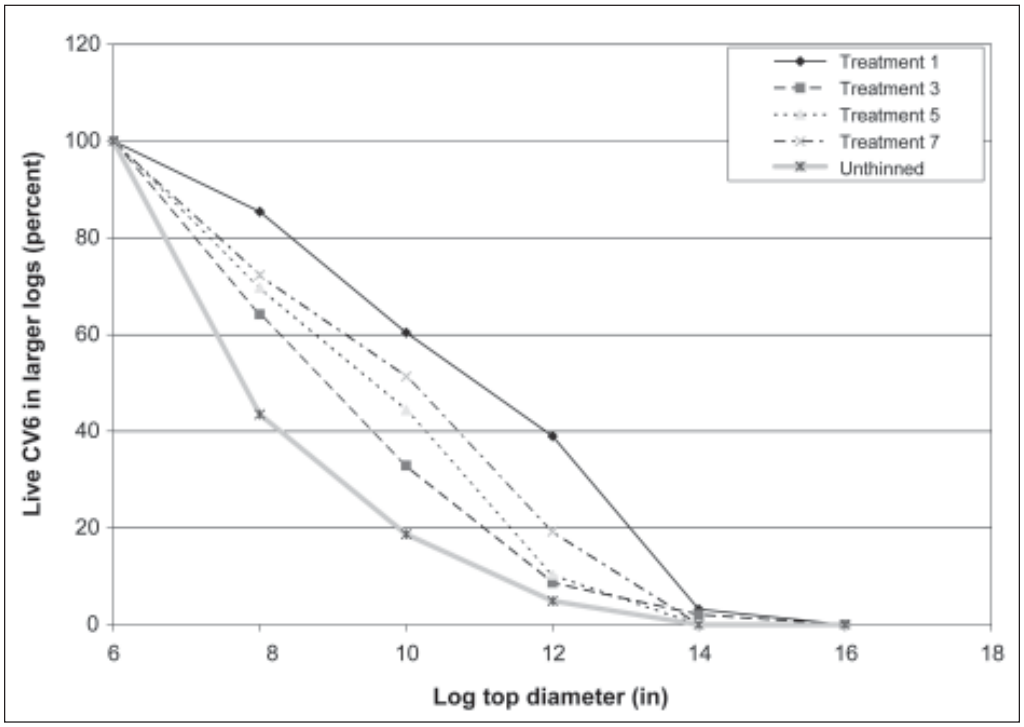

Figure 31—Percentage of live CV6 volume in 2006 in logs larger than the indicated scaling diameter, by treatments.

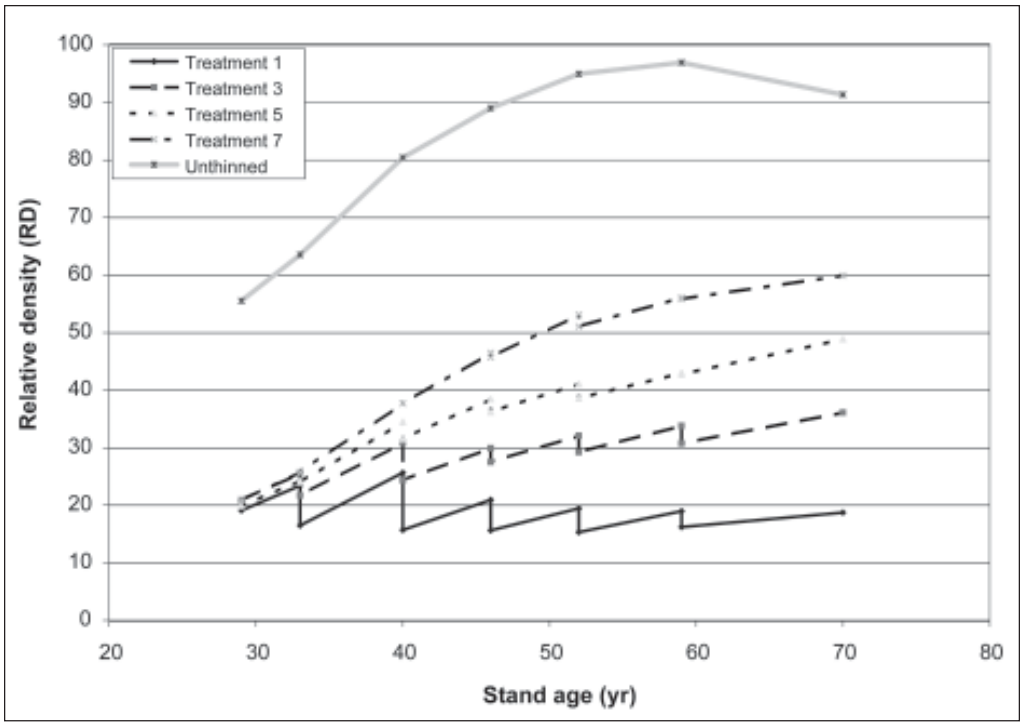

Figure 32—Trends in RD (Curtis 1982) over time, fixed treatments and unthinned.

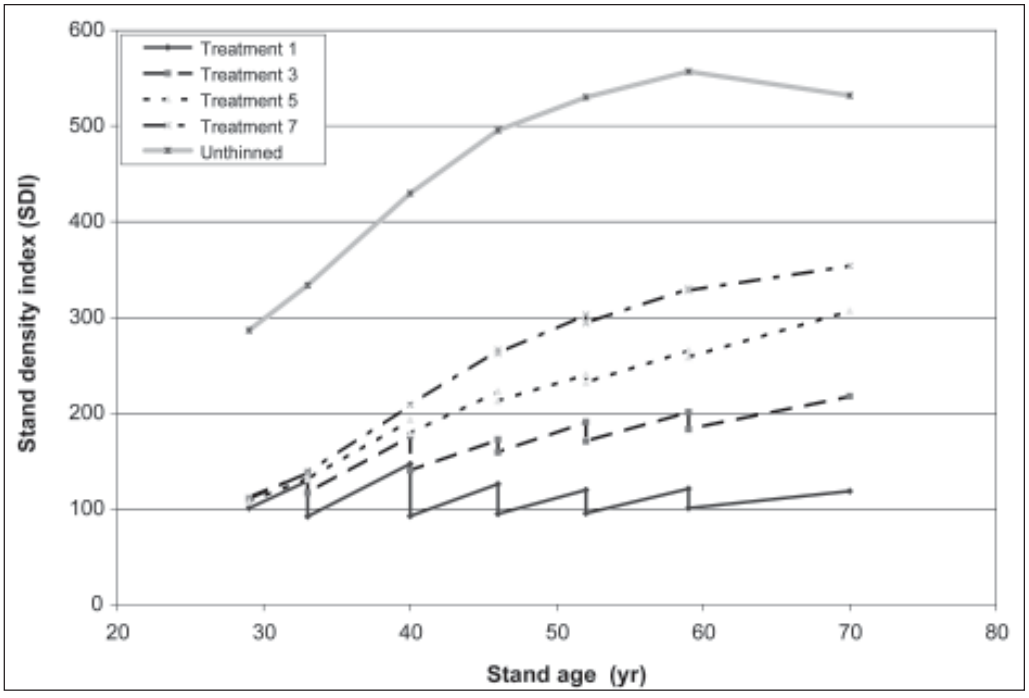

Figure 33—Trends in stand density index (Reineke 1933) over time, fixed treatments and unthinned.

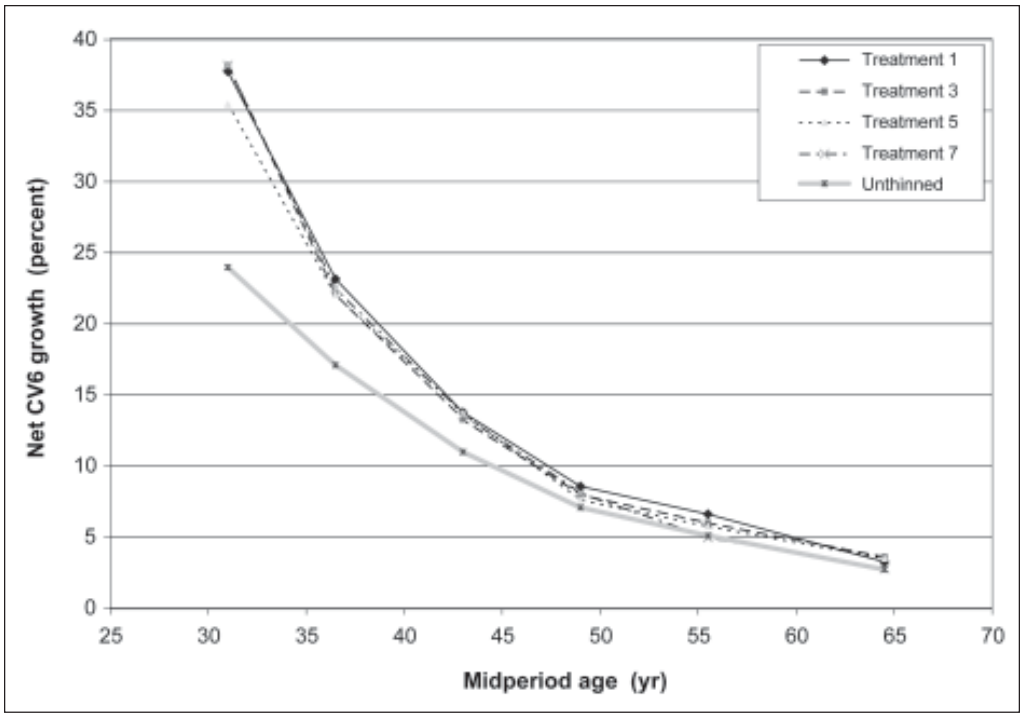

Figure 34—Cubic volume per acre (CV6) net growth percentage over time, fixed treatments and unthinned.

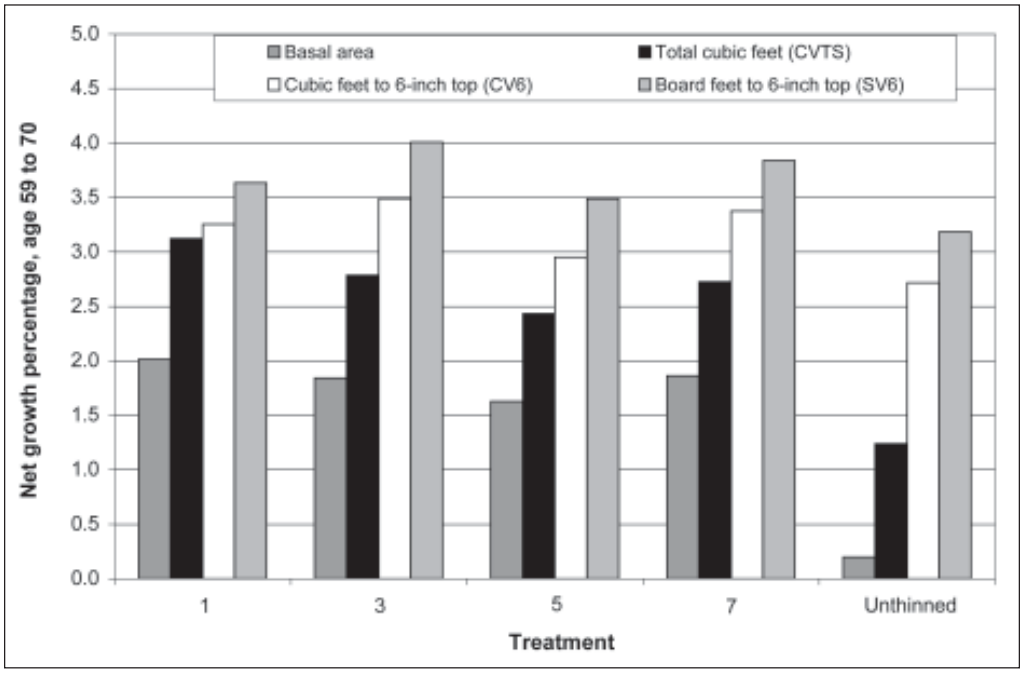

Figure 35—Comparative net growth percentages in different units of measure, for fixed treatments and unthinned, in the last measurement period (ages 59 to 70).

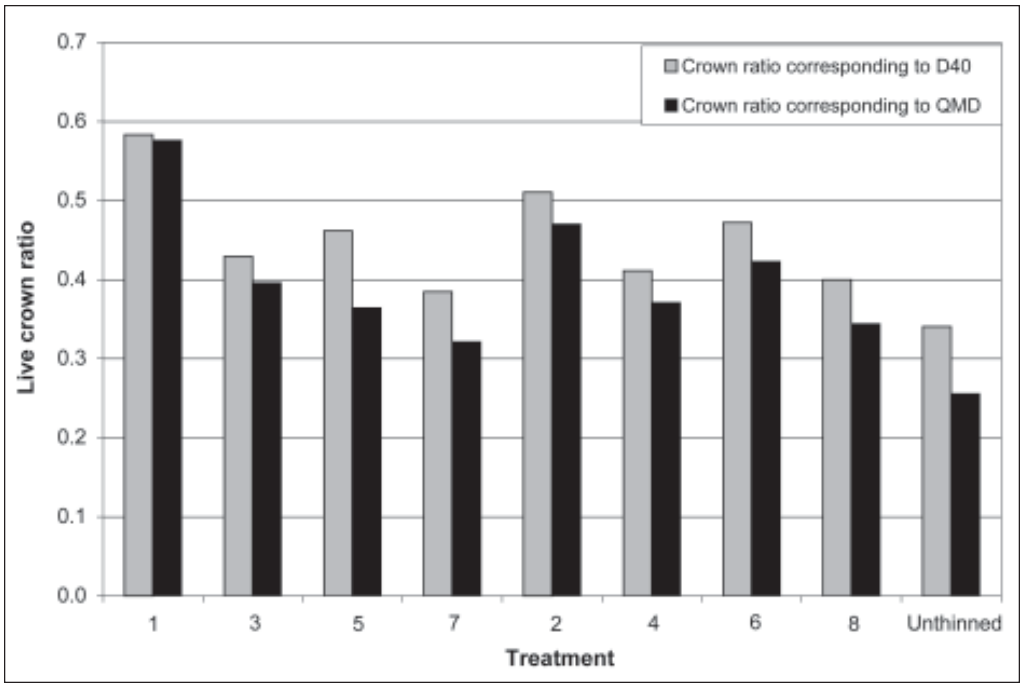

Figure 36—Live crown ratios corresponding to mean diameter at breast height of the largest 40 trees per acre (D40) and to quadratic mean diameter (QMD).

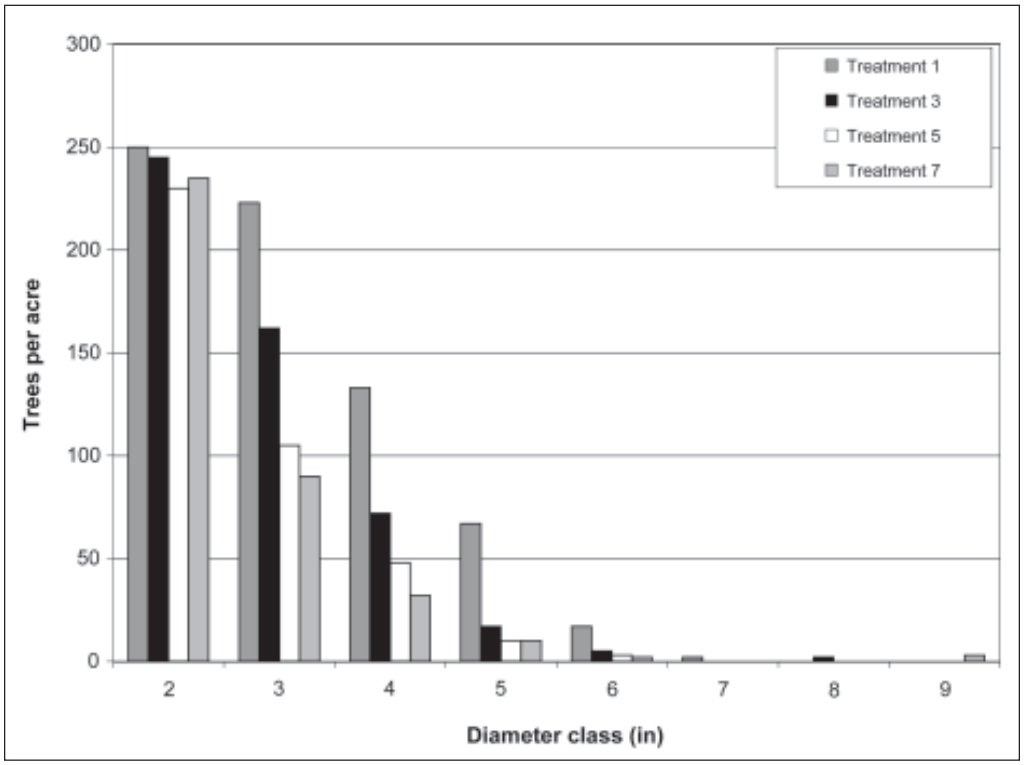

Figure 37—Distribution of ingrowth trees by diameter at age 70, fixed treatments.

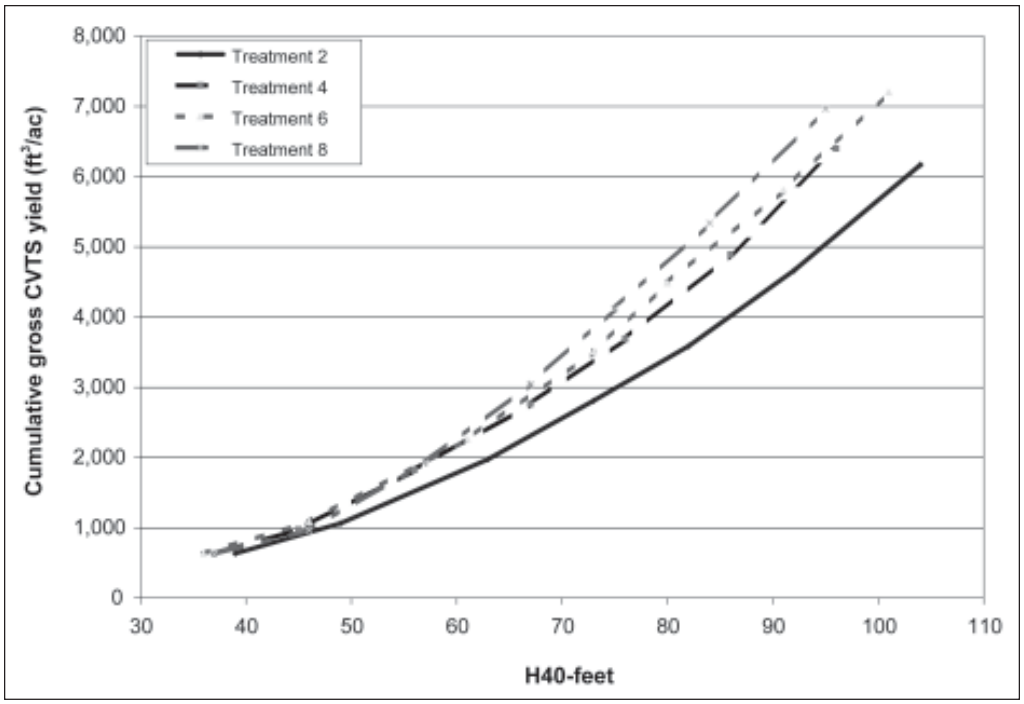

Figure 38—Cumulative gross yield in total cubic volume (CVTS) in relation to top height (H40).

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Web site	http://www.fs.fed.us/pnw
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, OR 97208-3890