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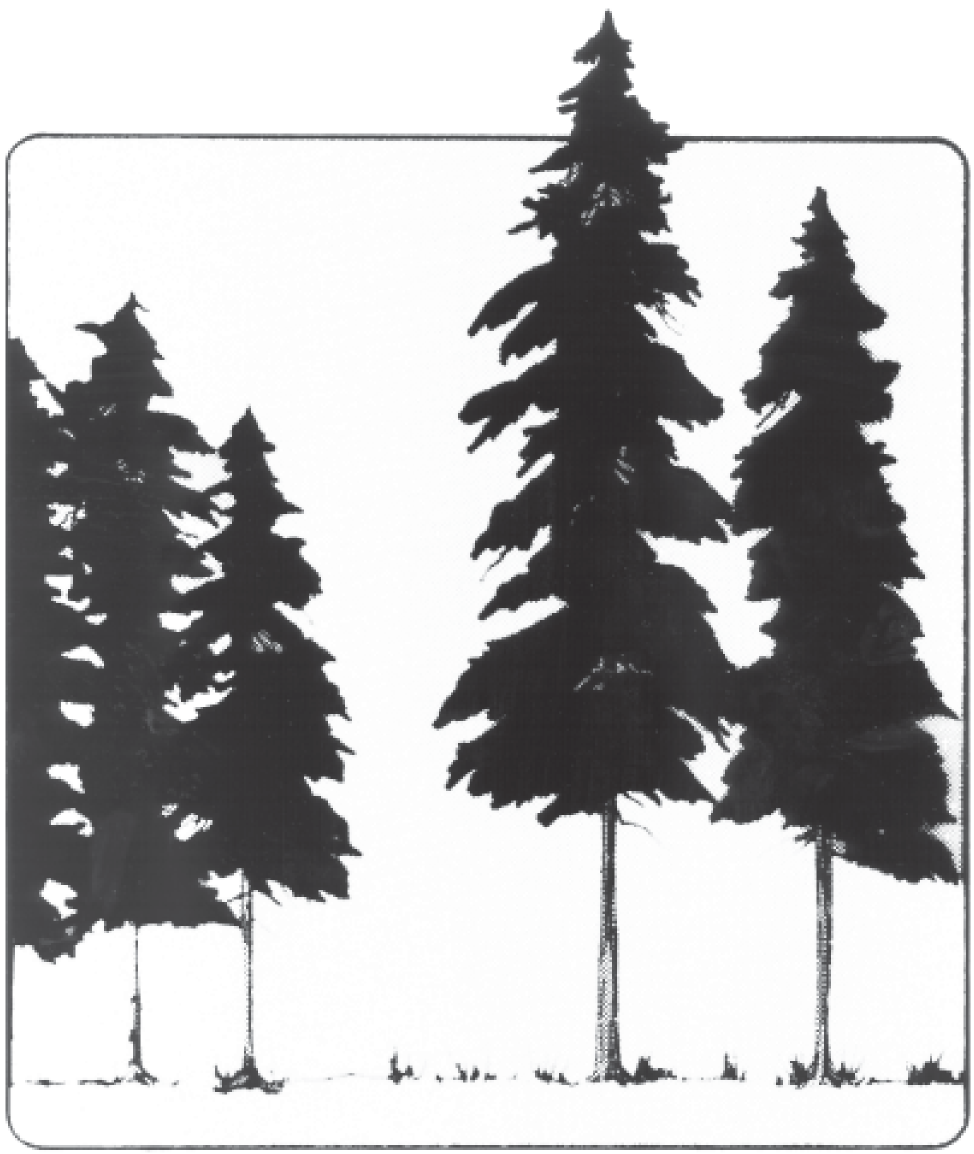
Levels-of-Growing-Stock Cooperative Study in Douglas-fir: Report No. 19—The Iron Creek Study, 1966–2006

Robert O. Curtis and David D. Marshall



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Abstract

Curtis, Robert O.; Marshall, David D. 2009. Levels-of-growing-stock cooperative study in Douglas-fir: report no. 19—The Iron Creek study, 1966–2006. Res. Pap. PNW-RP-580. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 78 p.

This report documents the history and results of the Iron Creek installation of the cooperative Levels-of-Growing-Stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), over the period 1966–2006 (ages 19 to 59). This is a 1949 plantation on an excellent site, and is one of nine installations in the study. Results are generally consistent with those from other LOGS installations. Volume production of thinned stands increased with increased growing stock. Current volume growth shows no sign of decreasing, and is still about twice mean annual increment. On similar public lands, rotations considerably longer than indicated by conventional economic analyses could reduce land use conflicts and increase carbon sequestration while maintaining or increasing long-term timber outputs. Small plot size prevents further thinning, which would otherwise be desirable in some treatments. 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 Iron Creek installation of the cooperative Levels-of-Growing-Stock (LOGS) study in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco, over the period 1966–2006 (ages 19 to 59). This 1949 plantation on an excellent site is one of nine installations in the study.

Site index is quite uniform across treatments and plots, and major damage has been limited to loss of one plot from *Phellinus weirii*. Results are generally consistent with those from other LOGS installations. Volume production of thinned stands increased with increased 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.). Data now include 17 years after the last thinning. Current volume growth shows no sign of decreasing, and is still about twice mean annual increment. On similar public lands, rotations considerably longer than indicated by conventional economic analyses could reduce land use conflicts and increase carbon sequestration while maintaining or increasing long-term timber outputs. At age 59, stands are in excellent condition and should respond well to thinning. Such an extension of the experiment is judged to be impractical because of the small plot size. The principal future value of the data is for use (in combination with other data) in development of growth models.

Introduction

The Iron Creek levels-of-growing-stock (LOGS) installation is one of nine installations in a regional study established in young even-aged Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) stands according to a common work plan[1] (see report No. 1, Williamson and Staebler 1971 in appendix 1 in this report (fig. 1). This study is a cooperative effort between the British Columbia Ministry of Forests, Canadian Forest Service, Oregon State University, USDA Forest Service, Washington Department of Natural Resources, and Weyerhaueser Company. The objective is to compare growth-growing stock relations, cumulative wood production, and tree size development under eight density control regimes begun before the onset of severe competition. The original study plan was developed at Weyerhaeuser Company, Centralia, Washington. Procedural details were developed by the Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon. The Pacific Northwest Research Station served as the coordinating agency in study installation and analyses.

Detailed progress reports on individual installations are contained in the series of LOGS publications listed in appendix 1. Eight of the nine installations have completed the full course of the experiment as originally planned.

The Iron Creek installation was established in 1966 by the Pacific Northwest Research Station and the Pacific Northwest Region (Region 6) of the USDA Forest Service. At the end of the 1989 growing season, Iron Creek had completed the fifth and final treatment period of the experiment as originally planned. Results as of that date have been given in Curtis and Clendenen (1994). No stand treatments have been applied since the 1984 thinning. However, remeasurements in 1994, 1999, and 2006 provide a record of 17 years of development subsequent to that given in the 1994 report, to stand age 59.

This report includes the information from the 1994 report and updates that report to provide in one publication information on stand development over the full period of record now available. We have included in the appendix a large number of detailed tables giving values by plot and by treatment. Most readers will not want this amount of detail, but—because this will probably be the last report on the installation—we wished to include as much as possible of the information that might be wanted by anyone interested in making their own comparisons. We also

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

Figure 1—Location of Levels-of-Growing-Stock study installations.

give information by treatment in the standard stand development table format (in both English and metric units) that has been used in other recent reports in the LOGS series, although this involves some duplication of information in other tables.

Objectives

The LOGS cooperative studies evolved from work in the late 1950s by George Staebler (1959, 1960). Staebler hypothesized 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 been tested. The objectives of the LOGS studies, as stated in the 1962 plan, were "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 the results would show "how to produce any combination of growing stock deemed optimum from a management standpoint." The study was not designed as a test of specific operational thinning regimes, but was intended to define the quantitative relations between growth and growing stock for a closely controlled initial stand condition and kind of thinning.

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Methods

Description of Study Area

The Iron Creek installation was established in 1966 in a Douglas-fir plantation located in section 30, T. 11 N., R. 7 E., Randle Ranger District, Gifford Pinchot National Forest, latitude 46° 57′ 5″ N, longitude 122° 57′ 36″ W. Stand age was 17 years since planting in 1949; 19 years from seed. Composition at time of establishment was recorded as nearly pure Douglas-fir; however, there evidently was abundant natural seeding of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and redcedar (*Thuja plicata* Donn ex. D. Donn) that had not yet reached sufficient size to be retained in the calibration cut, as shown by large numbers now present in an understory position on the unthinned plots.

The stand is in a midslope position at an elevation of about 2,500 feet. Aspect is easterly, with slopes averaging about 25 percent. It is in the *Tsuga heterophylla* zone of the Western Cascades Province of Franklin and Dyrness (1973). The plant association (Topik and others 1986) is western hemlock/swordfern (TSHE/POMU, *Tsuga heterophylla*/*Polystichum munitum*).

Estimated site index (King 1966) is 131 feet (base age 50 years at breast height), a high site II.

The deep well-drained soil (series undetermined) is derived from volcanic ash and lapilli overlying a residual soil developed on fractured volcanic rock. Surface soils range from sandy loam to loam, with interbedded pumice.

At the time the study was established, many trees had been damaged by bear. About 25 percent of the trees remaining after the calibration thinning had some injury. The area was then fenced, and further injury was limited to one episode after damage to the fence in 1975. Few of the remaining trees now show noticeable evidence of bear damage, although some butt scars can still be found.

The May 1980 eruption of Mount St. Helens deposited about 1 inch of ash on the study area. Foliage was still ash covered the following September.

Several plots have had substantial damage from root rot. One plot (plot 51 in treatment 1) has been virtually destroyed by *Phellinus weirii* and has been excluded from analyses. Redcedar and hemlock reproduction is now abundant in the openings created by root rot and as a developing understory in the more heavily thinned treatments.

Experimental Design

The experiment is a completely randomized design having three replications of eight density control treatments, plus unthinned. The 27 plots are one-fifth acre, square, and without buffers except that a 30-foot isolation strip was provided around the outer margins of the experimental area. Physical arrangement is shown in figure 2. Detailed criteria (see footnote 1) for area and plot selection provided a high degree of uniformity in initial conditions.

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

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

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

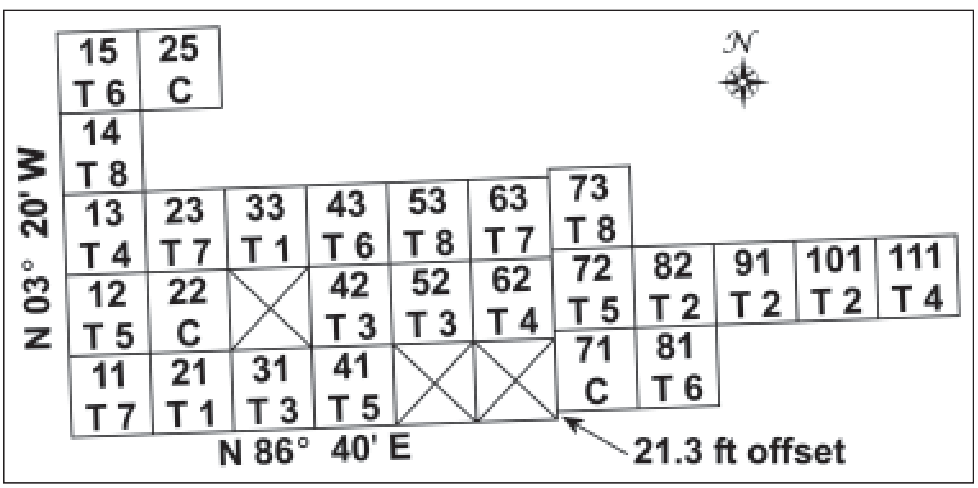

Figure 2—Arrangement of fifth-acre plots in the Iron Creek Levels-of-Growing-Stock study installation.

Calibration thinning—

An initial calibration thinning was made on the 24 plots assigned to thinning treatments, and was intended to reduce all to as nearly comparable condition as possible. All trees less than one-half the initial quadratic mean diameter (QMD) of the crop trees 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,

$$S = 0.6167 \text{ x QMD} + 8,$$

where S is the average spacing in feet and QMD is quadratic mean diameter of the leave trees. Marking was controlled by the specifications that QMD of the leave trees should be within 15 percent of the installation mean, and leave-tree basal areas should be within 3 percent. All leave trees on thinned plots were identified with permanent numbered tags. Trees 1.6 inches diameter at breast height (d.b.h.) and larger were tagged on the unthinned plots.

Treatment thinnings—

Treatment thinnings were made in 1970, 1973, 1977, 1980, and 1984 (ages 23, 26, 30, 33, and 37), which corresponded to approximate 10-foot increments in crop tree height. Thinning intensity was determined as percentages of gross basal area growth on the unthinned plots, as defined in table 1. Plots were randomly assigned to

Table 1—Treatments defined by percentage of gross basal area increment of control retained after thinning (calibration thinning excluded)

	Thinning				
Treatment	**First**	**Second**	**Third**	**Fourth**	**Fifth**
			Percent retention		
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

treatments (table 2). Gross basal area growth of the unthinned plots was assumed to represent the productive potential of the site at full stocking. Basal areas after thinning were calculated from the equation,

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

where

BA_n = basal area retained after thinning,

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

p = prespecified percentage of gross basal area growth of unthinned plots to be retained, and

GBAG = average gross basal area growth on unthinned plots.

The expected trends in basal area created by these specification are shown in figure 3.

Kind of thinning was further specified by the following requirements:

- Crop trees were not to be cut until after all noncrop trees had been removed.[2]
- Average diameter of trees removed in thinning should approximate the average diameter of trees available for thinning (that is, excluding crop trees until after all noncrop trees had been removed).
- Trees removed in thinning were to be distributed across the range of diameters of trees available for cutting.

The thinning specifications of the study plan were expected to result in a crown thinning. The d/D ratios were calculated for each of the five treatment thinnings. Overall means were about 0.90 with no clear trends over time or treatment.

Trees cut in thinnings were left on the site.

Data Collection and Summarization

Immediately after the calibration thinning, and at all subsequent measurement dates (1966, 1970, 1973, 1977, 1984, 1989, 1994, 1999, 2006), diameters of all tagged trees were measured to the nearest 0.1 inch. Heights were measured on a sample of trees; sample size differed at different measurement dates, but was never less than 12 trees per plot, and usually more, distributed across the range of diameters. Beginning with the 1973 measurement, heights to base of live crown were also measured.

[2] The original intent was that the initially selected crop trees would be retained until all other trees had been removed. However, damage and decline in vigor of some trees made some substitutions necessary.

Table 2—Assignment of treatments by plot numbers[a]

Treatment	Plot numbers
Fixed:	
1	21, 33
3	31, 42, 52
5	12, 41, 72
7	11, 23, 63
Increasing:	
2	82, 91, 101
4	13, 62, 111
Decreasing:	
6	15, 43, 81
8	14, 53, 73
Unthinned	22, 25, 71

[a] Plot 51 in treatment 1 has been eliminated because of extensive root disease mortality.

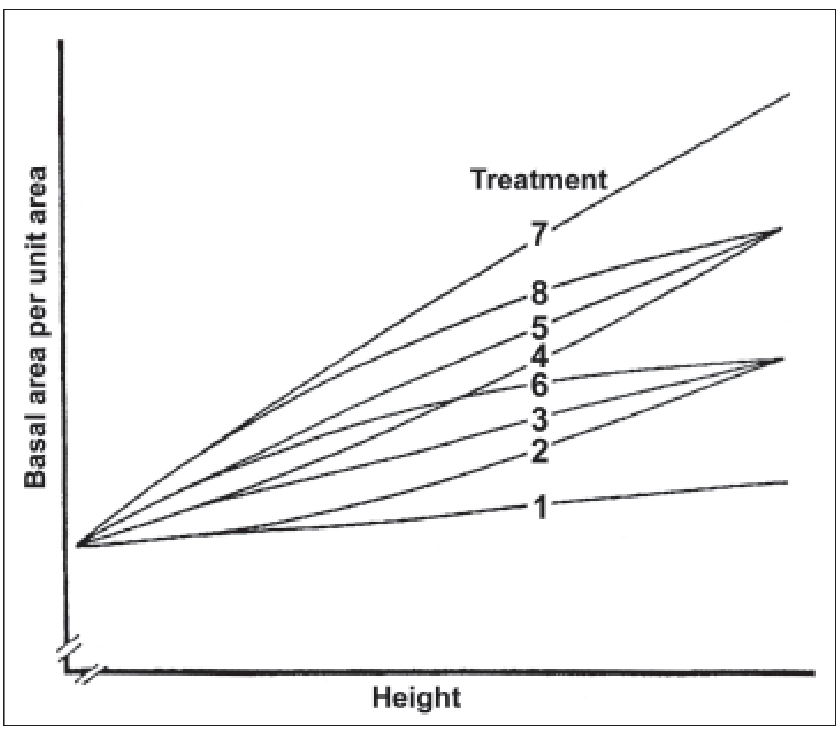

Figure 3—Idealized trends in basal area for the eight thinning regimes in the Levels-of-Growing-Stock study.

On unthinned plots only, the few ingrowth (1.6 inches and larger) trees present were tagged and measured.

Although considerable numbers of ingrowth trees (principally redcedar and hemlock) became established on thinned plots over subsequent years, these were not recorded over most of the course of the experiment. Inclusion of ingrowth would affect number of trees and quadratic mean diameter but, because of the small size of these trees, would make a negligible contribution to basal area and volume and to basal area and volume increments. Supplementary diameter class tallies of ingrowth trees were made at a number of the more recent measurement dates.

The plot and treatment statistics and discussion given below exclude ingrowth trees, except where specifically stated otherwise.

The data have been completely reworked, incorporating height-diameter curves fit by a slightly different procedure than that used in the 1994 report (which affects volume computations). Therefore, not all calculated values will be identical with those given in the 1994 report, although differences are small.

Constrained height-diameter curves were fit to each measurement on each plot (Flewelling and de Jong 1994). Tree total stem volumes 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 feet to a 6-inch top (CV6) with no minimum log length, using equations from Brackett (1973). Scribner volumes for 32-foot logs (SV6), with a minimum top log of 16 feet, were calculated using diameter estimates from Flewelling's (unpublished[3]) taper equations.

Stand heights were characterized as average height (H40) of the largest 40 trees (by d.b.h.) per acre for each plot, and were calculated as the means of the measured or estimated heights of all trees in this category.

Analyses follow the general pattern established by previous LOGS reports.

Analyses

The original study plan specified analysis of variance as the primary method of analysis. The results of such an analysis at the end of the last treatment period (1989) have been given by Curtis and Clendenen (1994), and will not be repeated here. Many aspects of the experiment are more meaningfully presented and interpreted through simple graphic comparisons, and this is the method employed in this

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

report. The underlying numerical values are summarized in a series of tables given in an appendix.

Results

Trends in Live-Stand Statistics

Unless otherwise specified, the plot statistics and discussion below exclude ingrowth trees (which are discussed in a later section).

Height of largest 40 trees per acre (H40) and site index (S50)—
H40 (defined above) is a useful measure of height development. This can be calculated objectively for all plots from the data available, is little affected by thinning, and is now quite commonly used as the basis for site estimates in the region.

Excluding plot 51 (severely damaged by root disease), the range in 2006 values of H40 was from 130 to 142 feet (tables 3a and b).

Site index (S50) values based on King (1966) were estimated from plot and treatment means of H40 at breast-high age 50, assuming that breast-high age = total age - 7. Overall mean site index was 131. Standard deviation of plot site index was 3.6 feet; that of treatment mean site indexes was 2.6 feet. There is no indication of treatment-related differences, and the installation appears to be remarkably uniform in site.

Figure 4 compares the observed trend of mean H40 with that predicted for S50 = 131 by King's (1966) site index curves. The observed trend of H40 is more nearly linear although the differences are relatively small.

Number of trees—
Trends over time in trees per acre (TPA) by thinning treatments (excluding ingrowth) are shown in appendix figures 5a and b. Corresponding numerical values, including those for the unthinned treatment (omitted in fig. 5), are given in appendix tables 4a and b.

Basal area—
Corresponding values of basal area over time are shown in appendix figures 6a and b and tables 5a and b.

Quadratic mean diameter (QMD)—
Trends in quadratic mean diameter (excluding ingrowth) are shown in appendix figures 7a and b and tables 6a and b. The shifts in position at successive ages are caused by a combination of actual growth on surviving trees and progressive removal in thinnings of trees somewhat smaller than overall stand QMD.

Table 3a—Mean heights of 40 largest (by diameter) trees per acre (H40) by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Feet																	
1	21	37.6	48.2	48.9	57.1	57.1	67.0	66.7	75.1	74.2	84.6	84.2	97.3	97.3	108.4	108.4	115.6	115.6	131.8
	33	38.1	49.3	48.7	56.5	56.8	64.3	65.3	73.0	73.4	80.1	82.1	94.6	94.6	104.3	104.3	114.4	114.4	132.6
	51	Deleted - root disease																	
	Mean	37.8	48.8	48.8	56.8	56.9	65.6	65.5	74.0	73.8	82.4	83.2	96.0	96.0	106.4	106.4	115.0	115.0	132.2
3	31	37.7	49.0	49.0	56.5	56.7	67.0	66.8	76.5	76.5	84.7	84.3	97.0	97.0	107.8	107.8	118.7	118.7	132.9
	42	38.2	50.7	50.9	57.7	57.7	68.4	68.4	76.4	76.4	86.0	86.0	99.6	99.6	107.6	107.6	117.8	117.8	133.0
	52	36.2	49.0	49.5	55.4	55.4	67.3	65.9	73.6	73.6	83.0	83.0	96.0	96.0	106.4	106.4	117.2	117.2	132.9
	Mean	37.4	49.6	49.8	56.5	56.6	67.5	67.0	75.5	75.5	84.6	84.4	97.5	97.5	107.2	107.2	117.9	117.9	132.9
5	12	39.7	51.6	51.6	60.5	60.5	70.5	70.5	79.1	79.1	88.0	88.0	103.0	103.0	117.0	117.0	126.4	126.4	142.3
	41	39.1	50.7	50.7	58.4	58.1	68.4	68.4	76.9	76.9	87.1	87.1	101.0	101.0	109.9	109.9	118.2	118.2	133.8
	72	38.3	49.8	49.8	58.2	58.2	69.5	69.5	78.4	78.4	90.6	90.6	102.0	102.0	114.2	114.2	124.6	124.6	141.3
	Mean	39.0	50.7	50.7	59.1	58.9	69.5	69.5	78.2	78.2	88.6	88.6	102.0	102.0	113.7	113.7	123.0	123.0	139.1
7	11	38.6	49.3	49.3	57.3	57.3	69.0	69.0	79.1	79.1	86.8	86.7	99.5	99.5	111.6	111.6	119.3	119.3	136.0
	23	38.7	50.4	50.4	59.3	59.3	71.0	71.0	77.6	77.6	87.1	87.1	102.4	102.4	111.2	111.2	122.7	122.7	140.1
	63	37.9	47.5	47.5	56.0	56.0	67.2	67.2	77.3	77.3	87.5	87.5	99.9	99.9	113.8	113.8	122.1	122.1	139.6
	Mean	38.4	49.1	49.1	57.5	57.5	69.0	69.0	78.0	78.0	87.1	87.1	100.6	100.6	112.2	112.2	121.4	121.4	138.6

[a] Before cut.

[b] After cut.

Table 3b—Mean heights of 40 largest (by diameter) trees per acre (H40) by treatment, plot, measurement date, and age (in parentheses), for variable treatments and unthinned

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Feet																	
Increasing:																			
2	82	39.2	49.9	49.4	57.4	57.4	68.8	68.8	75.6	75.6	86.3	86.3	101.0	101.0	113.9	113.9	125.5	125.5	140.1
	91	37.6	47.2	46.8	54.1	54.1	62.3	62.2	71.9	71.9	81.8	81.8	95.4	95.4	107.7	107.7	116.4	116.4	132.5
	101	40.3	51.5	51.1	58.7	58.8	69.7	69.7	78.4	78.4	88.1	88.1	101.3	101.3	111.3	111.3	122.2	122.2	136.1
	Mean	39.1	49.5	49.1	56.7	56.8	66.9	66.9	75.3	75.3	85.4	85.4	99.2	99.2	111.0	111.0	121.4	121.4	136.2
4	13	42.0	54.1	53.5	59.7	59.1	68.4	68.4	77.7	77.7	85.9	86.3	98.7	98.7	110.6	110.6	120.6	120.6	138.8
	62	38.7	51.2	51.2	57.3	57.3	65.8	64.6	73.5	73.5	82.5	82.5	96.0	96.0	108.3	108.3	118.7	118.7	134.2
	111	40.5	53.5	53.1	59.9	60.3	70.9	70.9	80.6	80.6	92.7	92.7	104.4	104.4	118.9	118.9	128.3	128.3	142.3
	Mean	40.4	52.9	52.6	59.0	58.9	68.4	68.0	77.3	77.3	87.0	87.2	99.7	99.7	112.6	112.6	122.6	122.6	138.4
Decreasing:																			
6	15	37.4	47.9	47.9	55.3	55.1	66.0	64.6	73.6	73.6	82.5	82.0	94.7	94.7	106.4	106.4	116.3	116.3	132.5
	43	36.5	47.7	47.5	54.5	54.5	66.7	66.8	75.2	75.6	84.5	83.8	98.8	98.8	109.4	109.4	120.9	120.9	137.9
	81	36.8	48.7	48.7	56.1	55.2	66.2	66.2	75.5	75.5	84.5	84.5	97.6	97.6	106.4	106.4	117.9	117.9	133.3
	Mean	36.9	48.1	48.0	55.3	54.9	66.3	65.9	74.8	74.9	83.8	83.4	97.0	97.0	107.4	107.4	118.4	118.4	134.5
8	14	40.2	50.7	50.7	59.2	59.2	69.3	69.3	76.9	76.9	86.5	86.5	99.6	99.6	110.8	110.8	122.3	122.3	138.0
	53	37.6	48.5	48.5	57.7	57.7	65.2	65.2	74.2	74.2	83.8	83.6	97.0	97.0	107.6	107.6	116.6	116.6	132.2
	73	40.9	51.8	51.8	59.6	59.6	71.0	71.0	78.7	78.7	87.4	87.4	101.8	101.8	112.4	112.4	120.8	120.8	136.4
	Mean	39.6	50.3	50.3	58.8	58.8	68.5	68.5	76.6	76.6	85.9	85.9	99.5	99.5	110.3	110.3	119.9	119.9	135.6
Unthinned	22	37.2	48.9	48.9	57.3	57.3	68.8	68.8	78.2	78.2	86.7	86.7	99.0	99.0	108.5	108.5	119.3	119.3	131.7
	25	37.0	49.1	49.1	57.3	57.3	68.6	68.6	75.3	75.3	86.8	86.8	98.7	98.7	108.5	108.5	119.3	119.3	132.9
	71	35.5	47.7	47.7	56.4	56.4	65.8	65.8	75.0	75.0	83.3	83.3	95.9	95.9	106.5	106.5	116.2	116.2	130.0
	Mean	36.6	48.6	48.6	57.0	57.0	67.7	67.7	76.2	76.2	85.6	85.6	97.9	97.9	107.9	107.9	118.3	118.3	131.5

[a] Before cut.

[b] After cut.

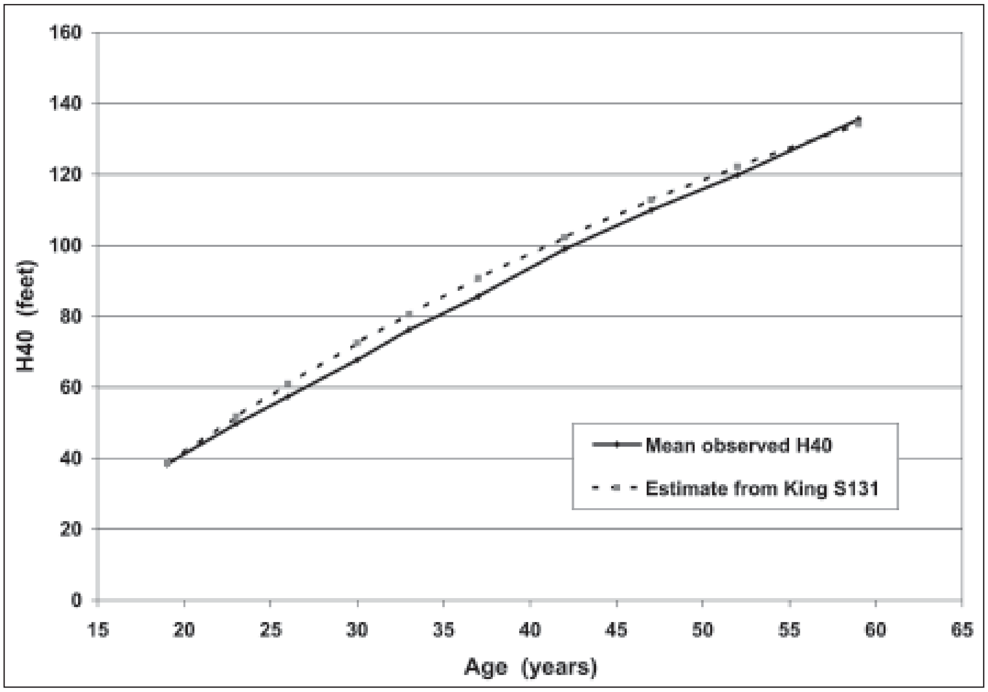

Figure 4—Trend of mean H40 (height of largest 40 trees per acre, averaged over all plots) over time compared with the trend predicted by King (1966) for site 131.

Diameter of largest 40 trees per acre (D40)—
The original study plan called for an initial selection of 80 crop trees per acre, based on a combination of vigor and spacing, with these trees to be favored during thinning and retained to the end of the experiment. Average diameter of these crop trees would become equal to QMD once the number of stems (some treatments only) had been reduced to 80 per acre.

Substitution of new crop trees for damaged and low-vigor trees has made diameters of the initially selected crop trees of questionable usefulness, and we adopt as a substitute the mean diameter of the largest 40 trees per acre, the same trees used in computation of H40. In most cases, these are the same trees at successive measurements, and the values of D40 are therefore little influenced by thinning.

The D40 trends over time are shown in figures 8a and b and in the stand development tables (app. 2). Clearly, D40 growth has been accelerated by thinning, although to a lesser extent than that of QMD of all trees. The mean D40 increment over the 40 years of observation for all thinned plots was 14.67 inches, vs. 11.33 inches for the unthinned plots; a significant difference (t = 5.61).

Standing volume—

Trends in live cubic-foot volume of total stem (CVTS) are shown in figures 9a and b, with numerical values given in tables 7a and b. Corresponding trends in live merchantable cubic-foot volume to a 6-inch top diameter inside bark (CV6) are shown in figures 10a and b with numerical values in tables 8a and b. Distribution of live CV6 volume in 2006 by log sizes is given in appendix table 9 and figure 11.

Scribner board-foot volume to a 6-inch top (SV6) trends resemble those for CV6, and are given in tables 10a and b.

Cut—

Number, basal area, QMD, and volume of trees cut are given in appendix tables 11 and 12, by treatment and growth period. Distribution of cut CV6 by log size is shown in table 13.

Mortality—

Mortality in number of trees, basal area, QMD, and volume is summarized in tables 14 and 15, by treatment and growth period. Mortality losses have been slight in the thinned treatments, but severe in the unthinned.

Cumulative Yields

Gross CVTS yields—

Cumulative gross yields in CVTS (live stand at age 59 + thinnings, including calibration cut, + mortality) are shown in figure 12 and stand development tables 16 through 24. The graphs include an estimated average calibration cut removal of 457 ft^3/ac, not included in the tables. The values shown represent total biological production of bole wood, including material too small to be usable. Cumulative gross production increased with stocking level, being highest and approximately equal for treatment 7 and the unthinned treatment.

Net CV6 yields—

Cumulative net yields in merchantable cubic-foot volume (CV6)—a more meaningful measure from a management standpoint—are shown in figure 13 and stand development tables 16 through 24. Values exclude the very small volume removed in the calibration cut. Net production (live stand at age 59 + thinnings) increased with stocking level in the thinned treatments, with treatments 5, 7, and 8 exceeding the unthinned, and treatment 4 being approximately the same as unthinned.

The wide difference between the values for thinned vs. the unthinned treatment, compared to differences in the gross CVTS yields shown above, are the result of mortality (primarily suppression) in the unthinned treatment.

Periodic annual increment (PAI) in basal area—
Trends in basal area gross and net PAI over age are shown in figures 14 and 15, for fixed treatments only. Gross increment is greater at the higher stocking levels, but is not greatly different among treatments, other than treatment 1, where the low stocking level has resulted in markedly lower increment.

Trends in net basal area PAI are similar for thinned treatments, but the unthinned treatment is markedly different because of windfall losses in the period age 42 through 47, concentrated in plot 71.

Periodic annual increment (PAI) and mean annual increment (MAI) in CV6 and CVTS—
Trends in gross cubic-foot volume (CVTS) and net merchantable cubic-foot volume (CV6) MAI and PAI over age are shown in figures 16 and 17 for fixed treatments, using numerical values from tables 16 through 24. Although not shown, board-foot MAI and PAI trends resemble those for CV6.

The hypothesis of near-constant volume increment over a wide range of stocking is clearly disproven for young Douglas-fir.

Both gross and net volume increments are strongly related to stocking level, and increase with stocking in thinned stands. The relative increase in volume increment with increase in stocking level is much greater than that for basal area increment. The hypothesis of near-constant volume increment over a wide range of stocking is clearly disproven for young Douglas-fir.

The PAIs in both gross CVTS and net CV6 have been near-constant for the unthinned treatment, and have been increasing for the thinned treatments. At age 59, PAI is still approximately twice MAI at the same age.

Fixed and Variable Treatments

Figure 3 illustrates the anticipated relations of variable treatments 2 and 6 to fixed treatment 3, and of variable treatments 4 and 8 to fixed treatment 5. Actual observed development of basal area (figs. 6a and b) resembled the anticipated pattern (fig. 3) through the end of the planned treatments at age 42. Treatment 2 (increasing, lowest stocking level) diverged sharply thereafter, in part because of heavy mortality in the period age 42 through 47 and consequent lower stocking.

Among variable treatments, treatment 2 had the greatest QMD at age 59 (fig. 7b) and treatment 8 had the least, whereas 4 and 6 were virtually the same. Conversely, treatment 8 had the highest gross CVTS volume yield and treatment 2 the lowest, while 4 and 6 were intermediate (fig.12). Net CV6 yields were considerably lower for treatment 2 (fig.13) than for the other variable treatments, which differed only slightly.

These results suggest that there is little practical difference in production of fixed vs. variable treatments having similar average stocking levels.

Growth Percentage

The argument that one should seek maximum return (measured as stand growth) 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,

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

where *X1* and *X2* are growing stocks at the beginning and end of the growth period, and PAI is net periodic annual increment.

Trends for net merchantable volume (CV6) and total stem volume (CVTS) growth percentages for fixed and unthinned treatments are shown in figures 18a and b. Although there is little difference among the CV6 curves, there are larger differences among the corresponding CVTS curves, with treatment 1 having the highest growth percentage. The different patterns of CV6 and CVTS growth percentages are associated with differences in the ratio of CV6 to CVTS among treatments (fig. 19).

Relative Stand Density

Values of two commonly used relative density measures, RD (Curtis 1982) and stand density index (SDI) (Reineke 1933), are shown in figures 20 and 21. Ingrowth has been excluded from the calculation.

The simple correlation coefficient between the two measures was r = 0.99, showing that for these data, there is no practical difference between these measures other than a scale factor, although there is a slight and probably inconsequential difference in the assumed power of QMD. (RD can be written in the form RD = $0.00545415 \times \text{TPA} \times (\text{QMD})^{1.5}$, whereas in SDI the exponent of QMD is 1.6.)

Values for the unthinned treatment seem consistent with the commonly accepted maxima of about RD 85 and SDI 500 for Douglas-fir. The "wobbles" in values for the unthinned condition reflect sporadic and increasing mortality.

Crown Development

For the 2006 data, a regression of live crown ratio (LCR) on diameter was fit separately for each treatment. The resulting equations were then entered with the treatment values of D40 and QMD, to estimate the corresponding LCRs. Results, shown in figure 22 for the fixed treatments and unthinned, show clear trends for LCRs corresponding to both D40 and QMD.

When the data are ordered by RD values, there is a clear trend of decreasing LCRs with increasing RD. The same is true for SDI. A plot of LCR over basal area showed a similar trend for the thinned treatments, but differed radically for the unthinned (fig. 23) reflecting the fact that QMD and D40 are much smaller and the observed basal area represents much more intense competition in the unthinned stand than the same basal area in a thinned stand of much larger QMD. Thus, although basal areas of treatment 7 and the unthinned treatment in 2006 were equal, the corresponding RD values were 72 for treatment 7 and 86 for the unthinned. The more intense competition has produced both a markedly smaller LCR and extensive suppression-related mortality in the unthinned condition in recent growth periods.

Understory Development

In thinned plots, all stems less than one-half the initial QMD of crop trees were removed as part of the calibration cut. Subsequent regeneration was not tagged or recorded over most of the life of the experiment.

Over time, some treatments developed abundant understories of small hemlock and redcedar. Although irrelevant to the original timber production objectives, present interest in wildlife habitat and development of complex stand structures made it desirable to collect information on the understory. Accordingly, in 1994, 1999, and 2006, we tallied all untagged (ingrowth) trees 1.6-inch and larger by diameter and species, on each thinned plot. The counts for the fixed treatments in 1994 (the end of the planned 60 feet of height growth) are shown in figure 24, and include roughly similar numbers of western hemlock and redcedar.

Obviously, the number of understory trees and their rate of development are strongly related to stocking level. The lower density treatments are probably headed toward an eventual multilayer stand structure.

Discussion

Results for variable treatments are little different from those for fixed treatments.

In most instances, results for variable treatments are little different from those for fixed treatments, with treatments 2 and 4 bracketing fixed treatment 3, and 6 and 8 bracketing fixed treatment 5. In the interest of brevity, we have therefore in many instances shown graphs for fixed treatments and unthinned only.

These fifth-acre plots are unbuffered, and there is a possibility of edge effects that might have some influence on comparisons. In most cases, thinned plots are adjacent to other thinned plots, and we think edge effects are probably small. Unthinned plots are often adjacent to thinned plots of much lower density, and there may well be a small upward bias in growth and yield estimates for the unthinned condition.

The graphs of PAI and MAI for gross CVTS and net CV6 (figs. 16 and 17) have a number of interesting features:

- The abrupt drop in PAI immediately after the peak coincides with the Mount St. Helens volcanic eruption. Field notes from a visit 5 months subsequent to the eruption indicate that there was then about 1 inch of ash on the ground and extensive ash coverage on foliage.
- Thereafter, PAI values are approximately twice the corresponding MAI values. These stands are well short of age of culmination (maximum mean annual volume increment).
- There are wide differences in PAI among stocking levels, with PAI and MAI of thinned stands increasing with stocking.
- From age 33 on, PAI values have been **increasing** on thinned plots, whereas values have been nearly constant on the unthinned. We regard this as primarily a delayed response to thinning, possibly associated with recovery from initial ash-fall damage to foliage and possible subsequent fertilization effects of volcanic ash.
- This increase in PAI is associated with increase in basal area and RD over time.

The pattern of PAI values is consistent with the belief that thinning will tend to increase the age of culmination. Age of culmination at Iron Creek is unknown, but is obviously several decades in the future.

Management Implications

Results from Iron Creek and those from the other LOGS installations clearly demonstrate that the so-called “Langsaeter hypothesis” of near-constant growth over a wide range of stocking, widely cited at the time the LOGS studies were

Reduction in increment associated with low growing stock has largely offset the increase in growth percentage from reduced volume that was expected at the time the study was designed.

designed, is simply **wrong** for young Douglas-fir still making rapid height growth. On the contrary, volume increment is strongly related to stocking.

At the time the LOGS study was designed, it was believed that low growing stock would provide greater growth percentages and hence would be financially attractive. This increase in growth percentage for CVTS is shown by figure 18b. However, the corresponding relationship for merchantable volume (CV6) shown in figure 18a is markedly different. Not only are initial growth percentages much higher (because of the small CV6 volume in the denominator), but there is little difference among treatments. We attribute the differences to the lesser CVTS growth at low stocking and the differences in CV6/CVTS ratios that result from the larger tree sizes associated with lower growing stock (fig. 19). The reduction in increment associated with low growing stock has largely offset the increase in growth percentage from reduced volume in the denominator that was expected at the time the study was designed.

Although LOGS is often referred to as a thinning study, it was not intended as a comparison of operational regimes. Rather, it was designed to determine the relation between level of growing stock and increment. The light and frequent thinnings used to maintain close control of growing stock would not be feasible on an operational basis. However, we believe that similar results could be achieved with a considerably longer thinning cycle designed to produce approximately similar average stocking over time.

It is clear from LOGS and other studies that thinning in these initially well-stocked uniform young Douglas-fir stands has produced little or no gain in total cubic-foot volume production to date, and only modest gains in merchantable volume, compared to the unthinned condition. (Although, the comparison with unthinned is somewhat suspect because of possible bias associated with edge effects.) The increasing PAIs in recent years suggest that net volume production relative to the unthinned condition might increase considerably over a longer timespan.

The principal gains from thinning are not enhanced volume production but (1) larger trees at a given age, (2) enhanced stand stability and vigor associated with lower height/diameter ratios and larger crowns, (3) reduced mortality and salvage of mortality that does occur (which becomes more important as stands age), and (4) in some regimes, establishment of a younger cohort where this is desirable for wildlife habitat. And, provision of intermediate income from thinnings can be important to owners that have forests with unbalanced age distributions.

There are tradeoffs involved between possible stocking levels. Relatively high stocking in the latter half of the rotation (with stands not allowed to exceed about RD65 or SDI400) is desirable for the objectives of timber production and carbon sequestration. Much lower stocking would be preferred if the primary objectives were early development of large trees, long crowns, and layered stand structure for wildlife habitat and biodiversity.

The trends in net volume PAI and MAI shown are pertinent to the question of appropriate rotations. The fact that PAI is still near constant or increasing as stocking builds up and is still roughly twice MAI at age 59 shows that lengthening rotations beyond the 40 to 50 years now common on private lands could produce substantial long-term increases in both total stemwood and merchantable timber production. The trends shown are generally consistent with those from other LOGS installations and from other older studies (Curtis 1995, 2006). The larger growing stocks associated with longer rotations would provide increased carbon sequestration and larger trees, and longer rotations would decrease the area in the unsightly early regeneration stage. Conflicts with scenic, wildlife, and recreational values would be reduced.

Larger growing stocks associated with longer rotations would provide increased carbon sequestration, and conflicts with scenic, wildlife, and recreational values would be reduced.

Private owners whose primary objective is investment income from timber are not likely to extend rotations in the absence of some form of subsidy (as suggested by Lippke and others 1996) or of a market for carbon sequestration credits. Owners with multiple objectives may find lengthened rotations advantageous.

Objectives of public owners commonly include enhancement of wildlife habitat and biodiversity, scenic values, and recreational values, and these objectives often take priority over the traditional objective of maximizing net present value based on discounted values of future timber yields. Carbon sequestration seems likely to be an important additional objective in the future. Long-rotation management seems well suited to these public objectives.

Future of the Iron Creek Study

The Iron Creek installation of the LOGS study is now 17 years past completion of the 60 feet of height growth originally planned as the duration of the study. Development following cessation of the thinning program has shown trends of much interest, as discussed above.

The principal present value of the study, beyond the results discussed above, is in the body of high-quality data that it has produced on tree and stand development under a wide range of growing-stock levels. This should have continuing value as a part of the data needed for development and improvement of growth models.

The installation provides a visually striking example of the effects of differences in growing-stock levels on stand development and stand characteristics (figs. 25, 26). It has continuing value as a demonstration area, although its somewhat remote location considerably reduces its usefulness.

With the small plot size and the small number of trees remaining on some treatments, further thinning is not feasible. With increasing tree size, edge effects can be expected to become more important. Therefore, from a research standpoint, we see little point in continuing measurement of the study.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters
Feet (ft)	0.3048	Meters
Miles (mi)	1.609	Kilometers
Square feet (ft^2)	0.929	Square meters
Acres (ac)	0.405	Hectares
Trees per acre	2.471	Trees per hectare
Square feet per acre (ft^2/ac)	0.229	Square meters per hectare
Cubic feet per acre (ft^3/ac)	0.070	Cubic meters per hectare

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Bruce, D.; DeMars, D.J. 1974. Volume equations for second-growth Douglas-fir. Res. Note PNW-239. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 5 p.

Curtis, R.O. 1982. A simple index of stand density for Douglas-fir. Forest Science. 28: 92–94.

Curtis, R.O. 1995. Extended rotations and culmination age of coast Douglas-fir: old studies speak to current issues. Res. Pap. PNW-RP-485. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 49 p.

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.

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. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 67 p.

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Franklin, J.F.; Dyrness, C.T. 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 417 p.

King, J.E. 1966. Site index curves for Douglas-fir in the Pacific Northwest. Paper 8. Centralia, WA: Weyerhaeuser Forestry Research Center. 49 p.

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Topik, C.; Halverson, N.M.; Brockway, D.G. 1986. Plant association and management guide for the western hemlock zone—Gifford Pinchot National Forest. R6-ECOL-230A-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 132 p.

APPENDIX 1: Other 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.

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.

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 effects of calibration thinnings are described for the three installations maintained by the USDA Forest Service in the cooperative LOGS study. Results of first treatment thinning are described for one area.

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. 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 feet of height growth planned for 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 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. 2001. 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 age 33 through the final planned treatment period at age 63 in a site-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 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-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 unthinned control has culminated for total cubic-foot volume and is near culmination for merchantable cubic-foot 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.

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 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 MAI. 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.

Curtis, R.O.; Marshall, D.D. 2009. Levels-of-growing-stock cooperative study in Douglas-fir: report No. 18—Rocky Brook: 1963–2006. Res. Pap. PNW-RP-578. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 90 p.

Documents history and results of the Rocky Brook installation over the 41-year period 1965–2006. This 1938 plantation is one of two in the series on poor sites (IV). Results are generally consistent in kind with those from other LOGS installations although growth has been much slower. Volume production increased with growing stock. Periodic annual increment is still considerably greater than mean annual increment. The principal future value of the data is for use in development of growth models.

Appendix 2: Data tables

Table 4a—Number of live trees per acre (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Number per acre																	
1	21	355	350	210	210	145	145	100	100	80	80	60	60	60	60	60	60	60	60
	33	360	355	225	215	150	150	110	110	80	80	65	65	65	65	65	65	65	65
	51	Deleted - root disease																	
	Mean	358	352	218	212	148	148	105	105	80	80	62	62	62	62	62	62	62	62
3	31	355	350	275	270	225	220	185	185	160	160	135	135	135	125	125	125	125	125
	42	335	335	215	210	165	165	145	145	125	125	100	100	100	100	100	100	100	100
	52	355	335	255	230	190	180	155	150	150	150	110	105	105	95	95	95	95	95
	Mean	348	340	248	237	193	188	162	160	145	145	115	113	113	107	107	107	107	107
5	12	345	335	275	275	230	230	215	215	195	195	165	165	165	165	165	160	160	155
	41	335	330	255	255	220	220	205	205	185	185	160	160	160	160	160	160	160	155
	72	360	350	300	290	275	260	260	260	250	240	210	210	210	195	195	180	180	180
	Mean	347	338	277	273	242	237	227	227	210	207	178	178	178	173	173	167	167	163
7	11	345	340	305	305	280	280	280	280	265	265	235	230	230	225	225	220	220	210
	23	355	345	340	335	325	310	310	310	305	300	270	270	270	240	240	230	230	210
	63	380	355	355	310	310	300	300	290	290	285	275	265	265	255	255	240	240	200
	Mean	360	347	333	317	305	297	297	293	287	283	260	255	255	240	240	230	230	207

[a] Before cut.
[b] After cut.

Table 4b—Number of live trees per acre (excluding ingrowth), by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treatments

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Number per acre																	
Increasing:																			
2	82	360	355	200	195	150	150	125	125	110	110	95	95	95	75	75	75	75	75
	91	375	350	215	190	175	175	135	130	130	130	110	110	110	105	105	100	100	100
	101	350	335	180	180	140	135	120	120	105	100	85	85	85	70	70	70	70	60
	Mean	362	347	198	188	155	153	127	125	115	113	97	97	97	83	83	82	82	78
4	13	335	330	200	190	155	155	150	145	140	140	130	130	130	130	130	130	130	125
	62	400	390	285	265	235	230	215	215	190	190	180	175	175	170	170	165	165	160
	111	355	345	245	230	200	190	175	175	165	165	150	150	150	140	140	135	135	130
	Mean	363	355	243	228	197	192	180	178	165	165	153	152	152	147	147	143	143	138
Decreasing:																			
6	15	350	335	290	285	240	235	205	200	170	165	130	130	130	130	130	125	125	125
	43	370	350	315	290	255	250	195	195	170	170	130	130	130	130	130	130	130	125
	81	360	345	315	310	260	255	210	210	175	175	125	125	125	120	120	120	120	115
	Mean	360	343	307	295	252	247	203	202	172	170	128	128	128	127	127	125	125	122
8	14	340	330	290	290	245	245	225	220	195	190	150	150	150	150	150	145	145	130
	53	360	350	345	315	310	305	285	275	270	265	230	225	225	215	215	190	190	185
	73	355	355	305	270	270	270	260	255	210	210	180	180	180	175	175	160	160	155
	Mean	352	345	313	292	275	273	257	250	225	222	187	185	185	180	180	165	165	157
Unthinned	22	1,340	1,325	1,325	1,240	1,240	1,145	1,145	1,055	1,055	990	990	810	810	660	650	555	550	440
	25	1,385	1,375	1,375	1,355	1,355	1,270	1,270	1,125	1,125	985	985	790	790	655	655	570	570	480
	71	1,105	1,055	1,055	1,030	1,030	955	955	865	865	745	745	665	665	450	450	390	370	315
	Mean	1,277	1,252	1,252	1,208	1,208	1,123	1,123	1,015	1,015	907	907	755	755	588	588	498	498	412

[a] Before cut.
[b] After cut.

Table 5a—Live basal area per acre (excluding ingrowth) by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)[a]	1970 (23)[b]	1970 (23)	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Square feet per acre																	
1	21	45.7	79.2	54.0	79.1	59.3	87.4	64.5	81.2	66.6	85.7	68.3	85.2	85.2	107.2	107.2	127.2	127.2	154.2
	33	44.0	79.5	53.1	76.9	56.0	84.9	64.5	82.0	63.0	81.0	68.0	86.6	86.6	107.5	107.5	125.3	125.3	152.3
	51	Deleted - root disease																	
	Mean	44.8	79.3	53.6	75.0	57.6	86.2	64.5	81.6	64.8	83.4	68.2	85.9	85.9	107.4	107.4	126.2	126.2	153.2
3	31	43.9	75.0	61.9	87.1	73.9	105.8	92.6	115.2	100.4	125.3	110.5	136.4	136.4	161.2	161.2	187.9	187.9	224.1
	42	51.0	88.7	62.2	86.8	69.3	100.7	92.9	114.5	100.6	121.9	104.7	129.5	129.5	160.1	160.1	181.6	181.6	213.3
	52	44.0	75.9	61.6	84.2	72.8	100.0	86.7	104.7	104.7	130.2	104.4	127.6	127.6	150.1	150.1	173.5	173.5	208.6
	Mean	46.3	79.9	61.9	86.0	72.0	102.1	90.7	111.5	101.9	125.8	106.5	131.1	131.1	157.1	157.1	181.0	181.0	215.3
5	12	48.2	82.5	71.4	101.6	92.3	129.1	122.1	147.5	134.2	160.0	141.1	169.1	169.1	201.2	201.2	227.2	227.2	264.9
	41	51.1	85.8	71.3	102.3	91.0	128.7	121.9	148.3	135.1	161.5	142.2	171.1	171.1	207.2	207.2	234.4	234.4	272.8
	72	46.5	79.4	71.3	95.3	90.6	118.1	118.1	140.2	135.4	157.0	141.8	168.6	168.6	185.1	185.1	203.9	203.9	238.8
	Mean	48.6	82.6	71.3	99.7	91.3	125.3	120.7	145.3	134.9	159.5	141.7	169.6	169.6	197.8	197.8	221.8	221.8	258.9
7	11	52.2	88.5	81.3	114.6	107.6	147.3	147.3	173.1	169.1	198.9	179.5	209.1	209.1	239.7	239.7	268.3	268.3	305.2
	23	46.8	81.3	79.5	109.6	107.5	144.0	144.0	170.5	169.1	195.1	179.5	208.6	208.6	225.0	225.0	252.1	252.1	278.6
	63	48.7	81.4	81.4	102.7	102.7	136.4	136.4	158.1	158.1	183.8	178.6	206.0	206.0	237.5	237.5	260.0	260.0	278.5
	Mean	49.2	83.7	80.7	108.9	105.9	142.6	142.6	167.2	165.4	192.6	179.2	207.9	207.9	234.0	234.0	260.1	260.1	287.4

[a] Before cut.
[b] After cut.

Table 5b—Live basal area per acre (excluding ingrowth) by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treatments

		Calibration period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)[a]	1970 (23)[b]	1970 (23)	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Square feet per acre																	
Increasing:																			
2	82	49.3	88.1	52.5	74.5	60.0	89.1	77.9	97.2	88.3	109.7	99.3	123.3	123.3	118.9	118.9	137.5	137.5	167.9
	91	45.0	77.2	51.2	67.1	61.7	92.8	74.6	89.2	89.2	112.4	98.7	123.4	123.4	146.6	146.6	164.0	164.0	197.1
	101	52.1	88.0	51.1	75.0	60.7	87.7	80.2	98.9	89.2	107.1	95.8	118.1	118.1	121.9	121.9	140.4	140.4	138.4
	Mean	48.8	84.4	51.6	72.2	60.8	89.9	77.5	95.1	88.9	109.7	97.9	121.6	121.6	129.1	129.1	147.3	147.3	167.8
4	13	51.8	90.6	61.8	85.4	74.6	108.5	106.0	125.5	123.0	147.3	135.9	163.6	163.6	193.6	193.6	218.8	218.8	244.6
	62	47.3	83.5	64.8	90.0	82.1	115.9	107.2	130.6	118.6	144.6	138.4	166.7	166.7	198.0	198.0	220.5	220.5	255.9
	111	50.1	85.3	64.0	85.9	76.3	109.0	102.9	126.7	120.7	148.2	137.0	164.2	164.2	187.8	187.8	208.9	208.9	238.0
	Mean	49.7	86.5	63.5	87.1	77.7	111.1	105.4	127.6	120.8	146.7	137.1	164.8	164.8	193.1	193.1	216.1	216.1	246.2
Decreasing:																			
6	15	46.3	80.6	72.0	102.3	86.8	121.7	105.6	126.1	110.8	131.7	110.3	135.5	135.5	166.8	166.8	189.5	189.5	224.5
	43	45.9	79.1	71.5	96.1	87.9	125.4	99.6	122.9	109.5	134.6	109.5	136.0	136.0	170.4	170.4	195.6	195.6	228.6
	81	43.9	77.5	72.1	101.7	86.8	122.3	104.7	128.9	112.5	137.6	109.4	134.8	134.8	162.8	162.8	189.2	189.2	216.7
	Mean	45.4	79.0	71.9	100.0	87.2	123.1	103.3	125.9	111.0	134.6	109.7	135.4	135.4	166.7	166.7	191.4	191.4	223.3
8	14	51.7	89.7	80.8	115.7	104.0	144.4	135.9	159.6	144.9	171.0	146.9	176.9	176.9	209.5	209.5	235.2	235.2	266.9
	53	46.4	82.9	81.6	103.0	101.7	137.2	127.8	148.4	144.8	167.5	146.5	171.9	171.9	201.8	201.8	212.4	212.4	241.4
	73	49.5	87.6	80.4	102.3	102.3	141.1	137.9	161.4	144.5	166.6	146.8	173.4	173.4	200.9	200.9	209.7	209.7	240.9
	Mean	49.2	86.7	80.9	107.0	102.6	140.9	133.9	156.5	144.8	168.3	146.8	174.1	174.1	204.1	204.1	219.1	219.1	249.8
Unthinned	22	97.3	146.0	146.0	180.7	180.7	220.6	220.6	241.8	241.8	263.8	263.8	268.1	268.1	277.5	277.5	288.8	288.8	300.0
	25	90.7	141.1	141.1	181.2	181.2	225.4	225.4	241.9	241.9	260.4	260.4	272.4	272.4	286.5	286.5	302.7	302.7	324.6
	71	71.0	113.9	113.9	148.6	148.6	179.5	179.5	199.1	199.1	214.3	214.3	231.6	231.6	205.6	205.6	220.4	220.4	239.4
	Mean	86.4	133.7	133.7	170.2	170.2	208.5	208.5	227.6	227.6	246.2	246.2	257.4	257.4	256.5	256.5	270.6	270.6	288.0

[a] Before cut
[b] After cut

Table 6a—Quadratic mean diameter (QMD) of live trees (excluding ingrowth) by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
										Inches									
1	21	4.9	6.4	6.9	8.3	8.7	10.5	10.9	12.2	12.4	14.0	14.5	16.1	16.1	18.1	18.1	19.7	19.7	21.7
	33	4.7	6.4	6.6	8.1	8.3	10.2	10.4	11.7	12.0	13.6	13.9	15.6	15.6	17.4	17.4	18.8	18.8	20.7
	51	Deleted - root disease																	
	Mean	4.8	6.4	6.8	8.2	8.5	10.4	10.6	12.0	12.2	13.8	14.2	15.8	15.8	17.8	17.8	19.2	19.2	21.2
3	31	4.8	6.3	6.4	7.7	7.8	9.4	9.6	10.7	10.7	12.0	12.3	13.6	13.6	15.4	15.4	16.6	16.6	18.1
	42	5.3	7.0	7.3	8.7	8.8	10.6	10.8	12.0	12.1	13.4	13.9	15.4	15.4	17.1	17.1	18.2	18.2	19.8
	52	4.8	6.4	6.7	8.2	8.4	10.1	10.1	11.3	11.3	12.6	13.2	14.9	14.9	17.0	17.0	18.3	18.3	20.1
	Mean	4.9	6.6	6.8	8.2	8.3	10.0	10.2	11.3	11.4	12.7	13.1	14.6	14.6	16.5	16.5	17.7	17.7	19.3
5	12	5.1	6.7	6.9	8.2	8.6	10.1	10.2	11.2	11.2	12.3	12.5	13.7	13.7	15.0	15.0	16.1	16.1	17.7
	41	5.3	6.9	7.2	8.6	8.7	10.4	10.4	11.5	11.6	12.7	12.8	14.0	14.0	15.4	15.4	16.4	16.4	18.0
	72	4.9	6.5	6.6	7.8	7.8	9.1	9.1	9.9	10.0	11.0	11.1	12.1	12.1	13.2	13.2	14.4	14.4	15.6
	Mean	5.1	6.7	6.9	8.2	8.4	9.9	9.9	10.9	10.9	12.0	12.1	13.3	13.3	14.5	14.5	15.6	15.6	17.1
7	11	5.3	6.9	7.0	8.3	8.4	9.8	9.8	10.6	10.8	11.7	11.8	12.9	12.9	14.0	14.0	15.0	15.0	16.3
	23	4.9	6.6	6.5	7.7	7.8	9.2	9.2	10.0	10.1	10.9	11.0	11.9	11.9	13.1	13.1	14.2	14.2	15.6
	63	4.8	6.5	6.5	7.8	7.8	9.1	9.1	10.0	10.0	10.9	10.9	11.9	11.9	13.1	13.1	14.1	14.1	16.0
	Mean	5.0	6.7	6.7	7.9	8.0	9.4	9.4	10.2	10.3	11.2	11.3	12.3	12.3	13.4	13.4	14.4	14.4	16.0

[a] Before cut.

[b] After cut.

Table 6b—Quadratic mean diameter of live trees (excluding ingrowth) by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treatments

		Calibration period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Inches																	
Increasing:																			
2	82	5.0	6.7	6.9	8.4	8.6	10.4	10.7	11.9	12.1	13.5	13.8	15.4	15.4	17.0	17.0	18.3	18.3	20.3
	91	4.7	6.4	6.6	8.0	8.0	9.9	10.1	11.2	11.2	12.6	12.8	14.3	14.3	16.0	16.0	17.3	17.3	19.0
	101	5.2	6.9	7.2	8.7	8.9	10.9	11.1	12.3	12.5	14.0	14.4	16.0	16.0	17.9	17.9	19.2	19.2	20.6
	Mean	5.0	6.7	6.9	8.4	8.5	10.4	10.6	11.8	11.9	13.4	13.7	15.2	15.2	17.0	17.0	18.3	18.3	19.9
4	13	5.3	7.1	7.5	9.1	9.4	11.3	11.4	12.6	12.7	13.9	13.8	15.2	15.2	16.5	16.5	17.6	17.6	18.9
	62	4.7	6.3	6.5	7.9	8.0	9.6	9.6	10.6	10.7	11.8	11.9	13.2	13.2	14.6	14.6	15.7	15.7	17.1
	111	5.1	6.7	6.9	8.3	8.4	10.3	10.4	11.5	11.6	12.8	12.9	14.2	14.2	15.7	15.7	16.8	16.8	18.3
	Mean	5.0	6.7	7.0	8.4	8.6	10.4	10.4	11.6	11.7	12.8	12.9	14.2	14.2	15.6	15.6	16.7	16.7	18.1
Decreasing:																			
6	15	4.9	6.6	6.7	8.1	8.1	9.7	9.7	10.8	10.9	12.1	12.5	13.8	13.8	15.3	15.3	16.7	16.7	18.1
	43	4.8	6.4	6.5	7.8	8.0	9.6	9.7	10.7	10.9	12.0	12.4	13.9	13.9	15.5	15.5	16.6	16.6	18.3
	81	4.7	6.4	6.5	7.8	7.8	9.4	9.6	10.6	10.9	12.0	12.7	14.1	14.1	15.8	15.8	17.0	17.0	18.6
	Mean	4.8	6.5	6.6	7.9	8.0	9.6	9.7	10.7	10.9	12.1	12.5	13.9	13.9	15.5	15.5	16.8	16.8	18.3
8	14	5.3	7.1	7.1	8.6	8.8	10.4	10.5	11.5	11.7	12.8	13.4	14.7	14.7	16.0	16.0	17.2	17.2	19.4
	53	4.9	6.6	6.6	7.7	7.8	9.1	9.1	9.9	9.9	10.8	10.8	11.8	11.8	13.1	13.1	14.3	14.3	15.5
	73	5.1	6.7	7.0	8.3	8.3	9.8	9.9	10.8	11.2	12.1	12.2	13.3	13.3	14.5	14.5	15.5	15.5	16.9
	Mean	5.1	6.8	6.9	8.2	8.3	9.8	9.8	10.8	10.9	11.9	12.1	13.3	13.3	14.5	14.5	15.7	15.7	17.3
Unthinned	22	3.6	4.5	4.5	5.2	5.2	5.9	5.9	6.5	6.5	7.0	7.0	7.8	7.8	8.8	8.8	9.8	9.8	11.2
	25	3.5	4.3	4.3	4.9	4.9	5.7	5.7	6.3	6.3	7.0	7.0	7.9	7.9	9.0	9.0	9.9	9.9	11.1
	71	3.4	4.4	4.4	5.1	5.1	5.8	5.8	6.5	6.5	7.2	7.2	8.0	8.0	9.1	9.1	10.4	10.2	11.8
	Mean	3.5	4.4	4.4	5.1	5.1	5.8	5.8	6.4	6.4	7.1	7.1	7.9	7.9	9.0	9.0	10.0	9.9	11.4

[a] Before cut.
[b] After cut.

Table 7a—Live cubic-foot volume of total stem (CVTS) per acre, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Cubic feet per acre																	
1	21	645	1,439	998	1,658	1,262	2,191	1,630	2,295	1,888	2,674	2,149	3,065	3,065	4,218	4,218	5,331	5,331	7,271
	33	617	1,454	982	1,615	1,192	2,097	1,618	2,313	1,788	2,506	2,123	3,083	3,083	4,223	4,223	5,335	5,335	7,250
	51	Deleted - root disease																	
	Mean	631	1,446	990	1,636	1,227	2,144	1,624	2,304	1,838	2,590	2,136	3,074	3,074	4,220	4,220	5,333	5,333	7,260
3	31	615	1,374	1,145	1,853	1,578	2,669	2,343	3,296	2,880	3,980	3,529	4,971	4,971	6,439	6,439	8,214	8,214	10,807
	42	741	1,696	1,208	1,914	1,532	2,616	2,419	3,332	2,922	3,939	3,390	4,837	4,837	6,375	6,375	7,888	7,888	10,240
	52	604	1,395	1,142	1,782	1,544	2,514	2,169	2,933	2,933	4,064	3,273	4,557	4,557	5,799	5,799	7,311	7,311	9,797
	Mean	653	1,489	1,165	1,849	1,551	2,600	2,310	3,187	2,912	3,994	3,398	4,788	4,788	6,204	6,204	7,804	7,804	10,281
5	12	735	1,609	1,404	2,308	2,119	3,467	3,283	4,440	4,040	5,347	4,732	6,466	6,466	8,482	8,482	10,312	10,312	13,408
	41	778	1,659	1,389	2,301	2,052	3,383	3,208	4,385	3,993	5,327	4,692	6,453	6,453	8,495	8,495	10,347	10,347	13,362
	72	702	1,525	1,379	2,114	2,011	3,081	3,081	4,087	3,950	5,201	4,721	6,383	6,383	7,694	7,694	9,207	9,207	12,064
	Mean	738	1,598	1,391	2,241	2,061	3,310	3,191	4,304	3,994	5,292	4,715	6,434	6,434	8,224	8,224	9,955	9,955	12,945
7	11	787	1,692	1,556	2,543	2,391	3,889	3,889	5,173	5,065	6,546	5,910	7,869	7,869	9,896	9,896	11,879	11,879	15,151
	23	705	1,550	1,515	2,424	2,381	3,807	3,807	5,064	5,024	6,400	5,886	7,842	7,842	9,330	9,330	11,225	11,225	13,949
	63	733	1,552	1,552	2,285	2,285	3,598	3,598	4,703	4,703	6,095	5,919	7,772	7,772	9,930	9,930	11,713	11,713	14,174
	Mean	742	1,598	1,541	2,417	2,352	3,765	3,765	4,980	4,931	6,347	5,905	7,828	7,828	9,719	9,719	11,606	11,606	14,425

[a] Before cut.

[b] After cut.

Table 7b—Live cubic-foot volume of total stem (CVTS) per acre, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treatments

		Calibration period		Treatment										Postreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Cubic feet per acre																	
Increasing:																			
2	82	763	1,735	1,045	1,699	1,377	2,391	2,117	2,871	2,620	3,686	3,351	4,692	4,692	5,005	5,005	6,294	6,294	8,388
	91	673	1,485	996	1,482	1,360	2,352	1,874	2,533	2,533	3,584	3,149	4,447	4,447	5,903	5,903	7,082	7,082	9,374
	101	811	1,734	1,016	1,693	1,373	2,309	2,123	2,895	2,612	3,490	3,124	4,366	4,366	5,007	5,007	6,234	6,234	6,773
	Mean	749	1,651	1,019	1,625	1,370	2,351	2,038	2,766	2,589	3,587	3,208	4,502	4,502	5,305	5,305	6,537	6,537	8,178
4	13	819	1,824	1,263	1,941	1,703	2,852	2,789	3,715	3,653	4,832	4,459	6,034	6,034	7,954	7,954	9,756	9,756	12,030
	62	709	1,611	1,266	1,975	1,806	2,985	2,748	3,778	3,435	4,678	4,478	6,114	6,114	8,040	8,040	9,740	9,740	12,531
	111	797	1,727	1,312	1,982	1,767	2,969	2,809	3,868	3,695	5,058	4,678	6,298	6,298	8,039	8,039	9,627	9,627	12,082
	Mean	775	1,721	1,280	1,966	1,759	2,935	2,782	3,787	3,594	4,856	4,538	6,149	6,149	8,011	8,011	9,708	9,708	12,214
Decreasing:																			
6	15	661	1,484	1,331	2,162	1,834	3,046	2,634	3,551	3,122	4,140	3,481	4,895	4,895	6,623	6,623	8,171	8,171	10,830
	43	638	1,437	1,302	2,006	1,843	3,128	2,481	3,467	3,093	4,238	3,485	4,961	4,961	6,809	6,809	8,537	8,537	11,264
	81	616	1,423	1,328	2,152	1,843	3,073	2,640	3,697	3,243	4,401	3,526	4,941	4,941	6,549	6,549	8,247	8,247	10,505
	Mean	638	1,448	1,321	2,107	1,840	3,082	2,585	3,571	3,153	4,260	3,497	4,932	4,932	6,661	6,661	8,318	8,318	10,866
8	14	808	1,747	1,582	2,588	2,342	3,754	3,540	4,641	4,222	5,560	4,801	6,635	6,635	8,635	8,635	10,570	10,570	13,408
	53	700	1,588	1,562	2,226	2,199	3,444	3,208	4,184	4,080	5,271	4,605	6,260	6,260	8,068	8,068	9,321	9,321	11,837
	73	784	1,730	1,605	2,328	2,328	3,749	3,667	4,776	4,314	5,508	4,870	6,611	6,611	8,399	8,399	9,442	9,442	12,049
	Mean	764	1,688	1,583	2,381	2,290	3,649	3,472	4,534	4,205	5,446	4,758	6,502	6,502	8,368	8,368	9,778	9,778	12,431
Unthinned	22	1,336	2,641	2,641	3,845	3,845	5,606	5,606	6,941	6,941	8,433	8,433	9,745	9,745	10,940	10,940	12,427	12,427	14,313
	25	1,220	2,509	2,509	3,793	3,793	5,640	5,640	6,809	6,809	8,245	8,245	9,847	9,847	11,269	11,269	12,962	12,962	15,378
	71	943	2,013	2,013	3,094	3,094	4,441	4,441	5,558	5,558	6,751	6,751	8,299	8,299	7,999	7,999	9,515	9,515	11,373
	Mean	1,167	2,388	2,388	3,577	3,577	5,229	5,229	6,436	6,436	7,810	7,810	9,297	9,297	10,069	10,069	11,634	11,634	13,688

[a] Before cut.

[b] After cut.

Table 8a—Live merchantable cubic-foot volume to 6-inch top (CV6) per acre, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Cubic feet per acre																	
1	21	24	412	345	995	814	1,781	1,359	2,032	1,680	2,468	1,997	2,890	2,890	4,011	4,011	5,087	5,087	6,955
	33	28	388	289	920	707	1,654	1,293	2,004	1,572	2,304	1,959	2,904	2,904	4,016	4,016	5,091	5,091	6,938
	51	Deleted - root disease																	
	Mean	26	400	317	958	760	1,718	1,326	2,018	1,626	2,386	1,978	2,897	2,897	4,014	4,014	5,089	5,089	6,946
3	31	24	383	346	988	852	1,950	1,743	2,713	2,377	3,496	3,135	4,564	4,564	6,047	6,047	7,774	7,774	10,283
	42	50	614	511	1,243	1,009	2,128	2,009	2,935	2,586	3,600	3,135	4,552	4,552	6,056	6,056	7,519	7,519	9,789
	52	23	414	377	1,031	933	1,966	1,701	2,499	2,499	3,641	2,980	4,259	4,259	5,498	5,498	6,961	6,961	9,359
	Mean	32	470	411	1,087	931	2,015	1,818	2,716	2,487	3,579	3,083	4,458	4,458	5,867	5,867	7,418	7,418	9,810
5	12	58	578	546	1,405	1,342	2,730	2,602	3,773	3,433	4,736	4,226	5,927	5,927	7,902	7,902	9,706	9,706	12,715
	41	68	618	555	1,450	1,323	2,706	2,585	3,781	3,449	4,786	4,228	5,961	5,961	7,970	7,970	9,770	9,770	12,711
	72	16	421	415	1,093	1,047	2,165	2,165	3,170	3,071	4,351	3,993	5,633	5,633	6,983	6,983	8,535	8,535	11,308
	Mean	47	539	505	1,316	1,237	2,534	2,450	3,575	3,318	4,624	4,149	5,840	5,840	7,619	7,619	9,337	9,337	12,245
7	11	61	655	629	1,564	1,492	2,988	2,988	4,250	4,191	5,674	5,148	7,087	7,087	9,103	9,103	11,052	11,052	14,251
	23	42	492	474	1,266	1,259	2,699	2,699	3,926	3,910	5,301	4,913	6,816	6,816	8,432	8,432	10,336	10,336	13,057
	63	19	391	391	1,163	1,163	2,506	2,506	3,635	3,635	5,048	4,914	6,785	6,785	8,966	8,966	10,775	10,775	13,348
	Mean	41	513	498	1,331	1,304	2,731	2,731	3,937	3,912	5,341	4,992	6,896	6,896	8,834	8,834	10,721	10,721	13,552

[a] Before cut.
[b] After cut.

Table 8b—Live merchantable cubic-foot volume to 6-inch top (CV6) per acre, ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treatments

		Calibration Period		Treatment										Posttreatment					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Cubic feet per acre																	
Increasing:																			
2	82	31	575	371	1,039	881	1,941	1,754	2,533	2,328	3,390	3,103	4,421	4,421	4,758	4,758	6,005	6,005	8,026
	91	19	375	279	813	745	1,793	1,459	2,152	2,152	3,219	2,849	4,136	4,136	5,572	5,572	6,726	6,726	8,942
	101	47	643	417	1,105	927	1,930	1,791	2,579	2,343	3,235	2,914	4,128	4,128	4,770	4,770	5,956	5,956	6,482
	Mean	32	531	356	986	851	1,888	1,668	2,421	2,275	3,282	2,955	4,228	4,228	5,033	5,033	6,229	6,229	7,817
4	13	97	804	628	1,363	1,235	2,439	2,393	3,338	3,292	4,462	4,115	5,659	5,659	7,528	7,528	9,272	9,272	11,472
	62	3	356	333	1,061	987	2,235	2,044	3,085	2,837	4,094	3,928	5,576	5,576	7,496	7,496	9,169	9,169	11,893
	111	26	568	472	1,193	1,084	2,363	2,262	3,340	3,200	4,573	4,240	5,837	5,837	7,564	7,564	9,127	9,127	11,508
	Mean	42	576	477	1,206	1,102	2,346	2,233	3,254	3,109	4,376	4,094	5,691	5,691	7,529	7,529	9,189	9,189	11,624
Decreasing:																			
6	15	45	498	474	1,256	1,079	2,307	1,990	2,926	2,606	3,637	3,102	4,489	4,489	6,186	6,186	7,707	7,707	10,280
	43	12	388	357	1,030	990	2,325	1,866	2,864	2,579	3,740	3,119	4,580	4,580	6,403	6,403	8,079	8,079	10,727
	81	9	362	348	1,088	957	2,222	1,953	3,013	2,690	3,857	3,166	4,565	4,565	6,164	6,164	7,817	7,817	10,009
	Mean	22	416	393	1,124	1,009	2,285	1,936	2,935	2,625	3,745	3,129	4,545	4,545	6,251	6,251	7,868	7,868	10,339
8	14	80	763	692	1,663	1,554	3,009	2,867	3,984	3,647	4,990	4,375	6,164	6,164	8,110	8,110	9,999	9,999	12,792
	53	18	500	493	1,169	1,162	2,398	2,223	3,226	3,136	4,339	3,801	5,444	5,444	7,301	7,301	8,625	8,625	11,094
	73	47	607	597	1,434	1,434	2,866	2,829	3,951	3,670	4,855	4,315	6,016	6,016	7,794	7,794	8,855	8,855	11,391
	Mean	48	623	594	1,422	1,383	2,758	2,640	3,721	3,484	4,728	4,164	5,875	5,875	7,735	7,735	9,160	9,160	11,759
Unthinned	22	25	347	347	1,091	1,091	2,489	2,489	3,717	3,717	5,152	5,152	6,940	6,940	8,740	8,740	10,571	10,571	12,844
	25	37	386	386	1,049	1,049	2,374	2,374	3,474	3,474	4,963	4,963	6,885	6,885	8,884	8,884	10,890	10,890	13,535
	71	24	293	293	926	926	1,991	1,991	3,049	3,049	4,338	4,338	6,038	6,038	6,544	6,544	8,150	8,150	10,149
	Mean	29	342	342	1,022	1,022	2,285	2,285	3,413	3,413	4,817	4,817	6,621	6,621	8,056	8,056	9,870	9,870	12,176

[a] Before cut.

[b] After cut.

Table 9—Percentage of merchantable cubic-foot volume (CV6) in material larger than indicated log-top diameter, for live trees present in 2006

Treatment	Scaling diameter (inches)						Total live CV6
	6	8	10	12	14	16	
	Percent						*Ft³/ac*
Fixed:							
1	100	92.2	85.4	74.3	60.0	33.2	6,946
3	100	88.8	81.2	67.7	44.5	18.1	9,810
5	100	87.2	72.6	52.4	27.7	9.6	12,245
7	100	83.3	66.0	43.7	20.4	5.0	13,552
Increasing:							
2	100	92.4	81.4	70.8	49.5	20.1	7,817
4	100	88.6	77.7	59.2	31.5	11.1	11,624
Decreasing:							
6	100	88.9	79.3	64.4	37.8	10.8	10,339
8	100	86.5	71.6	52.7	29.3	8.0	11,759
Unthinned	100	68.8	42.2	19.0	2.8	0.7	12,176

Table 10a—Live Scribner board-foot volume per acre to 6-inch top (SV6), ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for fixed treatments

		Calibration period		Treatment										Posttreament					
				Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
		Board feet per acre																	
1	21	0	431	431	3,079	2,510	5,624	4,286	6,551	5,448	8,693	7,137	11,259	11,259	16,978	16,978	22,985	22,985	35,500
	33	0	506	375	2,712	2,106	5,294	4,023	6,707	5,353	8,194	7,090	11,278	11,278	16,578	16,578	23,022	23,022	33,324
	51	Deleted - root disease																	
	Mean	0	468	403	2,896	2,302	5,459	4,154	6,629	5,400	8,484	7,114	11,268	11,268	16,778	16,778	23,004	23,004	34,412
3	31	0	231	231	2,860	2,473	6,601	5,969	9,454	8,195	12,923	11,480	19,013	19,013	25,427	25,427	35,137	35,137	49,087
	42	0	1,024	912	4,153	3,254	6,919	6,544	9,406	8,227	13,601	11,806	18,267	18,267	25,002	25,002	34,076	34,076	46,629
	52	0	468	468	2,941	2,798	6,580	5,691	8,365	8,365	13,499	11,166	16,659	16,659	22,556	22,556	31,940	31,940	44,703
	Mean	0	575	537	3,318	2,841	6,700	6,068	9,075	8,262	13,341	11,484	17,980	17,980	24,328	24,328	33,718	33,718	46,806
5	12	0	1,205	1,205	4,649	4,518	9,611	9,197	13,214	12,099	18,618	16,688	25,168	25,168	34,796	34,796	45,346	45,346	61,181
	41	0	1,155	1,155	4,699	4,356	9,451	8,919	12,868	11,752	18,546	16,327	25,082	25,082	34,925	34,925	44,586	44,586	60,904
	72	0	525	525	3,210	3,091	7,831	7,831	11,728	11,352	16,864	15,486	24,293	24,293	31,342	31,342	38,758	38,758	53,645
	Mean	0	962	962	4,186	3,988	8,964	8,649	12,603	11,734	18,009	16,167	24,848	24,848	33,687	33,687	42,897	42,897	58,577
7	11	0	706	706	5,317	4,993	10,107	10,107	14,336	14,085	22,011	20,119	30,188	30,188	39,962	39,962	50,381	50,381	67,463
	23	0	931	931	4,018	4,018	9,674	9,674	14,470	14,470	20,812	19,445	29,999	29,999	37,354	37,354	47,950	47,950	62,262
	63	0	318	318	3,560	3,560	8,963	8,963	12,951	12,951	20,721	20,095	30,029	30,029	40,294	40,294	49,255	49,255	63,357
	Mean	0	652	652	4,298	4,190	9,581	9,581	13,919	13,835	21,181	19,886	30,072	30,072	39,203	39,203	49,195	49,195	64,360

[a] Before cut.

[b] After cut.

Table 10b—Live Scribner board-foot volume per acre to 6-inch top (SV6), ingrowth excluded, by treatment, plot, measurement date, and age (in parentheses), for variable and unthinned treaments

				Treatment										Posttreatment					
		Calibration Period		Period 1		Period 2		Period 3		Period 4		Period 5		Period 6		Period 7		Period 8	
Treatment	Plot	1966 (19)	1970 (23)[a]	1970 (23)[b]	1973 (26)	1973 (26)	1977 (30)	1977 (30)	1980 (33)	1980 (33)	1984 (37)	1984 (37)	1989 (42)	1989 (42)	1994 (47)	1994 (47)	1999 (52)	1999 (52)	2006 (59)
										Board feet per acre									
Increasing:																			
2	82	0	899	362	3,855	3,342	6,802	6,095	8,242	7,666	12,794	11,671	17,894	17,894	20,485	20,485	27,969	27,969	38,373
	91	0	219	112	2,735	2,510	6,507	5,197	7,187	7,187	11,849	10,433	16,532	16,532	23,706	23,706	30,203	30,203	43,746
	101	0	924	575	3,324	2,899	6,346	5,827	8,595	7,767	12,275	11,064	16,386	16,386	21,100	21,100	27,928	27,928	31,005
	Mean	0	681	350	3,305	2,917	6,552	5,707	8,008	7,540	12,306	11,056	16,937	16,937	21,763	21,763	28,700	28,700	37,708
4	13	0	2,080	1,811	4,351	3,943	7,561	7,386	11,345	11,170	16,972	15,604	22,538	22,538	32,440	32,440	43,283	43,283	55,142
	62	0	125	125	3,436	3,299	8,121	7,508	10,771	9,737	15,417	14,841	23,678	23,678	32,117	32,117	41,312	41,312	55,108
	111	0	699	699	3,848	3,561	8,276	7,833	11,818	11,367	18,186	16,977	24,808	24,808	33,368	33,368	41,749	41,749	54,992
	Mean	0	968	878	3,878	3,601	7,986	7,576	11,311	10,758	16,858	15,807	23,675	23,675	32,642	32,642	42,115	42,115	55,081
Decreasing:																			
6	15	0	693	693	3,934	3,510	7,326	6,274	9,608	8,456	13,358	11,280	18,760	18,760	25,727	25,727	35,172	35,172	48,901
	43	0	200	100	3,079	3,079	8,052	6,466	9,793	8,770	13,792	11,449	19,212	19,212	26,665	26,665	36,862	36,862	51,427
	81	0	318	318	2,779	2,523	7,591	6,691	10,794	9,511	14,901	12,190	18,765	18,765	25,860	25,860	35,636	35,636	46,616
	Mean	0	404	371	3,264	3,037	7,656	6,477	10,065	8,912	14,017	11,640	18,912	18,912	26,084	26,084	35,890	35,890	48,981
8	14	0	1,911	1,699	5,530	5,224	9,956	9,423	12,614	11,535	19,737	17,206	25,351	25,351	35,753	35,753	46,718	46,718	61,496
	53	0	450	450	3,528	3,528	8,446	7,814	11,342	11,054	16,857	14,587	22,952	22,952	31,847	31,847	38,813	38,813	52,655
	73	0	962	962	4,974	4,974	9,970	9,851	13,541	12,558	18,989	17,078	25,421	25,421	34,042	34,042	41,294	41,294	53,353
	Mean	0	1,107	1,037	4,677	4,575	9,457	9,029	12,499	11,716	18,528	16,290	24,574	24,574	33,881	33,881	42,275	42,275	55,834
Unthinned	22	0	306	306	2,348	2,348	9,157	9,157	15,170	15,170	21,340	21,340	31,513	31,513	40,195	40,195	49,518	49,518	61,604
	25	0	649	649	2,985	2,985	8,007	8,007	12,729	12,729	20,635	20,635	31,034	31,034	40,823	40,823	51,062	51,062	64,221
	71	0	262	262	1,973	1,973	7,566	7,566	12,006	12,006	18,106	18,106	27,285	27,285	29,154	29,154	37,444	37,444	48,608
	Mean	0	406	406	2,436	2,436	8,244	8,244	13,302	13,302	20,027	20,027	29,944	29,944	36,724	36,724	46,008	46,008	58,144

[a] Before cut.
[b] After cut.

Table 11—Number, quadratic mean diameter, and basal area of live trees cut, by treatment, date, and age[a]

	Year (age)					
Treatment	**1970 (23)**	**1973 (26)**	**1977 (30)**	**1980 (33)**	**1984 (42)**	**Total**
			Trees per acre			
1	135	65	43	25	18	286
2	148	33	27	10	17	235
3	92	43	27	15	30	207
4	112	32	12	13	12	181
5	62	32	10	17	28	149
6	37	43	43	30	42	195
7	13	12	0	7	23	55
8	32	17	17	25	35	126
Unthinned	0	0	0	0	0	0
			Quadratic mean diameter (inches)			
1	5.9	7.6	9.6	11.1	12.4	8.0
2	6.4	8.0	9.2	10.7	11.3	7.6
3	6.0	7.7	8.8	10.8	10.9	8.0
4	6.1	7.4	9.4	9.8	12.3	7.4
5	5.8	6.9	9.2	10.6	10.8	8.0
6	6.0	7.4	9.2	9.6	10.4	8.7
7	6.5	6.8	0	7.1	10.3	8.4
8	5.8	6.8	8.7	9.3	10.6	8.6
Unthinned	0	0	0	0	0	0
			Basal area (square feet per acre)			
1	25.8	20.4	21.7	16.8	15.2	99.8
2	32.8	11.5	12.3	6.2	11.8	74.6
3	18.0	14.0	11.4	9.6	19.3	72.3
4	22.9	9.4	5.7	6.8	9.6	54.5
5	11.2	8.4	4.6	10.5	17.8	52.5
6	7.2	12.9	19.8	15.0	24.9	79.7
7	3.0	3.0	0	1.8	13.4	21.2
8	5.8	4.3	7.0	11.7	21.6	50.4
Unthinned	0	0	0	0	0	0

[a] Plot 51 excluded, ingrowth excluded.

Table 12—Cubic-foot volume of total stem (CVTS), merchantable cubic-foot (CV6), and Scribner (SV6) volumes of trees cut, by treatment and age (in parentheses)[a]

Treatment	Year (age) 1970 (23)	1973 (26)	1977 (30)	1980 (33)	1984 (42)	Total
	CVTS (cubic feet per acre)					
1	456	410	520	466	454	2,306
2	632	255	313	178	379	1,756
3	323	298	289	276	596	1,783
4	441	207	153	193	318	1,311
5	207	180	119	309	577	1,393
6	127	267	497	419	762	2,072
7	57	65	0	49	442	613
8	105	91	177	328	688	1,390
	CV6 (cubic feet to 6-inch top, per acre)					
1	83	197	391	392	408	1,471
2	175	135	220	146	327	1,003
3	59	156	197	229	496	1,136
4	98	104	112	145	282	741
5	34	79	83	257	475	927
6	23	115	348	310	616	1,412
7	15	26	0	24	349	415
8	29	39	118	237	564	987
	SV6 (Scribner board feet to 6-inch top, per acre)					
1	66	587	1,305	1,228	1,331	4,516
2	331	387	845	468	1,250	3,281
3	37	477	632	813	1,857	3,816
4	90	277	410	553	1,051	2,381
5	0	198	315	869	1,842	3,224
6	33	227	1,179	1,153	2,377	4,970
7	0	108	0	84	1,295	1,487
8	71	102	428	783	2,237	3,621

[a] Plot 51 excluded, ingrowth excluded.

Table 13—Percentage of merchantable cubic-foot volume (CV6) in trees removed in thinnings in material larger than indicated diameter

	Scaling diameter (inches)						
Treatment	**6**	**8**	**10**	**12**	**14**	**16**	**Total CV6**
	– – – – – – – – – – – – – – Percent – – – – – – – – – – – – –						*Ft^3/ac*
Fixed:							
1	100	70.2	56.6	46.0	32.6	14.2	1,471
3	100	59.7	43.5	32.2	21.2	7.6	1,136
5	100	65.8	51.0	30.2	11.6	4.9	927
7	100	55.6	33.8	22.9	13.2	0.0	415
Increasing:							
2	100	73.2	51.2	43.1	20.2	6.0	1,136
4	100	75.1	57.3	43.8	19.2	8.6	741
Decreasing:							
6	100	47.4	35.1	19.5	7.3	1.4	1,412
8	100	62.7	46.8	32.9	14.1	4.2	987

Table 14—Number, quadratic mean diameter, and basal area of dead trees recorded at end of period, by treatment, year, and age[a]

	Year (age)									
Treatment	**1970 (23)**	**1973 (26)**	**1977 (30)**	**1980 (33)**	**1984 (37)**	**1989 (42)**	**1994 (47)**	**1999 (53)**	**2006 (59)**	**Total**
					Trees per acre					
1	5	5	0	0	0	0	0	0	0	10
2	15	10	2	2	2	0	13	2	3	49
3	8	12	5	2	0	2	7	0	0	36
4	8	15	5	2	0	2	5	3	5	45
5	8	3	5	0	3	0	5	7	3	34
6	17	12	5	2	2	0	2	2	3	45
7	13	17	8	3	3	5	15	10	23	97
8	7	22	2	7	3	2	5	15	8	71
Unthinned	27	43	85	108	108	152	167	85	92	867
					Quadratic mean diameter (inches)					
1	3.4	6.8	0	0	0	0	0	0	0	5.4
2	5.0	7.7	5.8	10.3	10.1	0	15.5	12.4	21.3	11.3
3	4.5	6.5	8.4	8.7	0	10.5	12.3	0	0	8.0
4	4.9	6.9	5.5	10.0	0	5.6	11.8	9.8	14.5	8.6
5	4.9	8.2	7.5	0	6.7	0	12.4	8.4	10.3	8.5
6	4.2	6.3	6.6	8.3	11.4	0	10.6	5.4	14.4	7.1
7	4.8	6.6	7.5	8.9	6.2	6.3	10.3	8.4	9.7	8.2
8	4.4	7.7	5.9	6.5	8.0	7.6	9.3	10.0	11.3	8.4
Unthinned	2.5	2.9	3.2	3.5	3.8	4.7	6.3	5.4	6.3	4.8
					Basal area (square feet per acre)					
1	0.3	1.3	0	0	0	0	0	0	0	1.6
2	2.1	3.2	0.3	1.2	1.1	0	17.1	1.7	7.4	34.1
3	0.9	2.8	1.9	0.7	0	1.0	5.5	0	0	12.7
4	1.0	3.9	0.8	0.9	0	0.3	3.8	1.8	5.8	18.2
5	1.0	1.2	1.6	0	0.8	0	4.2	2.5	1.9	13.3
6	1.7	2.6	1.2	0.6	1.2	0	1.0	0.3	3.8	12.3
7	1.6	4.1	2.5	1.4	0.7	1.1	8.6	3.9	12.0	35.0
8	0.7	7.0	0.3	1.5	1.2	0.5	2.4	8.2	5.8	27.6
Unthinned	0.9	2.9	4.8	7.1	8.7	18.4	36.0	13.3	20.0	111.2

[a] Plot 51 excluded, ingrowth excluded, calibration period included.

Table 15—Cubic-foot total stem (CVTS), merchantable cubic-foot (CV6), and Scribner (SV6) board-foot volumes per acre of dead trees recorded at end of period, by treatment[a]

	Years (age)									
Treatment	**1970 (23)**	**1973 (26)**	**1977 (30)**	**1980 (33)**	**1984 (37)**	**1989 (42)**	**1994 (47)**	**1999 (52)**	**2006 (59)**	**Total**
					CVTS (cubic feet per acre)					
1	4.7	24.7	0	0	0	0	0	0	0	29.4
2	36.5	68.7	6.0	34.7	34.6	0	702.1	57.5	325.4	1,265.5
3	13.5	57.0	43.6	18.6	0	34.2	206.9	0	0	373.8
4	17.3	83.5	16.8	25.1	0	7.4	146.5	66.8	266.8	630.3
5	18.0	27.6	38.0	0	21.8	0	174.8	89.4	77.0	446.8
6	26.4	52.2	26.8	16.6	32.0	0	32.4	4.8	153.6	344.8
7	26.8	89.0	61.8	41.7	18.0	31.1	330.5	120.6	478.3	1,197.8
8	11.6	155.2	6.4	35.4	32.1	16.3	85.7	320.2	254.4	917.5
Unthinned	13.3	33.6	98.9	153.2	214.5	545.1	1,244.0	415.7	763.2	3,480.8
					CV6 (cubic feet to 6-inch top per acre)					
1	0	7.0	0	0	0	0	0	0	0	7.0
2	0.4	32.4	0	29.9	29.5	0	661.3	53.1	311.4	1,118.0
3	0	22.9	25.6	12.0	0	27.9	183.3	0	0	271.7
4	0	17.5	1.1	19.7	0	0	128.5	51.0	248.8	486.6
5	0.2	15.6	17.2	0	5.4	0	154.7	56.1	61.5	310.6
6	0	13.7	7.8	9.7	27.7	0	26.7	0	142.2	227.8
7	2.0	33.5	25.8	27.7	2.9	5.1	259.3	75.4	360.3	792.0
8	0	75.6	0	7.7	17.4	7.4	61.5	252.9	217.4	639.8
Unthinned	0	0	28.5	4.4	2.3	75.9	592.8	134.2	197.4	1,215.4
					SV6 (Scribner board feet to 6-inch top, per acre)					
1	0	0	0	0	0	0	0	0	0	0
2	0	42	0	96	96	0	2,940	205	1,464	4,842
3	0	92	60	54	0	96	798	0	0	1,100
4	0	135	0	84	0	0	560	265	1,124	2,168
5	0	46	52	0	0	0	715	286	313	1,412
6	0	37	37	46	84	0	96	0	661	962
7	0	110	96	123	0	0	1,185	361	1,753	3,629
8	0	268	0	0	62	42	316	1,171	1,045	2,904
Unthinned	0	0	96	0	0	296	2,688	657	2,130	5,867

[a] Plot 51 excluded, ingrowth excluded, calibration period included.

Table 16a—Stand development table for treatment 1 (plots 21 and 33), per-acre basis (ingrowth excluded), English units

		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* – – –	
1966	19	38	6.5	358	4.8	44.8	631	26	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	49	8.5	218	6.7	53.5	990	317	135	5.9	25.8	456	83	3.4	1.4	.92	5	3.5	.3	5	0
1973	26	57	10.2	148	8.5	57.7	1,227	761	65	7.6	20.4	410	197	6.3	3.4	.92	5	6.8	1.3	25	7
1977	30	66	12.2	105	10.6	64.5	1,624	1,326	43	9.7	21.7	520	391	12.1	9.1	.94	0	0	0	0	0
1980	33	74	13.5	80	12.2	64.8	1,838	1,626	25	11.1	16.8	466	392	18.6	15.7	.93	0	0	0	0	0
1984	37	82	15.2	63	14.2	68.2	2,136	1,978	18	12.6	15.2	454	408	25.2	22.7	.92	0	0	0	0	0
1989	42	96	17.0	63	15.9	85.9	3,074	2,897	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	106	19.0	63	17.8	107.4	4,221	4,013	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	52	115	20.7	63	19.3	126.2	5,333	5,089	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	59	132	22.9	63	21.2	153.2	7,261	6,947	0	0	0	0	0	0	0	0	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* – – – – – – – – –				– – – – – – – – *ft³* – – – – – – – – –			
1966	19	631	631	26	26	0	0	0	0	0	33	0	1	0	33	0	1
1970	23	1,446	1,451	400	400	.41	.40	8.6	8.7	204	63	94	17	205	63	94	17
1973	26	2,093	2,122	1,040	1,047	.49	.50	8.2	8.6	216	80	213	40	224	82	216	40
1977	30	3,010	3,040	1,997	2,004	.47	.47	7.1	7.1	229	100	239	67	229	101	239	67
1980	33	3,690	3,719	2,689	2,696	.44	.44	5.7	5.7	227	112	231	81	227	113	231	82
1984	37	4,442	4,471	3,449	3,456	.41	.41	4.6	4.6	188	120	190	93	188	121	190	93
1989	42	5,379	5,409	4,368	4,375	.35	.35	3.5	3.5	188	128	184	104	188	129	184	104
1994	47	6,526	6,556	5,484	5,491	.38	.38	4.3	4.3	229	139	223	117	229	139	223	117
1999	52	7,638	7,668	6,560	6,567	.30	.30	3.8	3.8	222	147	215	126	222	147	215	126
2006	59	9,566	9,596	8,418	8,425	.28	.28	3.9	3.9	275	162	265	143	275	163	265	143

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 2,306 cubic feet (24 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 25 cubic feet (0 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 16b—Stand development table for treatment 1 (plots 21, and 33), per-hectare basis (ingrowth excluded), metric units

		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*	*m²*	– – – *m³* – – –		*No.*	*cm*	*m²*	– – – – – – – – – *m³* – – – – – – – – –					*No.*	*cm*	*m²*	– – – *m³* – – –	
1966	19	11.5	16.5	883	12.2	10.3	44.1	1.8	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	14.9	21.7	537	17.1	12.3	69.3	22.2	333	15.0	5.9	31.9	5.8	0	0	.92	12	8.8	.1	.3	0
1973	26	17.3	25.8	364	21.5	13.2	85.9	53.2	161	19.2	4.7	28.7	13.8	.2	.1	.92	12	17.4	.3	1.7	.5
1977	30	20.0	31.0	259	27.0	14.8	113.7	92.8	105	24.6	5.0	36.4	27.4	.3	.3	.93	0	0	0	0	0
1980	33	22.6	34.4	198	31.0	14.9	128.6	113.8	62	28.2	3.9	32.6	27.4	.5	.4	.93	0	0	0	0	0
1984	37	25.1	38.5	154	36.0	15.7	149.5	138.4	43	32.1	3.5	31.8	28.5	.7	.7	.91	0	0	0	0	0
1989	42	29.2	43.1	154	40.4	19.7	215.1	202.7	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	32.4	48.2	154	45.1	24.7	295.3	280.8	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	52	35.1	52.5	154	48.9	29.0	373.2	356.1	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	59	40.3	58.1	154	53.9	35.2	508.0	486.1	0	0	0	0	0	0	0	0	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	– – – – – – – – – – *m³* – – – – – – – – – –				– – – – *cm* – – – –		– – – – *m²* – – – –		– *m³* –							
1966	19	44.1	44.1	1.8	1.8	0	0	0	0	0	2.3	0	0.1	0	2.3	0	0.1
1970	23	101.2	101.5	28.0	28.0	1.03	1.02	2.0	2.0	14.3	4.4	6.5	1.2	14.3	4.4	6.5	1.2
1973	26	146.4	148.5	72.8	73.3	1.26	1.26	1.9	2.0	15.1	5.6	14.9	2.8	15.7	5.7	15.1	2.8
1977	30	210.6	212.7	139.8	140.2	1.20	1.20	1.6	1.6	16.0	7.0	16.7	4.7	16.0	7.1	16.7	4.7
1980	33	258.2	260.2	188.2	188.6	1.12	1.12	1.3	1.3	15.9	7.8	16.1	5.7	15.9	7.9	16.1	5.7
1984	37	310.8	312.9	241.3	241.8	1.04	1.04	1.1	1.1	13.2	8.4	13.3	6.5	13.2	8.5	13.3	6.5
1989	42	376.4	378.5	305.7	306.2	.88	.88	.8	.8	13.1	9.0	12.9	7.3	13.1	9.0	12.9	7.3
1994	47	456.6	458.7	383.8	384.2	.95	.95	1.0	1.0	16.0	9.7	15.6	8.2	16.0	9.8	15.6	8.2
1999	52	534.5	536.5	459.0	459.5	.76	.76	.9	.9	15.6	10.3	15.1	8.8	15.6	10.3	15.1	8.8
2006	59	669.4	671.4	589.0	589.5	.71	.71	.9	.9	19.3	11.3	18.6	10.0	19.3	11.4	18.6	10.0

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 161.4 cubic meters (24 percent of the total gross yield at age 59); volume (CVTS) in mortality = 2.0 cubic meters (0 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 17a—Stand development table for treatment 2 (plots 82, 91, and 101), per acre basis (ingrowth excluded), English units

		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	CV
	Years	ft	in	No.	in	ft^2	ft^3		No.	in	ft^2	ft					No.	in	ft^2	ft^3	
1966	19	39	6.5	362	5.0	48.8	749	32	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	50	8.5	198	6.9	51.6	1,019	356	148	6.4	32.8	632	175	4.3	2.3	.95	15	5.0	2.1	36	0
1973	26	57	9.9	155	8.5	60.8	1,370	851	33	7.9	11.5	255	135	7.7	4.2	.95	10	7.7	3.2	69	32
1977	30	67	11.9	127	10.6	77.5	2,038	1,668	27	9.2	12.3	313	220	11.6	8.1	.89	2	5.8	.3	6	0
1980	33	75	13.2	115	11.9	88.9	2,589	2,275	10	10.7	6.2	178	146	17.8	14.6	.90	2	11.3	1.2	35	30
1984	37	85	14.7	97	13.7	97.9	3,208	2,955	17	11.4	11.8	379	327	22.3	19.2	.86	2	11.1	1.1	35	29
1989	42	99	16.5	97	15.2	121.6	4,502	4,228	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	111	18.3	83	17.0	129.1	5,305	5,033	0	0	0	0	0	0	0	0	13	15.3	17.1	702	661
1999	52	121	19.8	82	18.3	147.3	6,537	6,229	0	0	0	0	0	0	0	0	2	13.6	1.7	57	53
2006	59	136	21.7	78	19.9	167.8	8,178	7,817	0	0	0	0	0	0	0	0	3	20.2	7.4	325	311

		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	ft^3				in		ft^2		ft^3							
1966	19	749	749	32	32	0	0	0	0	0	39	0	2	0	39	0	2
1970	23	1,651	1,688	531	531	.43	.43	8.9	9.4	226	72	125	23	235	73	125	23
1973	26	2,257	2,362	1,161	1,194	.49	.51	6.9	7.9	202	87	210	45	225	91	221	46
1977	30	3,238	3,349	2,198	2,231	.48	.47	7.3	7.4	245	108	259	73	247	112	259	74
1980	33	3,966	4,112	2,951	3,014	.40	.41	5.9	6.2	243	120	251	89	254	125	261	91
1984	37	4,964	5,145	3,958	4,050	.36	.35	5.2	5.5	250	134	252	107	258	139	259	109
1989	42	6,258	6,438	5,231	5,323	.31	.31	4.7	4.7	259	149	255	125	259	153	255	127
1994	47	7,061	7,944	6,036	6,789	.35	.34	1.5	4.9	161	150	161	128	301	169	293	144
1999	52	8,293	9,233	7,232	8,038	.26	.26	3.6	4.0	246	159	239	139	258	178	250	155
2006	59	9,934	11,200	8,819	9,937	.24	.25	2.9	4.0	235	168	227	149	281	190	271	168

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,757 cubic feet (16 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 1,230 cubic feet (11 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 17b—Stand development table for treatment 2 (plots 82, 91, and 101), per hectare basis (ingrowth excluded), metric units

		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*	*m²*	– – – *m³* – – –		*No.*	*cm*	*m²*	– – – – – – – – – *m³* – – – – – – – – – –					*No.*	*cm*	*m²*	– – – *m³* – – –	
1966	19	11.9	16.6	893	12.6	11.2	52.4	2.2	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	15.1	21.6	490	17.6	11.9	71.3	24.9	366	16.2	7.5	44.2	12.2	.1	.1	.95	37	12.8	.5	2.6	0
1973	26	17.3	25.1	383	21.6	14.0	95.8	59.6	82	20.2	2.6	17.8	9.4	.2	.1	.95	25	19.5	.7	4.8	2.3
1977	30	20.4	30.2	313	26.9	17.8	142.6	116.7	66	23.4	2.8	21.9	15.4	.3	.2	.89	4	14.8	.1	.4	0
1980	33	23.0	33.5	284	30.3	20.4	181.1	159.2	25	27.1	1.4	12.4	10.2	.5	.4	.90	4	28.7	.3	2.4	2.1
1984	37	26.0	37.4	239	34.8	22.5	224.5	206.8	41	29.0	2.7	26.5	22.8	.6	.6	.86	4	28.2	.3	2.4	2.1
1989	42	30.2	41.9	239	38.7	27.9	315.0	295.9	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	33.8	46.6	206	43.1	29.6	371.2	352.2	0	0	0	0	0	0	0	0	33	38.9	3.9	49.1	46.3
1999	52	37.0	50.4	202	46.5	33.8	457.4	435.9	0	0	0	0	0	0	0	0	4	34.5	.4	4.0	3.7
2006	59	41.5	55.2	193	50.7	38.5	572.3	546.9	0	0	0	0	0	0	0	0	8	51.4	1.7	22.8	21.8

		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	– – – – – – – – – – *m³* – – – – – – – – – –				– – – *cm* – – –		– – – *m²* – – –		– – – – – – – – – – – – – – – – – – – *m³* – – – – – – – – – – – – – – – – – – –							
1966	19	52.4	52.4	2.2	2.2	0	0	0	0	0	2.8	0	0.1	0	2.8	0	0.1
1970	23	115.5	118.1	37.1	37.2	1.08	1.09	2.0	2.2	15.8	5.0	8.7	1.6	16.4	5.1	8.7	1.6
1973	26	157.9	165.3	81.2	83.5	1.24	1.29	1.6	1.8	14.1	6.1	14.7	3.1	15.7	6.4	15.5	3.2
1977	30	226.6	234.3	153.8	156.1	1.21	1.19	1.7	1.7	17.2	7.6	18.1	5.1	17.3	7.8	18.1	5.2
1980	33	277.5	287.7	206.5	210.9	1.03	1.04	1.3	1.4	17.0	8.4	17.6	6.3	17.8	8.7	18.3	6.4
1984	37	347.4	360.0	276.9	283.4	.91	.90	1.2	1.3	17.5	9.4	17.6	7.5	18.1	9.7	18.1	7.7
1989	42	437.9	450.5	366.0	372.5	.79	.79	1.1	1.1	18.1	10.4	17.8	8.7	18.1	10.7	17.8	8.9
1994	47	494.1	555.8	422.3	475.1	.88	.86	.3	1.1	11.2	10.5	11.3	9.0	21.1	11.8	20.5	10.1
1999	52	580.3	646.0	506.0	562.5	.67	.65	.8	.9	17.2	11.2	16.7	9.7	18.0	12.4	17.5	10.8
2006	59	695.1	783.7	617.1	695.3	.60	.62	.7	.9	16.4	11.8	15.9	10.5	19.7	13.3	19.0	11.8

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 122.8 cubic meters (19.9 percent of the total gross yield at age 59); volume (CVTS) in mortality = 87.7 cubic meters (14 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 18a—Stand development table for treatment 3 (plots 31, 42, and 52), per acre basis (ingrowth excluded), English units

		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* – – –	
1966	19	37	6.6	348	4.9	46.3	653	32	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	50	8.6	248	6.8	61.9	1,165	411	92	6.0	18.0	323	59	3.5	1.4	.91	8	4.4	.9	14	0
1973	26	57	10.1	193	8.3	72.0	1,551	931	43	7.7	14.0	298	156	6.9	4.1	.94	12	6.6	2.7	57	23
1977	30	68	12.0	162	10.2	90.7	2,310	1,818	27	8.9	11.4	289	197	10.7	8.6	.89	5	8.4	1.9	44	26
1980	33	76	13.3	145	11.4	101.9	2,912	2,487	15	10.8	9.6	276	229	18.4	15.3	.96	2	8.7	.7	19	12
1984	37	85	14.8	115	13.1	106.5	3,398	3,083	30	10.9	19.3	596	496	19.9	16.5	.86	0	0	0	0	0
1989	42	98	16.5	113	14.6	131.1	4,788	4,458	0	0	0	0	0	0	0	0	2	10.5	1.0	34	28
1994	47	107	18.5	107	16.5	157.1	6,204	5,867	0	0	0	0	0	0	0	0	7	12.3	5.5	207	183
1999	52	118	19.9	107	17.7	181.0	7,804	7,418	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	59	133	21.9	107	19.3	215.3	10,281	9,810	0	0	0	0	0	0	0	0	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* – – – – – – – – – – – – – – – – – – –							
1966	19	653	653	32	32	0	0	0	0	0	34	0	2	0	34	0	2
1970	23	1,489	1,502	470	470	.41	.40	8.4	8.6	209	65	109	20	212	65	109	20
1973	26	2,173	2,243	1,146	1,169	.47	.47	8.1	9.0	228	84	225	44	247	86	233	45
1977	30	3,221	3,335	2,229	2,278	.43	.43	7.5	8.0	262	107	271	74	273	111	277	76
1980	33	4,098	4,231	3,127	3,188	.39	.38	6.9	7.1	292	124	299	95	298	128	303	97
1984	37	5,180	5,313	4,219	4,279	.32	.32	6.0	6.0	271	140	273	114	271	144	273	116
1989	42	6,571	6,738	5,594	5,682	.31	.30	4.9	5.1	278	156	275	133	285	160	281	135
1994	47	7,987	8,361	7,003	7,275	.37	.35	5.2	6.3	283	170	282	149	325	178	318	155
1999	52	9,587	9,960	8,554	8,825	.24	.24	4.8	4.8	320	184	310	164	320	192	310	170
2006	59	12,063	12,437	10,946	11,218	.23	.23	4.9	4.9	354	204	342	186	354	211	342	190

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,782 cubic feet (14 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 375 cubic feet (3 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 18b—Stand development table for treatment 3 (plots 31, 42, and 52), per hectare basis (ingrowth excluded), metric units

		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 – – –	
1966	19	11.4	16.8	860	12.5	10.6	45.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	15.1	21.8	613	17.2	14.2	81.5	28.8	226	15.2	4.1	22.6	4.1	.1	.0	.91	21	11.1	.2	.9	0
1973	26	17.2	25.7	478	21.1	16.5	108.6	65.2	107	19.6	3.2	20.9	10.9	.2	.1	.94	29	16.7	.6	4.0	1.6
1977	30	20.6	30.5	399	25.9	20.8	161.7	127.2	66	22.5	2.6	20.2	13.8	.3	.2	.89	12	21.3	.4	3.1	1.8
1980	33	23.0	33.7	358	29.0	23.4	203.7	174.0	37	27.5	2.2	19.3	16.0	.5	.4	.96	4	22.1	.2	1.3	.8
1984	37	25.8	37.5	284	33.3	24.5	237.7	215.7	74	27.6	4.4	41.7	34.7	.6	.5	.86	0	0	0	0	0
1989	42	29.7	41.9	280	37.2	30.1	335.1	312.0	0	0	0	0	0	0	0	0	4	26.7	.2	2.4	2.0
1994	47	32.7	47.0	263	41.9	36.1	434.1	410.5	0	0	0	0	0	0	0	0	16	31.1	1.3	14.5	12.8
1999	52	35.9	50.7	263	45.0	41.6	546.1	519.1	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	59	40.5	55.7	263	49.1	49.4	719.4	686.4	0	0	0	0	0	0	0	0	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 – – – – – – – – – – – – – – – – – – –							
1966	19	45.7	45.7	2.3	2.3	0	0	0	0	0	2.4	0	0.1	0	2.4	0	0.1
1970	23	104.2	105.1	32.9	32.9	1.03	1.03	1.9	2.0	14.6	4.5	7.7	1.4	14.8	4.6	7.7	1.4
1973	26	152.0	157.0	80.2	81.8	1.19	1.19	1.8	2.1	16.0	5.8	15.8	3.1	17.3	6.0	16.3	3.1
1977	30	225.4	233.4	156.0	159.4	1.09	1.09	1.7	1.8	18.3	7.5	19.0	5.2	19.1	7.8	19.4	5.3
1980	33	286.7	296.0	218.8	223.1	.98	.97	1.6	1.6	20.5	8.7	20.9	6.6	20.9	9.0	21.2	6.8
1984	37	362.5	371.8	295.2	299.4	.80	.80	1.4	1.4	18.9	9.8	19.1	8.0	18.9	10.0	19.1	8.1
1989	42	459.8	471.5	391.4	397.6	.79	.77	1.1	1.2	19.5	10.9	19.2	9.3	19.9	11.2	19.6	9.5
1994	47	558.9	585.0	490.0	509.0	.95	.89	1.2	1.4	19.8	11.9	19.7	10.4	22.7	12.4	22.3	10.8
1999	52	670.8	697.0	598.5	617.5	.61	.61	1.1	1.1	22.4	12.9	21.7	11.5	22.4	13.4	21.7	11.9
2006	59	844.1	870.3	765.9	784.9	.58	.58	1.1	1.1	24.8	14.3	23.9	13.0	24.8	14.8	23.9	13.3

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 124.7 cubic meters (14 percent of the total gross yield at age 59); volume (CVTS) in mortality = 26.2 cubic meters (3 percent of the total gross yield).

[f] Net periodic annual aincrement (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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 19a—Stand development table for treatment 4 (plots 13, 62, and 111), per acre basis (ingrowth excluded), English units

		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*	ft^2	– – – ft^3 – – –		*No.*	*in*	ft^2	– – – – – – – – ft^3 – – – – – – – –					*No.*	*in*	ft^2	– – – ft^3 – – –	
1966	19	40	6.5	363	5.0	49.7	775	42	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	53	8.5	243	7.0	63.5	1,280	477	112	6.1	22.9	441	98	3.9	2.2	.92	8	4.8	1.0	17	0
1973	26	59	10.1	197	8.6	77.7	1,759	1,102	32	7.4	9.4	207	104	6.5	4.7	.89	15	6.9	3.9	84	37
1977	30	68	12.1	180	10.4	105.4	2,782	2,233	12	9.5	5.7	153	112	12.8	9.3	.92	5	5.5	.8	17	1
1980	33	77	13.3	165	11.7	120.8	3,594	3,109	13	9.7	6.8	193	145	14.8	11.2	.85	2	10.0	.9	25	20
1984	37	87	14.7	153	12.9	137.1	4,538	4,094	12	12.3	9.6	318	282	26.5	23.5	.96	0	0	0	0	0
1989	42	100	16.2	152	14.2	164.8	6,149	5,691	0	0	0	0	0	0	0	0	2	5.6	.3	7	0
1994	47	113	17.8	147	15.6	193.1	8,011	7,529	0	0	0	0	0	0	0	0	5	11.8	3.8	147	129
1999	52	123	19.1	143	16.7	216.1	9,708	9,189	0	0	0	0	0	0	0	0	3	9.8	1.8	67	51
2006	59	138	20.9	138	18.1	246.2	12,214	11,624	0	0	0	0	0	0	0	0	5	14.5	5.8	267	249

		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	– – – – – – – – – – ft^3 – – – – – – – – – –				– – – – *in* – – – –		– – – ft^2 – – –		– ft^3 –							
1966	19	775	775	42	42	0	0	0	0	0	41	0	2	0	41	0	2
1970	23	1,721	1,738	576	576	.42	.42	9.2	9.5	236	75	133	25	241	76	133	25
1973	26	2,406	2,507	1,304	1,341	.48	.48	7.9	9.2	229	93	243	50	256	96	255	52
1977	30	3,583	3,701	2,547	2,586	.45	.44	8.4	8.6	294	119	311	85	298	123	311	86
1980	33	4,588	4,731	3,569	3,627	.37	.37	7.4	7.7	335	139	340	108	343	143	347	110
1984	37	5,850	5,993	4,836	4,894	.30	.30	6.5	6.5	315	158	317	131	315	162	317	132
1989	42	7,460	7,610	6,432	6,490	.26	.25	5.5	5.6	322	178	319	153	324	181	319	155
1994	47	9,322	9,619	8,271	8,457	.28	.27	5.7	6.4	372	198	368	176	402	205	393	180
1999	52	11,019	11,383	9,931	10,168	.22	.20	4.6	4.9	339	212	332	191	353	219	342	196
2006	59	13,526	14,156	12,365	12,852	.21	.20	4.3	5.1	358	229	348	210	396	240	383	218

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,312 cubic feet (9 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 631 cubic feet (4 percent of the total gross yield).

[f] Net 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 19b—Stand development table for treatment 4 (plots 13, 62, and 111), per hectare basis (ingrowth excluded), metric units

		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*	*m²*	*– – – m³ – – –*		*No.*	*cm*	*m²*	*– – – – – – – – – m³ – – – – – – – – –*					*No.*	*cm*	*m²*	*– – – m³ – – –*	
1966	19	12.3	16.6	897	12.8	11.4	54.2	3.0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	16.1	21.5	601	17.7	14.6	89.6	33.4	276	15.6	5.3	30.8	6.9	.1	.1	.92	21	12.2	.2	1.2	0
1973	26	18.0	25.6	486	21.8	17.8	123.0	77.1	78	18.8	2.2	14.5	7.2	.2	.1	.88	37	17.5	.9	5.8	2.6
1977	30	20.8	30.7	445	26.5	24.2	194.7	156.3	29	24.1	1.3	10.7	7.9	.4	.3	.92	12	13.9	.2	1.2	.1
1980	33	23.6	33.8	408	29.6	27.7	251.5	217.6	33	24.6	1.6	13.5	10.2	.4	.3	.85	4	25.4	.2	1.8	1.4
1984	37	26.5	37.3	379	32.7	31.5	317.6	286.5	29	31.2	2.2	22.2	19.7	.8	.7	.96	0	0	0	0	0
1989	42	30.4	41.1	375	36.1	37.8	430.2	398.2	0	0	0	0	0	0	0	0	4	14.3	.1	.5	0
1994	47	34.3	45.3	362	39.7	44.3	560.5	526.8	0	0	0	0	0	0	0	0	12	30.0	.9	10.3	9.0
1999	52	37.4	48.6	354	42.4	49.6	679.3	643.0	0	0	0	0	0	0	0	0	8	24.9	.4	4.7	3.6
2006	59	42.2	53.1	342	46.1	56.5	854.7	813.4	0	0	0	0	0	0	0	0	12	36.9	1.3	18.7	17.4

		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	*– – – – – – – – – – m³ – – – – – – – – – –*				*– – – cm – – –*		*– – – m² – – –*		*– – – – – – – – – – – – – – – – – – – m³ – – – – – – – – – – – – – – – – – – –*							
1966	19	54.2	54.2	3.0	3.0	0	0	0	0	0	2.9	0	0.2	0	2.9	0	0.2
1970	23	120.4	121.6	40.3	40.3	1.07	1.06	2.1	2.2	16.5	5.2	9.3	1.8	16.8	5.3	9.3	1.8
1973	26	168.4	175.4	91.2	93.9	1.22	1.23	1.8	2.1	16.0	6.5	17.0	3.5	17.9	6.7	17.9	3.6
1977	30	250.7	258.9	178.3	180.9	1.15	1.11	1.9	2.0	20.6	8.4	21.8	5.9	20.9	8.6	21.8	6.0
1980	33	321.0	331.0	249.7	253.8	.94	.93	1.7	1.8	23.4	9.7	23.8	7.6	24.0	10.0	24.3	7.7
1984	37	409.3	419.3	338.4	342.4	.75	.75	1.5	1.5	22.1	11.1	22.2	9.1	22.1	11.3	22.2	9.3
1989	42	522.0	532.5	450.1	454.1	.66	.64	1.3	1.3	22.5	12.4	22.3	10.7	22.6	12.7	22.3	10.8
1994	47	652.3	673.0	578.7	591.8	.72	.69	1.3	1.5	26.1	13.9	25.7	12.3	28.1	14.3	27.5	12.6
1999	52	771.0	796.5	694.9	711.5	.55	.50	1.1	1.1	23.7	14.8	23.2	13.4	24.7	15.3	23.9	13.7
2006	59	946.4	990.5	865.2	899.3	.52	.50	1.0	1.2	25.1	16.0	24.3	14.7	27.7	16.8	26.8	15.2

[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 at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 91.7 cubic meters (9 percent of the total gross yield at age 59); volume (CVTS) in mortality = 44.2 cubic meters (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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 20a—Stand development table for treatment 5 (plots 12, 41, and 72), per acre basis (ingrowth excluded), English units

		Afterthinning							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* – – –	
1966	19	39	6.8	347	5.1	48.6	738	47	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	51	8.8	277	6.9	71.3	1,391	505	62	5.8	11.2	207	34	3.3	1.5	.87	8	4.8	1.0	18	0
1973	26	59	10.3	242	8.4	91.3	2,061	1,237	32	7.0	8.4	180	79	5.6	4.0	.85	3	8.2	1.2	28	16
1977	30	69	12.1	227	9.9	120.7	3,191	2,450	10	9.2	4.6	119	83	11.9	8.3	.93	5	7.5	1.6	38	17
1980	33	78	13.3	210	10.9	134.9	3,994	3,318	17	10.7	10.5	309	257	18.2	15.1	.99	0	0	0	0	0
1984	37	89	14.6	178	12.1	141.7	4,715	4,149	28	10.7	17.8	577	475	20.6	17.6	.90	3	6.7	.8	22	5
1989	42	102	16.1	178	13.3	169.6	6,434	5,840	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	114	17.8	173	14.5	197.8	8,224	7,619	0	0	0	0	0	0	0	0	5	12.5	4.2	175	155
1999	52	123	19.1	167	15.6	221.8	9,955	9,337	0	0	0	0	0	0	0	0	7	8.4	2.5	89	56
2006	59	139	21.1	163	17.1	258.9	12,945	12,245	0	0	0	0	0	0	0	0	3	10.3	1.9	77	62

		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* – – – – – – – – – – – – – – – – – –							
1966	19	738	738	47	47	0	0	0	0	0	39	0	2	0	39	0	2
1970	23	1,598	1,616	539	539	.41	.40	8.5	8.8	215	69	123	23	219	70	123	23
1973	26	2,448	2,493	1,349	1,365	.43	.44	9.5	9.9	283	94	270	52	293	96	275	53
1977	30	3,697	3,781	2,646	2,679	.38	.38	8.5	8.9	312	123	324	88	322	126	328	89
1980	33	4,811	4,894	3,770	3,803	.32	.32	8.2	8.2	371	146	375	114	371	148	375	115
1984	37	6,108	6,213	5,076	5,115	.26	.25	6.2	6.4	324	165	327	137	330	168	328	138
1989	42	7,827	7,932	6,768	6,806	.23	.23	5.6	5.6	344	186	338	161	344	189	338	162
1994	47	9,617	9,897	8,546	8,739	.25	.25	5.6	6.5	358	205	356	182	393	211	387	186
1999	52	11,348	11,718	10,264	10,514	.23	.19	4.8	5.3	346	218	344	197	364	225	355	202
2006	59	14,338	14,785	13,172	13,483	.21	.19	5.3	5.6	427	243	415	223	438	251	424	229

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,392 cubic feet (9 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 447 cubic feet (3 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 20b—Stand development table for treatment 5 (plots 12, 41, and 72), per hectare basis (ingrowth excluded), metric units

		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 – – –	
1966	19	11.9	17.2	856	12.9	11.2	51.7	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	15.5	22.3	683	17.5	16.4	97.3	35.4	152	14.7	2.6	14.5	2.3	.1	0	.86	21	12.2	.2	1.3	0
1973	26	18.0	26.3	597	21.2	21.0	144.2	86.6	78	17.7	1.9	12.6	5.5	.2	.1	.85	8	20.8	.3	1.9	1.1
1977	30	21.2	30.8	560	25.2	27.7	223.3	171.5	25	23.3	1.1	8.4	5.8	.3	.2	.93	12	19.2	.4	2.7	1.2
1980	33	23.8	33.8	519	27.8	31.0	279.5	232.2	41	27.3	2.4	21.6	18.0	.5	.4	.99	0	0	0	0	0
1984	37	27.0	37.0	440	30.8	32.5	329.9	290.3	70	27.3	4.1	40.4	33.3	.6	.5	.90	8	17.1	.2	1.5	.4
1989	42	31.1	40.9	440	33.7	38.9	450.2	408.6	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	34.6	45.1	428	36.9	45.4	575.4	533.1	0	0	0	0	0	0	0	0	12	31.6	1.0	12.2	10.8
1999	52	37.5	48.5	412	39.8	50.9	696.6	653.3	0	0	0	0	0	0	0	0	16	21.2	.6	6.3	3.9
2006	59	42.4	53.5	403	43.4	59.4	905.8	856.8	0	0	0	0	0	0	0	0	8	26.1	.4	5.4	4.3

		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 – – – – – – – – – – – – – – – – – – –							
1966	19	51.7	51.7	3.3	3.3	0	0	0	0	0	2.7	0	0.2	0	2.7	0	0.2
1970	23	111.8	113.0	37.7	37.7	1.03	1.03	2.0	2.0	15.0	4.9	8.6	1.6	15.3	4.9	8.6	1.6
1973	26	171.3	174.5	94.4	95.5	1.10	1.12	2.2	2.3	19.8	6.6	18.9	3.6	20.5	6.7	19.3	3.7
1977	30	258.7	264.6	185.1	187.4	.97	.96	2.0	2.0	21.9	8.6	22.7	6.2	22.5	8.8	23.0	6.2
1980	33	336.6	342.5	263.8	266.1	.82	.82	1.9	1.9	26.0	10.2	26.2	8.0	26.0	10.4	26.2	8.1
1984	37	427.4	434.7	355.2	357.9	.66	.63	1.4	1.5	22.7	11.6	22.9	9.6	23.1	11.7	22.9	9.7
1989	42	547.7	555.0	473.5	476.2	.58	.58	1.3	1.3	24.1	13.0	23.7	11.3	24.1	13.2	23.7	11.3
1994	47	672.9	692.5	598.0	611.5	.63	.63	1.3	1.5	25.0	14.3	24.9	12.7	27.5	14.7	27.1	13.0
1999	52	794.1	819.9	718.2	735.7	.57	.49	1.1	1.2	24.2	15.3	24.0	13.8	25.5	15.8	24.8	14.1
2006	59	1,003.2	1,034.5	921.7	943.4	.52	.49	1.2	1.3	29.9	17.0	29.1	15.6	30.7	17.5	29.7	16.0

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 97.5 cubic meters (9 percent of the total gross yield at age 59); volume (CVTS) in mortality = 31.3 cubic meters (3 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 21a—Stand development table for treatment 6 (plots 15, 43, and 81), 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* – – – –	
1966	19	37	6.4	360	4.8	45.4	638	22	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	48	8.4	307	6.6	71.9	1,321	393	37	6.0	7.2	127	23	3.4	1.9	.92	17	4.3	1.7	26	0
1973	26	55	9.9	252	8.0	87.2	1,840	1,009	43	7.4	12.9	267	115	6.2	3.1	.94	12	6.4	2.6	52	14
1977	30	66	11.7	203	9.7	103.3	2,585	1,936	43	9.2	19.8	497	348	11.6	8.1	.96	5	6.6	1.2	27	8
1980	33	75	13.0	172	10.9	111.0	3,153	2,625	30	9.6	15.0	419	310	14.0	10.3	.90	2	8.3	.6	17	10
1984	37	84	14.3	128	12.5	109.7	3,497	3,129	42	10.5	24.9	762	616	18.1	14.7	.87	2	11.4	1.2	32	28
1989	42	97	15.9	128	13.9	135.4	4,932	4,545	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	107	17.8	127	15.5	166.7	6,661	6,251	0	0	0	0	0	0	0	0	2	10.6	1.0	32	27
1999	52	118	19.2	125	16.8	191.4	8,318	7,868	0	0	0	0	0	0	0	0	2	5.4	.3	5	0
2006	59	135	21.2	122	18.3	223.3	10,866	10,339	0	0	0	0	0	0	0	0	3	14.4	3.7	154	142

		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* – – – – – – – – – – – – – – – – – – –							
1966	19	638	638	22	22	0	0	0	0	0	34	0	1	0	34	0	1
1970	23	1,448	1,474	416	416	.42	.42	8.4	8.8	202	63	98	18	209	64	98	18
1973	26	2,234	2,312	1,147	1,161	.44	.44	9.4	10.3	262	86	244	44	279	89	248	45
1977	30	3,476	3,581	2,423	2,445	.40	.39	9.0	9.3	311	116	319	81	317	119	321	81
1980	33	4,463	4,585	3,421	3,452	.35	.35	7.6	7.8	329	135	333	104	334	139	336	105
1984	37	5,569	5,723	4,541	4,600	.29	.29	5.9	6.2	277	151	280	123	285	155	287	124
1989	42	7,004	7,158	5,957	6,015	.28	.28	5.1	5.1	287	167	283	142	287	170	283	143
1994	47	8,733	8,919	7,663	7,748	.32	.32	6.2	6.4	346	186	341	163	352	190	347	165
1999	52	10,390	10,582	9,280	9,365	.24	.23	4.9	5.0	332	200	323	178	333	203	323	180
2006	59	12,938	13,283	11,751	11,978	.23	.22	4.6	5.1	364	219	353	199	386	225	373	203

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 2,072 cubic feet (16 percent of the total gross yield at at age 59); volume (CVTS) in mortality = 313 cubic feet (2 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 21b—Stand development table for treatment 6 (plots 15, 43, and 81), per hectare basis (ingrowth excluded), metric units

		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 – – –	
1966	19	11.2	16.3	889	12.2	10.4	44.7	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	14.7	21.3	757	16.7	16.5	92.4	27.5	91	15.2	1.6	8.9	1.6	.1	.1	.92	41	10.9	.4	1.8	0
1973	26	16.9	25.2	622	20.3	20.0	128.7	70.6	107	18.8	3.0	18.7	8.1	.2	.1	.94	29	16.3	.6	3.7	1.0
1977	30	20.2	29.8	502	24.5	23.7	180.9	135.5	107	23.3	4.6	34.8	24.4	.3	.2	.96	12	16.7	.3	1.9	.5
1980	33	22.8	32.9	424	27.7	25.5	220.6	183.7	74	24.3	3.4	29.3	21.7	.4	.3	.89	4	21.1	.1	1.2	.7
1984	37	25.5	36.4	317	31.8	25.2	244.7	219.0	103	26.6	5.7	53.3	43.1	.5	.4	.87	4	28.9	.3	2.2	1.9
1989	42	29.6	40.4	317	35.3	31.1	345.1	318.0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	47	32.7	45.3	313	39.5	38.3	466.1	437.4	0	0	0	0	0	0	0	0	4	26.9	.2	2.3	1.9
1999	52	36.1	48.9	309	42.6	43.9	582.1	550.5	0	0	0	0	0	0	0	0	4	13.8	.1	.3	0
2006	59	41.0	53.8	301	46.6	51.3	760.3	723.4	0	0	0	0	0	0	0	0	8	36.5	.9	10.7	10.0

		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 –							
1966	19	44.7	44.7	1.5	1.5	0	0	0	0	0	2.4	0	0.1	0	2.4	0	0.1
1970	23	101.3	103.1	29.1	29.1	1.07	1.06	1.9	2.0	14.2	4.4	6.9	1.3	14.6	4.5	6.9	1.3
1973	26	156.3	161.8	80.3	81.2	1.13	1.12	2.2	2.4	18.3	6.0	17.1	3.1	19.6	6.2	17.4	3.1
1977	30	243.2	250.6	169.5	171.0	1.01	1.00	2.1	2.1	21.7	8.1	22.3	5.7	22.2	8.4	22.5	5.7
1980	33	312.3	320.8	239.4	241.6	.89	.88	1.7	1.8	23.0	9.5	23.3	7.3	23.4	9.7	23.5	7.3
1984	37	389.7	400.5	317.7	321.9	.74	.74	1.4	1.4	19.4	10.5	19.6	8.6	19.9	10.8	20.1	8.7
1989	42	490.1	500.9	416.8	420.9	.71	.71	1.2	1.2	20.1	11.7	19.8	9.9	20.1	11.9	19.8	10.0
1994	47	611.0	624.1	536.2	542.2	.83	.80	1.4	1.5	24.2	13.0	23.9	11.4	24.6	13.3	24.2	11.5
1999	52	727.0	740.4	649.3	655.3	.62	.58	1.1	1.1	23.2	14.0	22.6	12.5	23.3	14.2	22.6	12.6
2006	59	905.3	929.5	822.2	838.1	.58	.55	1.0	1.2	25.5	15.3	24.7	13.9	27.0	15.8	26.1	14.2

[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 at breast height.

[c] All volumes are total stem cubic meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 145.0 cubic meters (16 percent of the total gross yield at age 59); volume (CVTS) in mortality = 24.1 cubic meters (3 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 is thus unaffected by mortality).

[g] MAI – mean annual increment.

Table 22a—Stand development table for treatment 7 (plots 11, 23, and 63), per acre basis (ingrowth excluded), English units

		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*	ft^2	ft^3		*No.*	*in*	ft^2	ft^3					*No.*	*in*	ft^2	ft^3	
1966	19	38	6.7	360	5.0	49.2	742	41	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	49	8.7	333	6.7	80.7	1,541	498	13	6.4	3.0	57	15	4.4	2.1	.96	13	4.7	1.6	27	2
1973	26	58	10.3	305	8.0	105.9	2,352	1,304	12	6.9	3.0	65	26	5.4	3.7	.87	17	6.7	4.1	89	33
1977	30	69	12.0	297	9.4	142.6	3,765	2,731	0	0	0	0	0	0	0	0	8	7.4	2.5	62	26
1980	33	78	13.2	287	10.3	165.4	4,931	3,912	7	7.1	1.8	49	24	7.0	8.0	.69	3	8.9	1.4	42	28
1984	37	87	14.4	260	11.3	179.2	5,905	4,992	23	10.3	13.4	442	349	19.2	15.2	.92	3	6.2	.7	18	3
1989	42	101	15.7	255	12.3	207.9	7,828	6,896	0	0	0	0	0	0	0	0	5	6.3	1.1	31	5
1994	47	112	17.2	240	13.4	234.0	9,719	8,834	0	0	0	0	0	0	0	0	15	10.3	8.6	330	259
1999	52	121	18.5	230	14.4	260.1	11,606	10,721	0	0	0	0	0	0	0	0	10	8.4	3.9	121	75
2006	59	139	20.4	207	16.0	287.4	14,425	13,552	0	0	0	0	0	0	0	0	23	9.7	12.0	478	360

		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	ft^3				*in*		ft^2		ft^3							
1966	19	742	742	41	41	0	0	0	0	0	39	0	2	0	39	0	2
1970	23	1,598	1,625	513	515	.41	.41	8.6	9.0	214	69	118	22	221	71	119	22
1973	26	2,474	2,590	1,345	1,381	.42	.43	9.4	10.8	292	95	277	52	322	100	289	53
1977	30	3,887	4,064	2,772	2,834	.35	.35	9.2	9.8	353	130	357	92	369	135	363	94
1980	33	5,102	5,321	3,978	4,067	.28	.28	8.2	8.7	405	155	402	121	419	161	411	123
1984	37	6,518	6,756	5,406	5,498	.22	.21	6.8	7.0	354	176	357	146	359	183	358	149
1989	42	8,441	8,709	7,311	7,408	.20	.18	5.7	6.0	385	201	381	174	391	207	382	176
1994	47	10,332	10,931	9,248	9,604	.23	.21	5.2	6.9	378	220	387	197	444	233	439	204
1999	52	12,219	12,939	11,136	11,567	.20	.17	5.2	6.0	377	235	377	214	402	249	393	222
2006	59	15,038	16,236	13,967	14,759	.22	.16	3.9	5.6	403	255	404	237	471	275	456	250

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 613 cubic feet (4 percent of the total gross yield at age 59); volume (CVTS) in mortality = 1,198 cubic feet (7 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 22b—Stand development table for treatment 7 (plots 11, 23, and 63), per hectare basis (ingrowth excluded), metric units

		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	m	cm	No.	cm	m^2	m^3		No.	cm	m^2	m^3					No.	cm	m^2	m	
1966	19	11.7	17.1	889	12.7	11.3	51.9	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	15.0	22.1	823	17.0	18.5	107.8	34.9	33	16.3	.7	4.0	1.0	.1	.1	.96	33	12.0	.4	1.9	.1
1973	26	17.5	26.0	753	20.3	24.3	164.6	91.3	29	17.5	.7	4.5	1.8	.2	.1	.87	41	17.1	.9	6.2	2.3
1977	30	21.0	30.5	733	23.9	32.7	263.4	191.1	0	0	0	0	0	0	0	0	21	18.8	.6	4.3	1.8
1980	33	23.8	33.5	708	26.2	38.0	345.0	273.8	16	18.0	.4	3.5	1.7	.2	.3	.69	8	22.5	.3	2.9	1.9
1984	37	26.5	36.5	642	28.6	41.1	413.2	349.3	58	26.1	3.1	30.9	24.4	.5	.4	.92	8	15.7	.2	1.3	.2
1989	42	30.7	39.8	630	31.1	47.7	547.7	482.5	0	0	0	0	0	0	0	0	12	16.1	.3	2.2	.4
1994	47	34.2	43.6	593	34.0	53.7	680.0	618.1	0	0	0	0	0	0	0	0	37	26.0	2.0	23.1	18.1
1999	52	37.0	47.0	568	36.6	59.7	812.1	750.2	0	0	0	0	0	0	0	0	25	21.4	.9	8.4	5.3
2006	59	42.2	51.7	510	40.6	66.0	1,009.3	948.3	0	0	0	0	0	0	0	0	58	24.7	2.8	33.5	25.2

		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							
1966	19	51.9	51.9	2.9	2.9	0	0	0	0	0	2.7	0	0.2	0	2.7	0	0.2
1970	23	111.8	113.7	35.9	36.0	1.04	1.04	2.0	2.1	15.0	4.9	8.3	1.6	15.4	4.9	8.3	1.6
1973	26	173.1	181.2	94.1	96.6	1.08	1.09	2.2	2.5	20.4	6.7	19.4	3.6	22.5	7.0	20.2	3.7
1977	30	272.0	284.4	194.0	198.3	.89	.88	2.1	2.2	24.7	9.1	25.0	6.5	25.8	9.5	25.4	6.6
1980	33	357.0	372.3	278.3	284.6	.71	.70	1.9	2.0	28.3	10.8	28.1	8.4	29.3	11.3	28.8	8.6
1984	37	456.1	472.7	378.3	384.7	.56	.53	1.6	1.6	24.8	12.3	25.0	10.2	25.1	12.8	25.0	10.4
1989	42	590.6	609.4	511.5	518.3	.50	.46	1.3	1.4	26.9	14.1	26.7	12.2	27.3	14.5	26.7	12.3
1994	47	723.0	764.9	647.1	672.0	.58	.52	1.2	1.6	26.5	15.4	27.1	13.8	31.1	16.3	30.7	14.3
1999	52	855.0	905.3	779.2	809.4	.52	.43	1.2	1.4	26.4	16.4	26.4	15.0	28.1	17.4	27.5	15.6
2006	59	1,052.2	1,136.1	977.3	1,032.7	.57	.41	.9	1.3	28.2	17.8	28.3	16.6	33.0	19.3	31.9	17.5

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 42.9 cubic meters (4 percent of the total gross yield at age 59); volume (CVTS) in mortality = 83.8 cubic meters (7 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 23a—Stand development table for treatment 8 (plots 14, 53, and 73), per acre basis (ingrowth excluded), English units

		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*	ft^2	– – – ft^3 – – –		*No.*	*in*	ft^2	– – – – – – – – ft^3 – – – – – – – –					*No.*	*in*	ft^2	– – – ft^3 – – –	
1966	19	40	6.7	352	5.1	49.2	764	48	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	50	8.8	313	6.9	80.9	1,583	594	32	5.8	5.8	105	29	3.3	2.4	.85	7	4.5	.7	12	0
1973	26	59	10.4	275	8.3	102.6	2,290	1,383	17	6.9	4.3	91	39	5.4	3.9	.84	22	7.7	7.0	155	76
1977	30	68	12.2	257	9.8	133.9	3,472	2,640	17	8.8	7.0	177	118	10.4	7.9	.91	2	5.9	.3	6	0
1980	33	77	13.4	225	10.9	144.8	4,205	3,484	25	9.3	11.7	328	237	13.1	10.3	.86	7	6.5	1.5	35	8
1984	37	86	14.7	187	12.1	146.8	4,758	4,164	35	10.6	21.6	688	564	19.7	16.1	.90	3	8.0	1.2	32	17
1989	42	99	16.1	185	13.3	174.1	6,502	5,875	0	0	0	0	0	0	0	0	2	7.6	.5	16	7
1994	47	110	17.7	180	14.5	204.1	8,368	7,735	0	0	0	0	0	0	0	0	5	9.3	2.4	86	61
1999	52	120	18.9	165	15.7	219.1	9,778	9,160	0	0	0	0	0	0	0	0	15	10.0	8.3	320	253
2006	59	136	20.7	157	17.3	249.8	12,431	11,759	0	0	0	0	0	0	0	0	8	11.3	5.8	254	217

		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	– – – – – – – – – – ft^3 – – – – – – – – – –				– – – – *in* – – – –		– – – ft^2 – – –		– ft^3 –							
1966	19	764	764	48	48	0	0	0	0	0	40	0	3	0	40	0	3
1970	23	1,688	1,700	623	623	.43	.43	9.4	9.6	231	73	144	27	234	74	144	27
1973	26	2,486	2,653	1,451	1,527	.44	.46	8.7	11.0	266	96	276	56	318	102	301	59
1977	30	3,845	4,018	2,826	2,902	.36	.36	9.6	9.6	340	128	344	94	341	134	344	97
1980	33	4,907	5,116	3,907	3,991	.31	.29	7.5	8.0	354	149	360	118	366	155	363	121
1984	37	6,148	6,389	5,151	5,252	.24	.23	5.9	6.2	310	166	311	139	318	173	315	142
1989	42	7,893	8,150	6,862	6,970	.23	.22	5.5	5.6	349	188	342	163	352	194	344	166
1994	47	9,758	10,101	8,722	8,892	.25	.24	6.0	6.5	373	208	372	186	390	215	384	189
1999	52	11,168	11,831	10,147	10,569	.23	.17	3.0	4.7	282	215	285	195	346	228	335	203
2006	59	13,822	14,739	12,746	13,386	.22	.19	4.4	5.2	379	234	371	216	415	250	402	227

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 1,389 cubic feet (9 percent of the total gross yield at age 59); volume (CVTS) in mortality = 916 cubic feet (6 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 23b—Stand development table for treatment 8 (plots 14, 53, and 73), per hectare basis (ingrowth excluded), metric units

		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*	*m²*	– – – *m³* – – –		*No.*	*cm*	*m²*	– – – – – – – – *m³* – – – – – – – –					*No.*	*cm*	*m²*	– – – *m³* – – –	
1966	19	12.1	17.1	869	12.9	11.3	53.5	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	15.3	22.3	774	17.5	18.6	110.8	41.6	78	14.7	1.3	7.4	2.1	.1	.1	.85	16	11.4	.2	.8	0
1973	26	17.9	26.3	679	21.1	23.6	160.2	96.8	41	17.5	1.0	6.4	2.7	.1	.1	.84	54	19.6	1.6	10.9	5.3
1977	30	20.9	31.0	634	24.9	30.7	242.9	184.7	41	22.3	1.6	12.4	8.3	.3	.2	.90	4	15.0	.1	.4	0
1980	33	23.3	34.0	556	27.8	33.2	294.2	243.8	62	23.5	2.7	23.0	16.6	.4	.3	.86	16	16.5	.4	2.5	.5
1984	37	26.2	37.2	461	30.9	33.7	332.9	291.4	86	27.0	5.0	48.2	39.5	.6	.5	.90	8	20.3	.3	2.2	1.2
1989	42	30.3	41.0	457	33.7	40.0	455.0	411.1	0	0	0	0	0	0	0	0	4	19.3	.1	1.1	.5
1994	47	33.6	45.1	445	36.9	46.9	585.5	541.2	0	0	0	0	0	0	0	0	12	23.6	.5	6.0	4.3
1999	52	36.5	48.1	408	39.9	50.3	684.2	640.9	0	0	0	0	0	0	0	0	37	25.5	1.9	22.4	17.7
2006	59	41.3	52.7	387	43.8	57.3	869.8	822.8	0	0	0	0	0	0	0	0	21	28.6	1.3	17.8	15.2

		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	– – – – – – – – *m³* – – – – – – – –				– – – *cm* – – –		– – – *m²* – – –		– – – – – – – – – – – – – – *m³* – – – – – – – – – – – – – –							
1966	19	53.5	53.5	3.4	3.4	0	0	0	0	0	2.8	0	0.2	0	2.8	0	0.2
1970	23	118.1	119.0	43.6	43.6	1.10	1.09	2.2	2.2	16.2	5.1	10.1	1.9	16.4	5.2	10.1	1.9
1973	26	173.9	185.6	101.6	106.9	1.11	1.17	2.0	2.5	18.6	6.7	19.3	3.9	22.2	7.1	21.1	4.1
1977	30	269.0	281.2	197.8	203.0	.92	.92	2.2	2.2	23.8	9.0	24.0	6.6	23.9	9.4	24.0	6.8
1980	33	343.4	358.0	273.4	279.2	.79	.73	1.7	1.8	24.8	10.4	25.2	8.3	25.6	10.8	25.4	8.5
1984	37	430.2	447.1	360.4	367.5	.60	.58	1.4	1.4	21.7	11.6	21.8	9.7	22.3	12.1	22.1	9.9
1989	42	552.3	570.2	480.1	487.7	.57	.56	1.3	1.3	24.4	13.1	23.9	11.4	24.6	13.6	24.0	11.6
1994	47	682.8	706.8	610.3	622.2	.64	.61	1.4	1.5	26.1	14.5	26.0	13.0	27.3	15.0	26.9	13.2
1999	52	781.4	827.8	710.0	739.5	.58	.44	.7	1.1	19.7	15.0	19.9	13.7	24.2	15.9	23.5	14.2
2006	59	967.1	1,031.3	891.9	936.6	.57	.48	1.0	1.2	26.5	16.4	26.0	15.1	29.1	17.5	28.2	15.9

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut;

volume (CVTS) removed in thinnings = 97.4 cubic meters (9 percent of the total gross yield at age 59); volume (CVTS) in mortality = 64.1 cubic meters (6 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 24a—Stand development table for unthinned treatment (plots 22, 25, and 71), per acre basis (ingrowth excluded), English units

		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*	ft^2	ft^3		*No.*	*in*	ft^2	ft^3					*No.*	*in*	ft^2	ft^3	
1966	19	37	6.5	1,277	3.5	86.1	1,167	29	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	49	8.3	1,252	4.4	133.4	2,388	342	0	0	0	0	0	0	0	0	27	2.5	.9	13	0
1973	26	57	9.5	1,208	5.1	169.8	3,577	1,022	0	0	0	0	0	0	0	0	43	2.9	2.0	34	0
1977	30	68	10.8	1,123	5.8	208.1	5,229	2,285	0	0	0	0	0	0	0	0	85	3.2	4.8	99	28
1980	33	76	11.7	1,015	6.4	227.2	6,436	3,413	0	0	0	0	0	0	0	0	108	3.5	7.1	153	4
1984	37	86	12.7	907	7.1	245.7	7,810	4,817	0	0	0	0	0	0	0	0	108	3.8	8.7	215	2
1989	42	98	13.8	755	7.9	256.9	9,297	6,621	0	0	0	0	0	0	0	0	152	4.7	18.4	545	76
1994	47	108	15.1	588	9.0	256.0	10,069	8,056	0	0	0	0	0	0	0	0	167	6.3	35.9	1,244	593
1999	52	118	16.3	498	10.0	270.2	11,634	9,870	0	0	0	0	0	0	0	0	85	5.4	13.3	416	134
2006	59	132	17.9	412	11.4	287.6	13,688	12,176	0	0	0	0	0	0	0	0	92	6.3	20.0	762	397

		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	ft^3				*in*		ft^2		ft^3							
1966	19	1,167	1,167	29	29	0	0	0	0	0	61	0	2	0	61	0	2
1970	23	2,388	2,401	342	342	.23	.22	11.8	12.0	305	104	78	15	309	104	78	15
1973	26	3,577	3,624	1,022	1,022	.22	.21	12.2	12.8	397	138	227	39	408	139	227	39
1977	30	5,229	5,375	2,285	2,313	.19	.16	9.6	10.8	413	174	316	76	438	179	323	77
1980	33	6,436	6,735	3,413	3,446	.19	.13	6.4	8.7	402	195	376	103	453	204	378	104
1984	37	7,810	8,323	4,817	4,853	.16	.10	4.6	6.8	343	211	351	130	397	225	352	131
1989	42	9,297	10,356	6,621	6,732	.17	.09	2.2	5.9	297	221	361	158	407	247	376	160
1994	47	10,069	12,372	8,056	8,760	.21	.13	-.2	7.0	154	214	287	171	403	263	405	186
1999	52	11,634	14,353	9,870	10,708	.21	.12	2.8	5.5	313	224	363	190	396	276	390	206
2006	59	13,688	17,169	12,176	13,412	.19	.10	2.5	5.3	293	232	329	206	402	291	386	227

[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-inch top diameter inside bark (CV6).

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

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 0 cubic feet (0 percent of the total gross yield at age 59); volume (CVTS) in mortality = 3,481 cubic feet (20 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Table 24b—Stand development table for unthinned treatment (plots 22, 25, and 71), per hectare basis (ingrowth excluded), metric units

		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 – – –	
1966	19	11.1	16.6	3,153	8.9	19.8	81.6	2.0	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	23	14.8	21.0	3,092	11.2	30.6	167.1	24.0	0	0	0	0	0	0	0	0	66	6.5	.2	.9	0
1973	26	17.4	24.2	2,985	12.9	39.0	250.3	71.5	0	0	0	0	0	0	0	0	107	7.3	.5	2.4	0
1977	30	20.6	27.4	2,775	14.8	47.8	365.9	159.9	0	0	0	0	0	0	0	0	210	8.2	1.1	6.9	2.0
1980	33	23.2	29.7	2,507	16.3	52.2	450.4	238.8	0	0	0	0	0	0	0	0	268	8.8	1.6	10.7	.3
1984	37	26.1	32.2	2,239	17.9	56.4	546.5	337.1	0	0	0	0	0	0	0	0	268	9.7	2.0	15.0	.2
1989	42	29.8	35.0	1,865	20.1	59.0	650.5	463.3	0	0	0	0	0	0	0	0	375	12.0	4.2	38.2	5.3
1994	47	32.9	38.3	1,453	22.7	58.8	704.6	563.7	0	0	0	0	0	0	0	0	412	16.0	8.3	87.0	41.5
1999	52	36.0	41.3	1,231	25.5	62.0	814.1	690.6	0	0	0	0	0	0	0	0	210	13.6	3.1	29.1	9.4
2006	59	40.1	45.4	1,017	28.9	66.0	957.8	852.0	0	0	0	0	0	0	0	0	226	16.1	4.6	53.3	27.8

		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 –							
1966	19	81.6	81.6	2.0	2.0	0	0	0	0	0	4.3	0	0.1	0	4.3	0	0.1
1970	23	167.1	168.0	23.9	23.9	.58	.57	2.7	2.8	21.4	7.3	5.5	1.0	21.6	7.3	5.5	1.0
1973	26	250.3	253.6	71.5	71.5	.56	.52	2.8	2.9	27.8	9.6	15.9	2.8	28.5	9.8	15.9	2.8
1977	30	365.9	376.1	159.9	161.9	.48	.41	2.2	2.5	28.9	12.2	22.1	5.3	30.6	12.5	22.6	5.4
1980	33	450.4	471.3	238.8	241.1	.49	.33	1.5	2.0	28.2	13.6	26.3	7.2	31.7	14.3	26.4	7.3
1984	37	546.5	582.4	337.1	339.5	.41	.26	1.1	1.6	24.0	14.8	24.6	9.1	27.8	15.7	24.6	9.2
1989	42	650.5	724.6	463.3	471.1	.43	.24	.5	1.4	20.8	15.5	25.2	11.0	28.4	17.3	26.3	11.2
1994	47	704.6	865.7	563.7	612.9	.53	.33	0	1.6	10.8	15.0	20.1	12.0	28.2	18.4	28.4	13.0
1999	52	814.1	1,004.3	690.6	749.3	.54	.30	.7	1.3	21.9	15.7	25.4	13.3	27.7	19.3	27.3	14.4
2006	59	957.8	1,201.3	852.0	938.4	.49	.25	.6	1.2	20.5	16.2	23.1	14.4	28.1	20.4	27.0	15.9

[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 meters (CVTS) or merchantable cubic meters to a 15.2-cm top diameter inside bark (CV6).

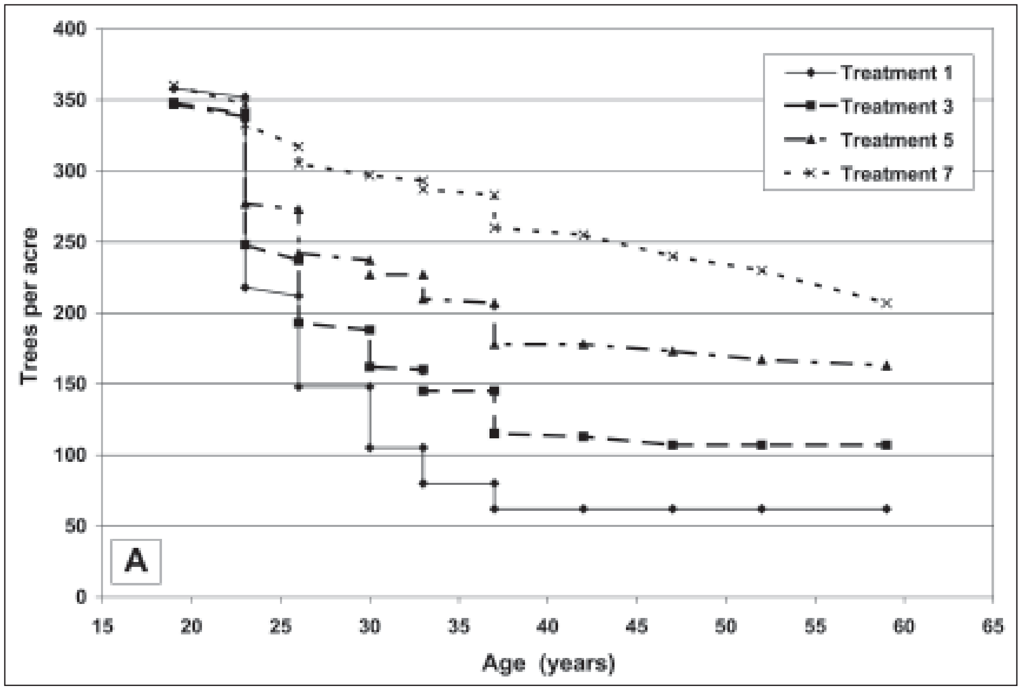
[d] Average d.b.h. cut/average d.b.h. before thinning.

[e] Net = standing + thinning; gross = standing + thinning + mortality; yield does not include volume removed in the calibration cut; volume (CVTS) removed in thinnings = 0 cubic meters (0 percent of the total gross yield at age 59); volume (CVTS) in mortality = 243.5 cubic meters (20 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 is thus unaffected by mortality).

[g] MAI = mean annual increment.

Appendix 3: Figures



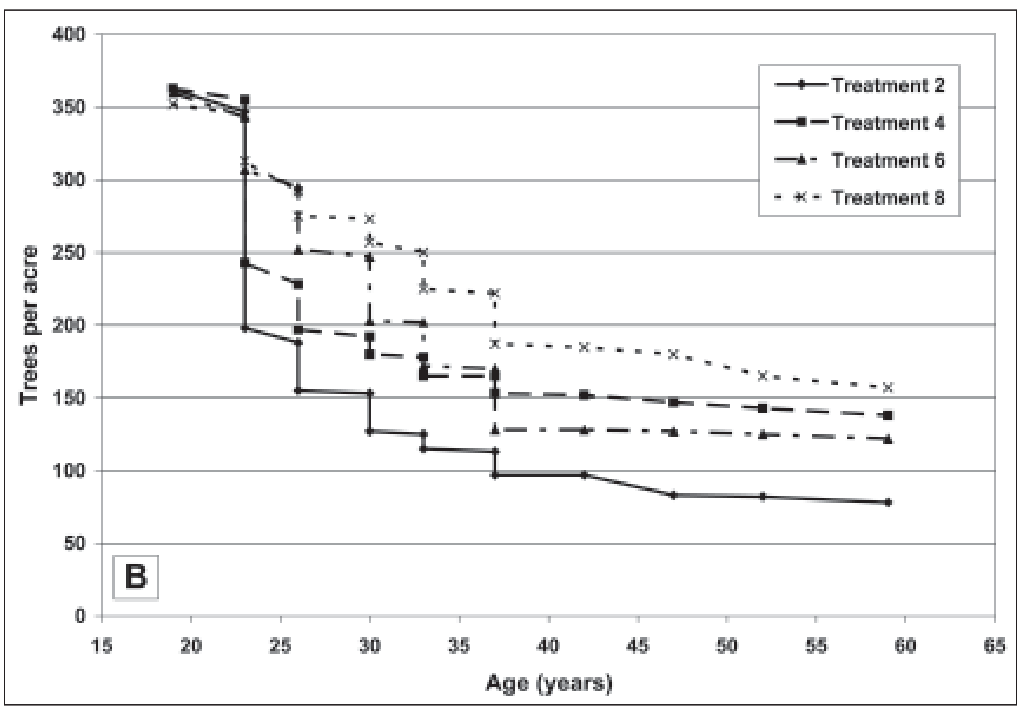
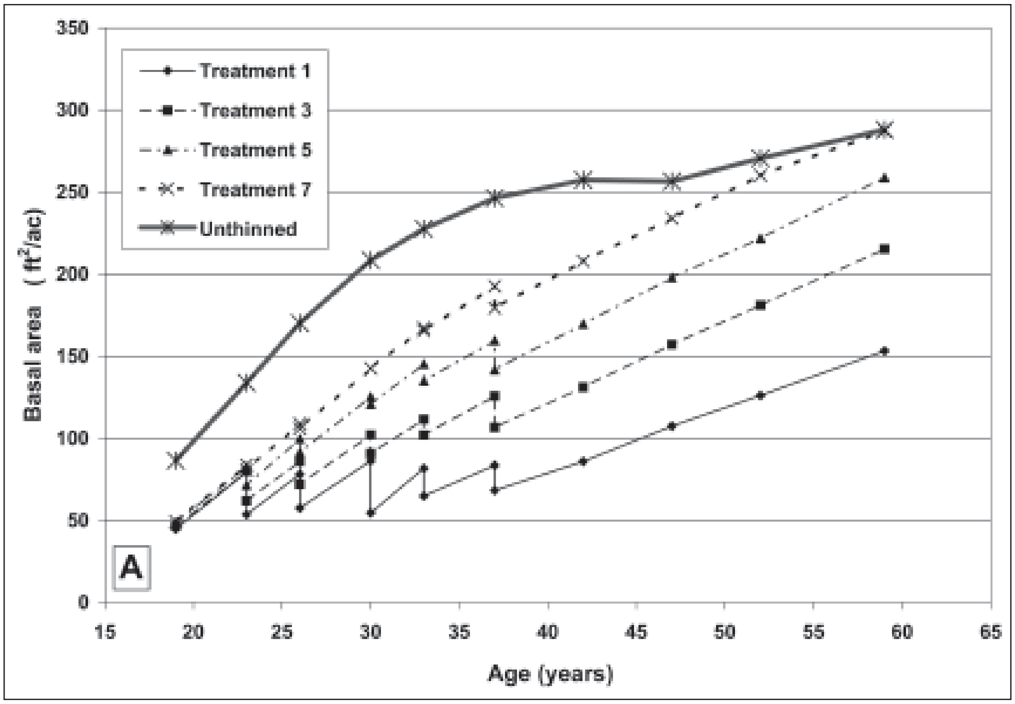


Figure 5—Trends in number of live trees per acre for (A) fixed treatments and (B) variable treatments, ingrowth excluded.



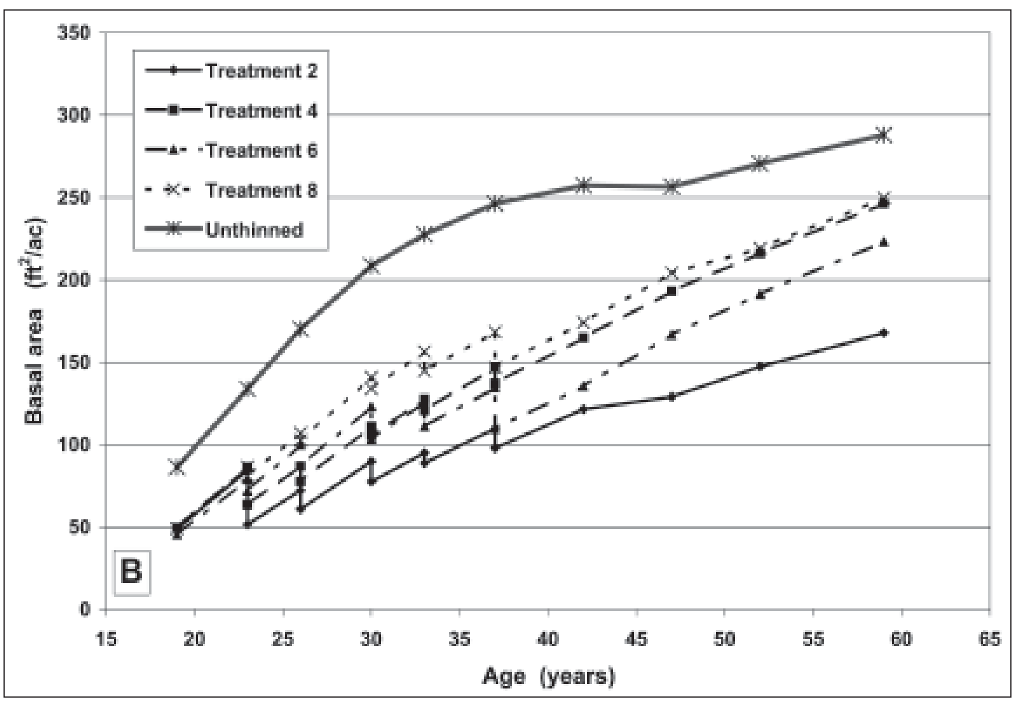
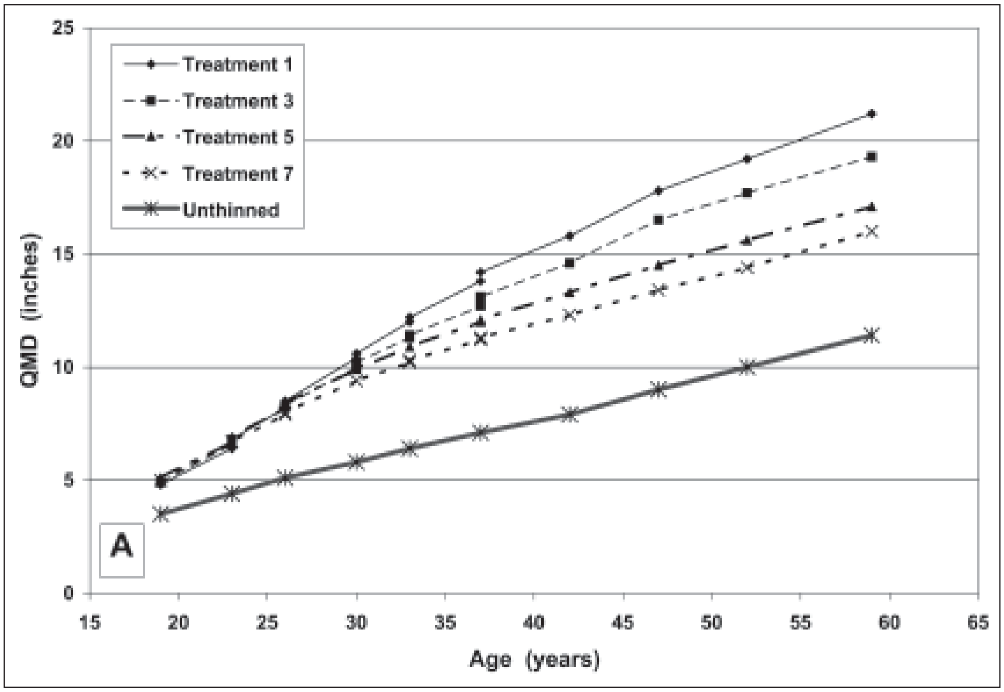


Figure 6—Trends in live basal area per acre for (A) fixed and unthinned treatments, and (B) variable and unthinned treatments.



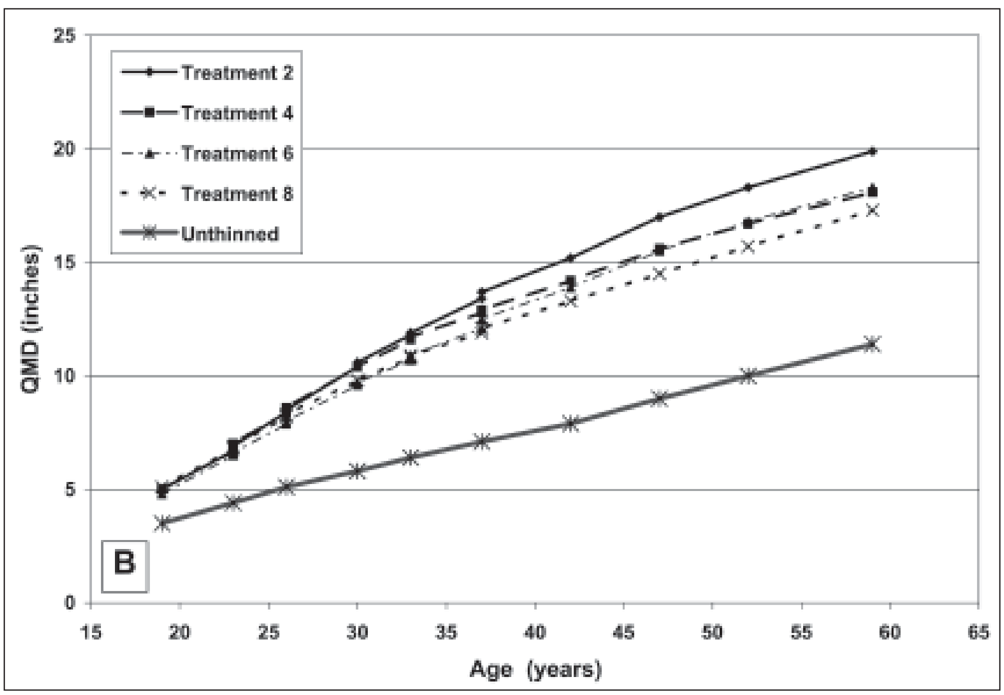
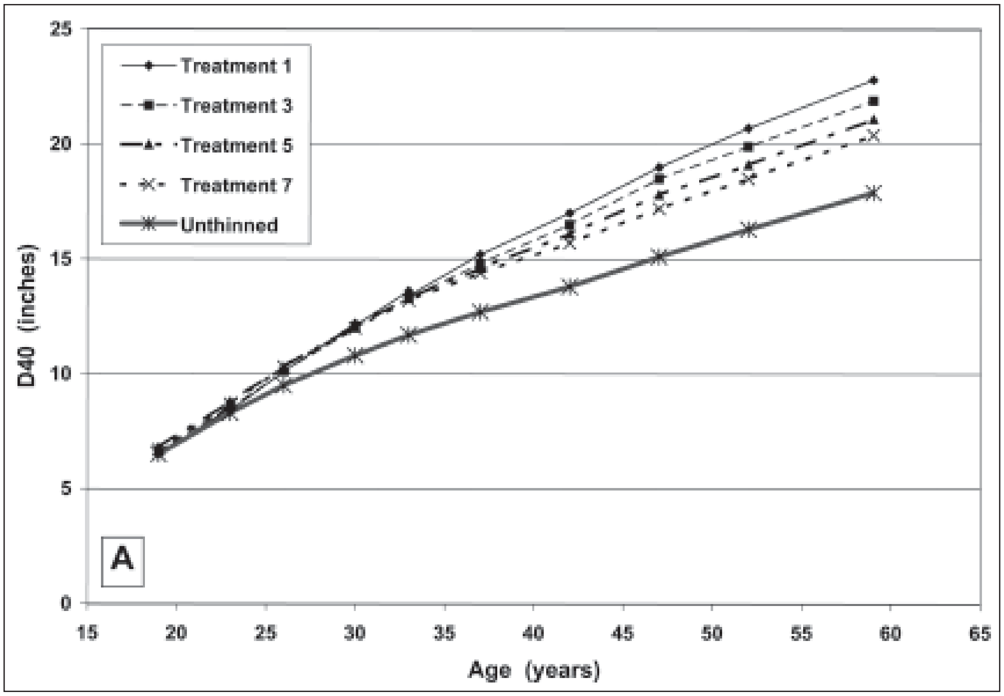


Figure 7—Trends in quadratic mean diameter (QMD) for (A) fixed and unthinned treatments, and (B) variable and unthinned treatments.



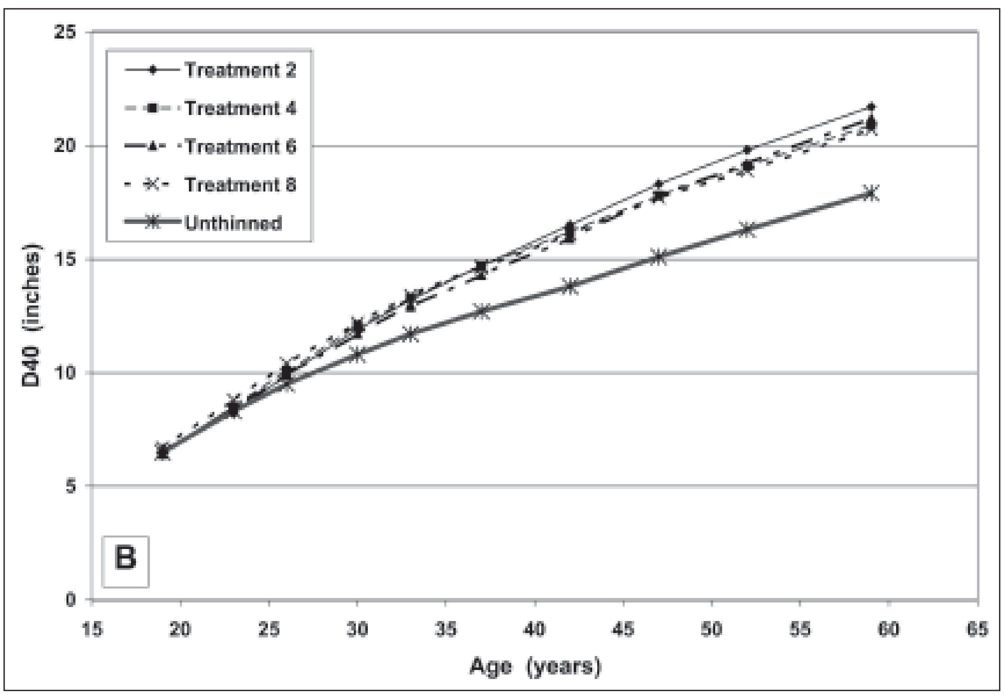
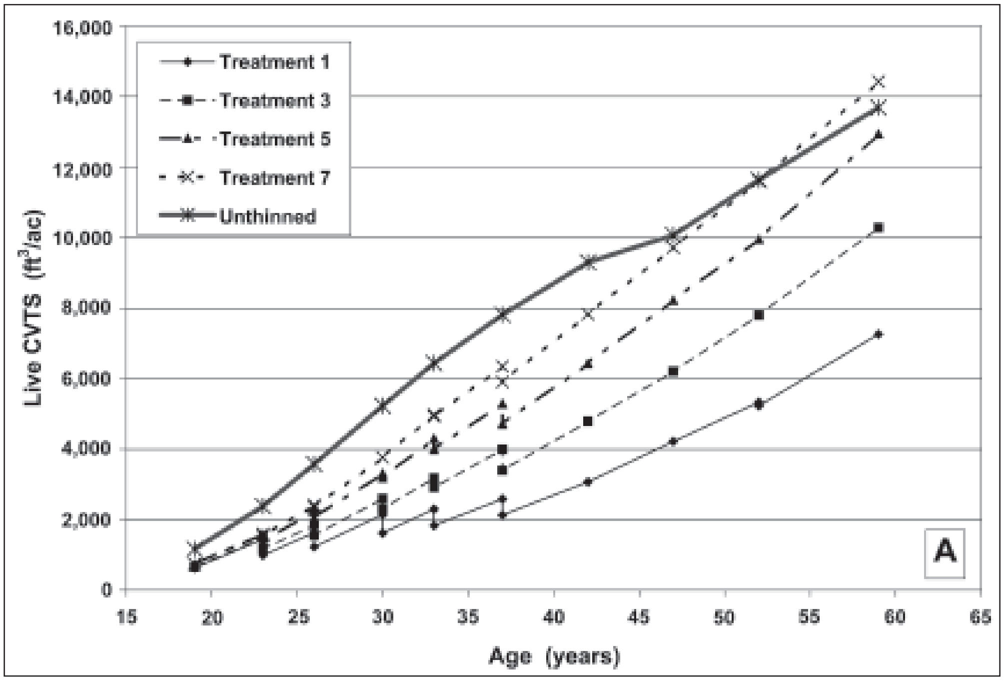


Figure 8—Trends in diameter of the 40 largest trees per acre (D40) for (A) fixed and unthinned treatments, and (B) variable and unthinned treatments.



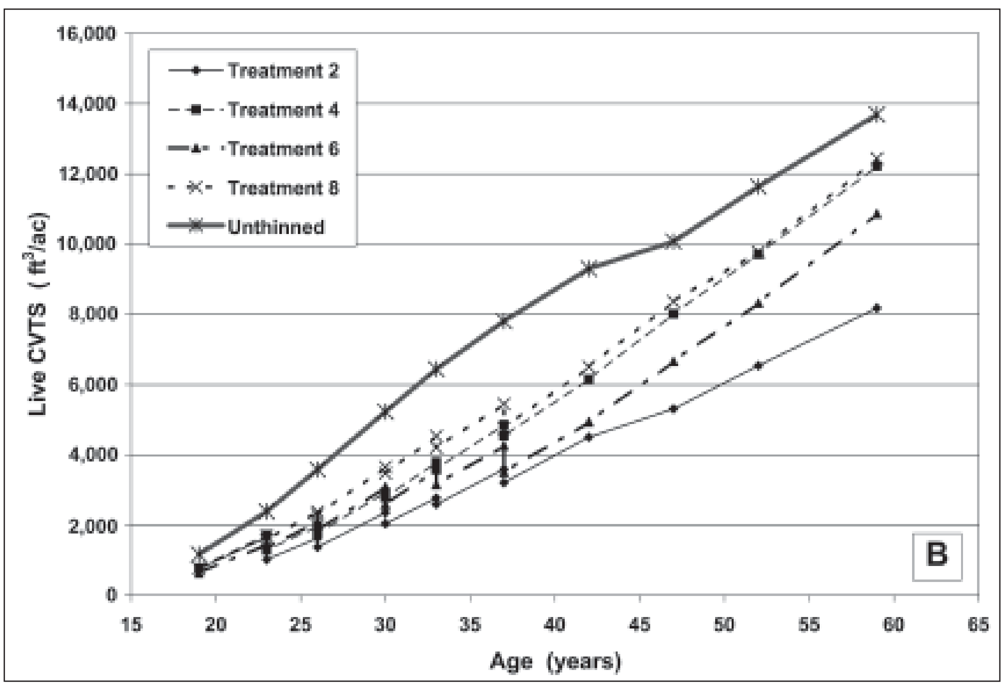
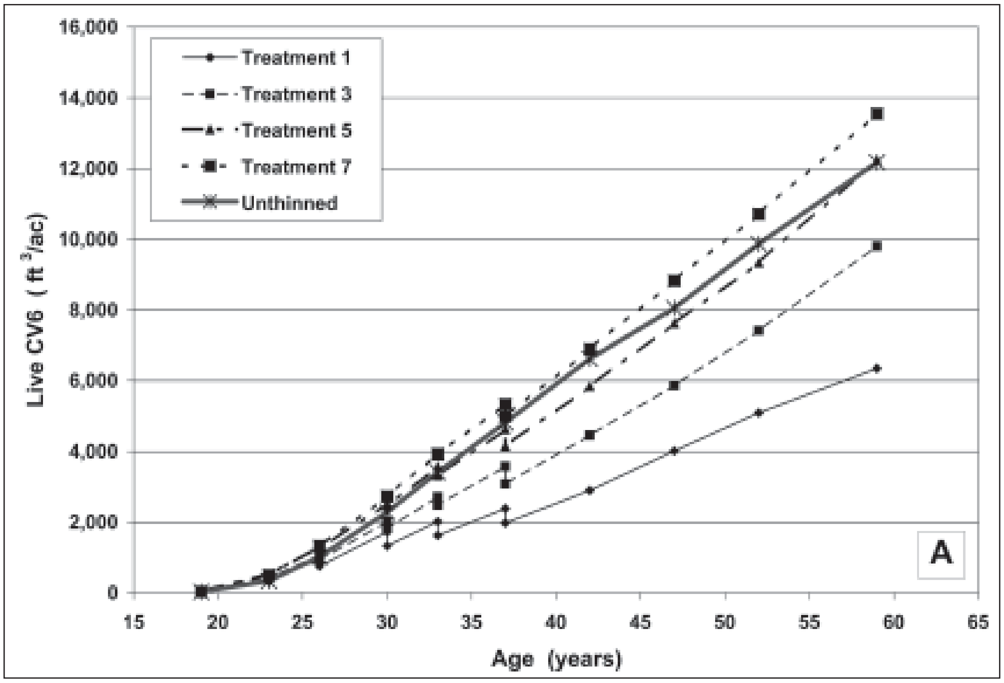


Figure 9—Trends in live total stem volume (CVTS) for (A) fixed and unthinned treatments, and (B) variable and unthinned treatments.



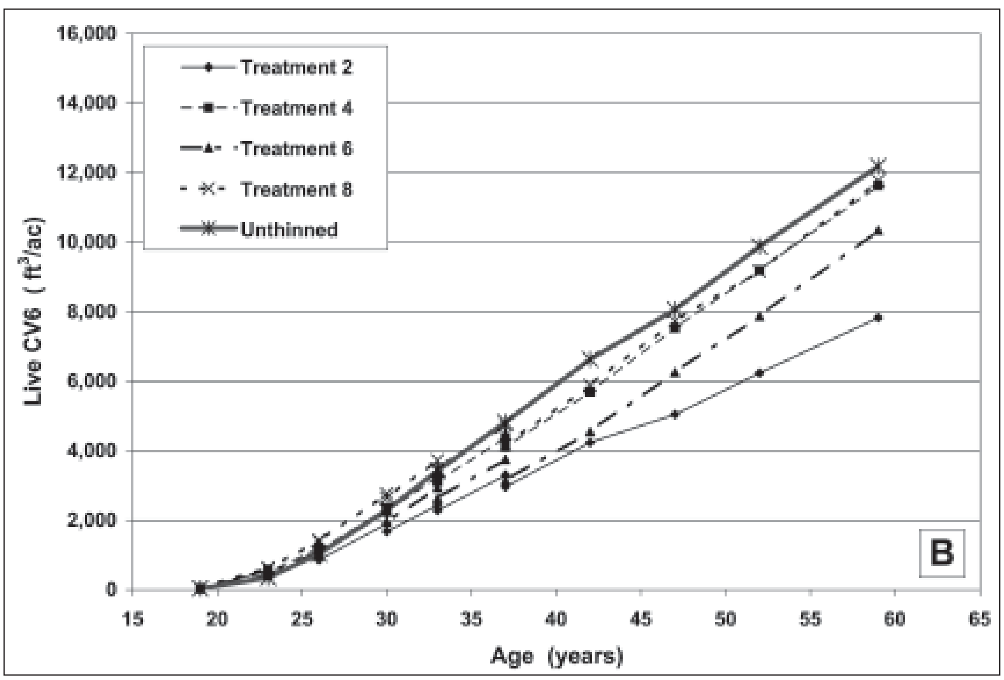


Figure 10—Trends in live merchantable cubic-foot volume (CV6) for (A) fixed and unthinned treatments, and (B) variable and unthinned treatments.

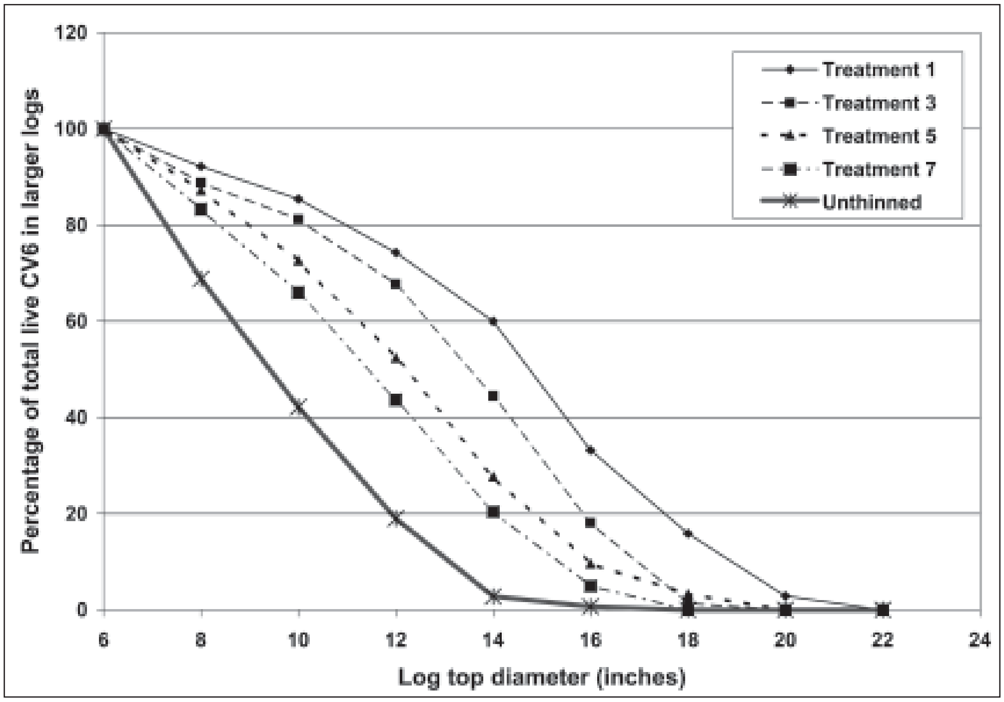


Figure 11—Percentage of live merchantable cubic-foot volume (CV6) in logs larger than indicated diameters, for fixed and unthinned treatments at age 59.

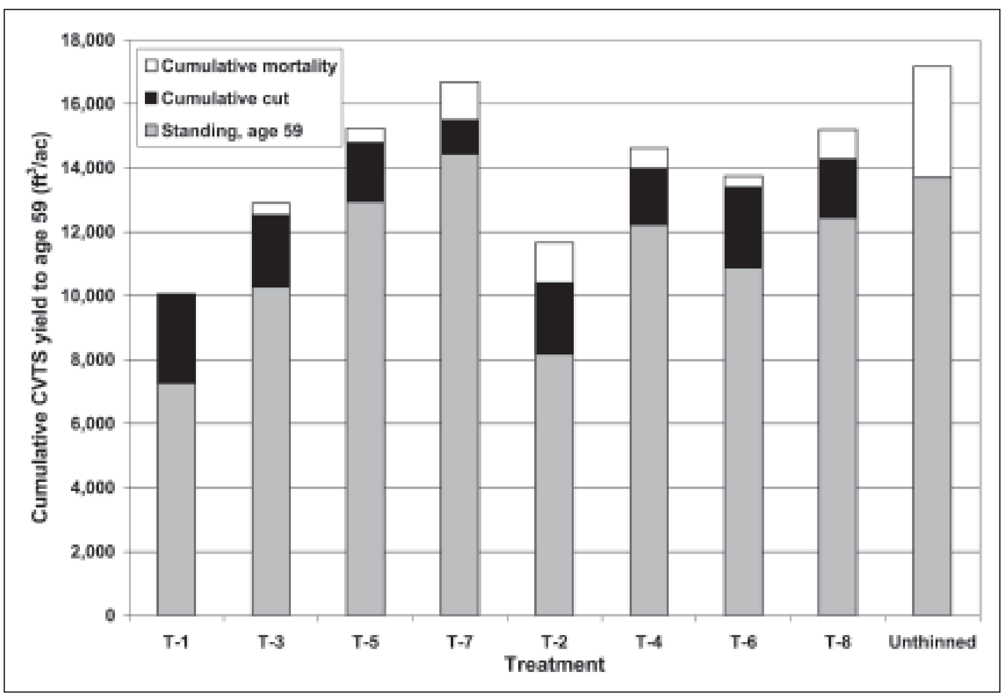


Figure 12—Cumulative gross total stem volume (CVTS) production to age 59, by treatment, including estimated calibration cut of 457 ft^3 per acre.

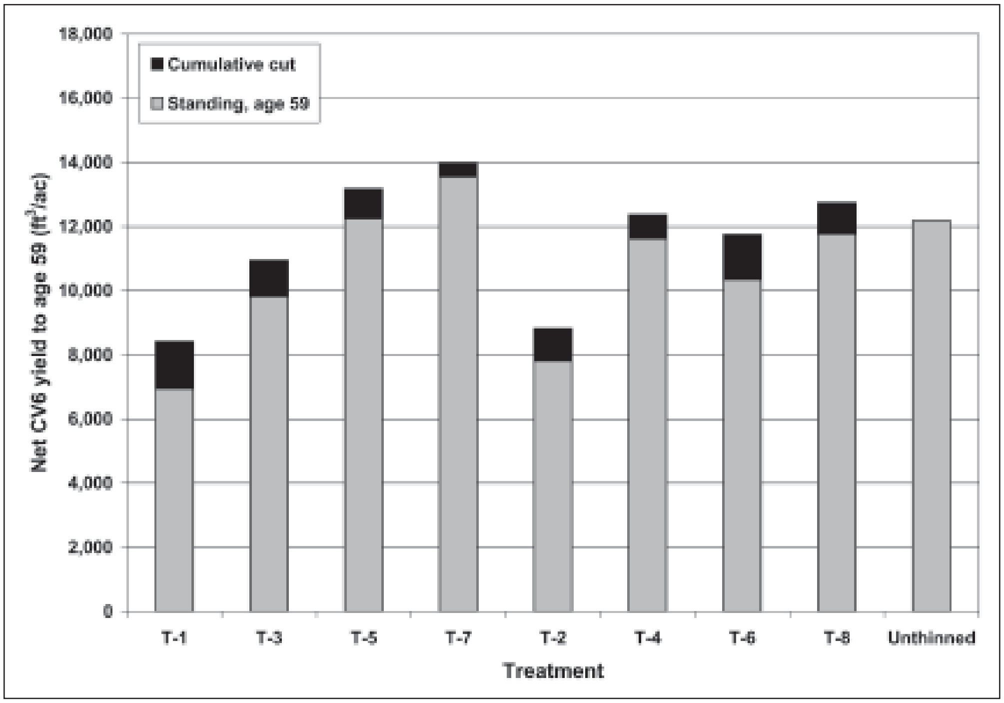


Figure 13—Cumulative net merchantable volume production (CV6) to age 59, by treatments.

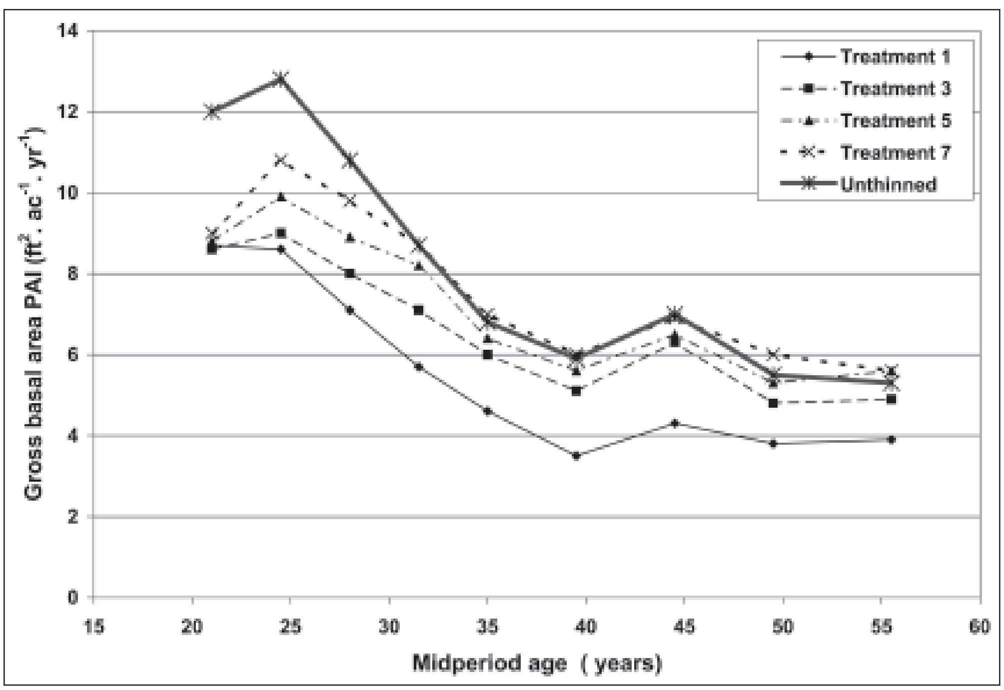


Figure 14—Gross basal area periodic annual increment (PAI) by age, for fixed and unthinned treatments.

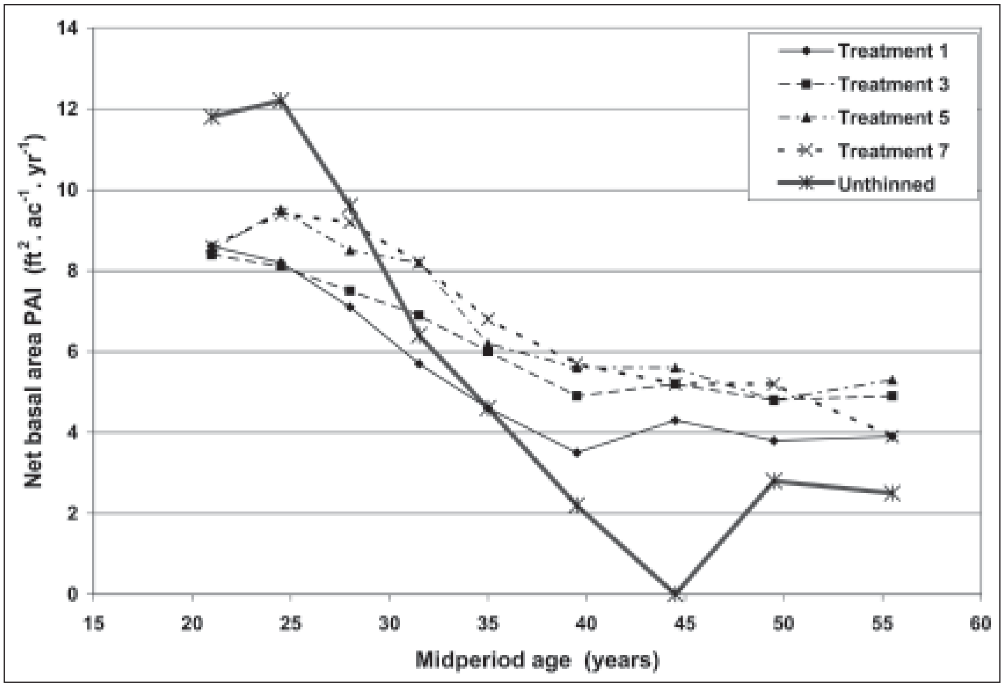


Figure 15—Net basal area periodic annual increment (PAI) by age, for fixed and unthinned treatments.

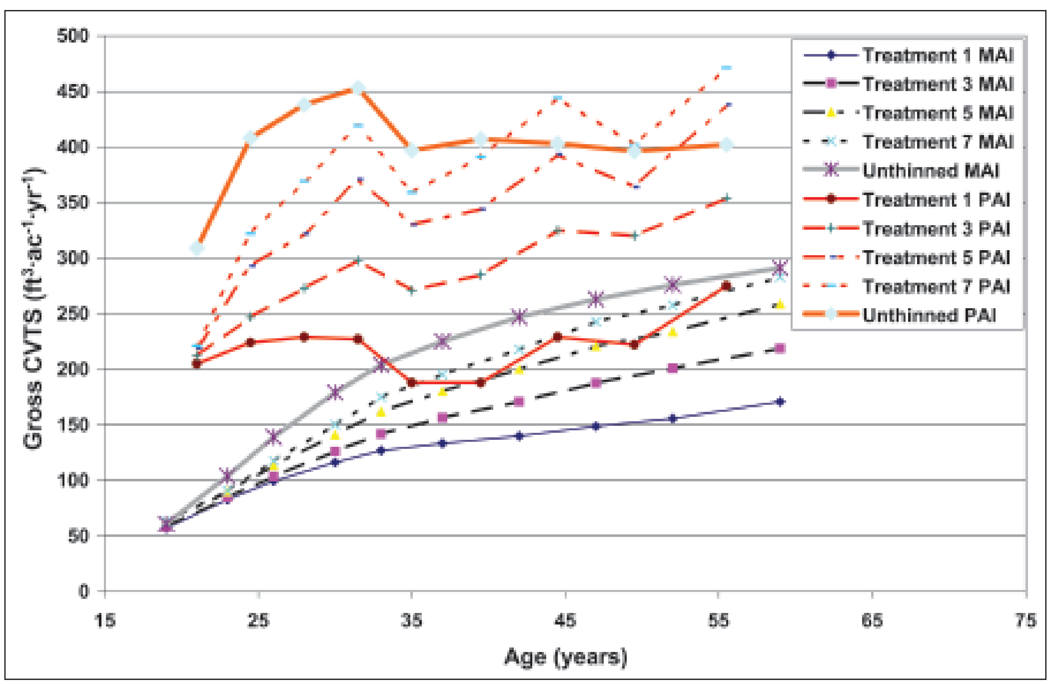


Figure 16—Periodic and mean annual increment (PAI and MAI) trends in gross total cubic-foot volume (CVTS) by age, for fixed and unthinned treatments.

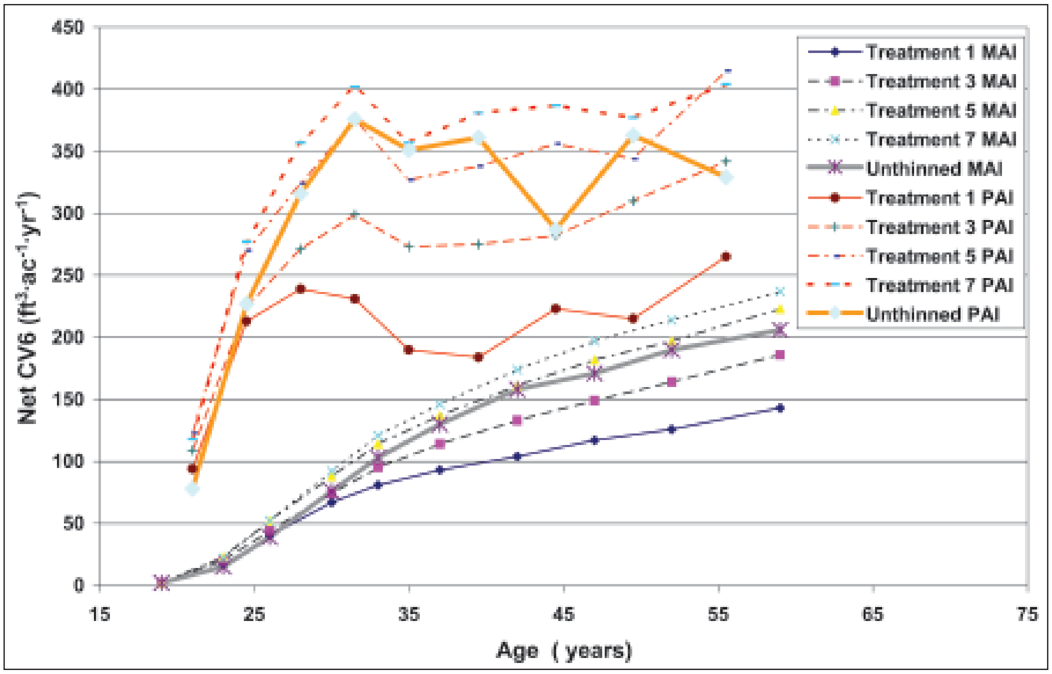


Figure 17—Periodic and mean annual increment (PAI and MAI) trends in net merchantable cubic volume (CV6) over age, for fixed and unthinned treatments.

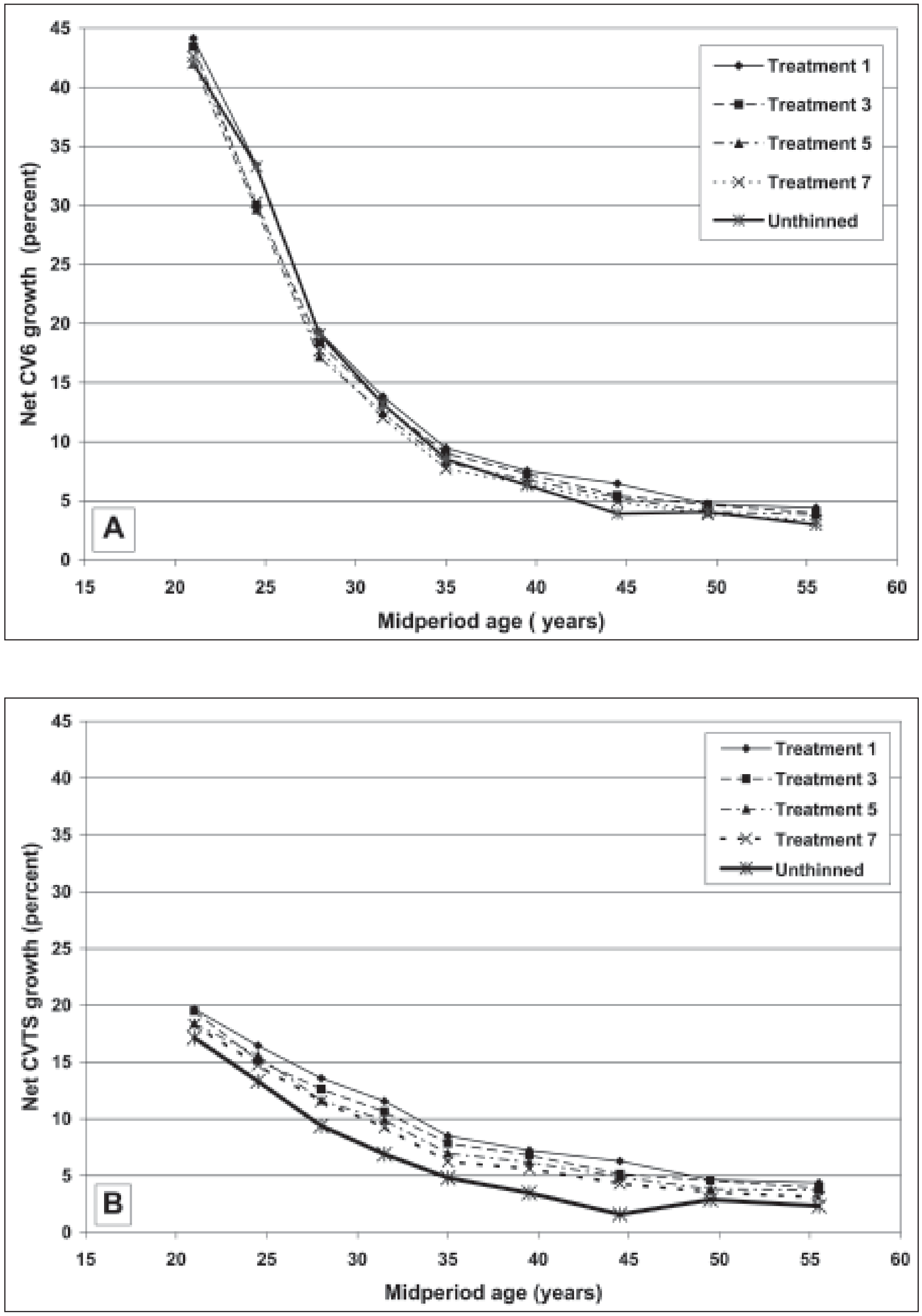


Figure 18—Growth percentages for fixed and unthinned treatments, in (A) net merchantable cubic-foot volume (CV6) and (B) net total stem cubic-foot volume (CVTS).

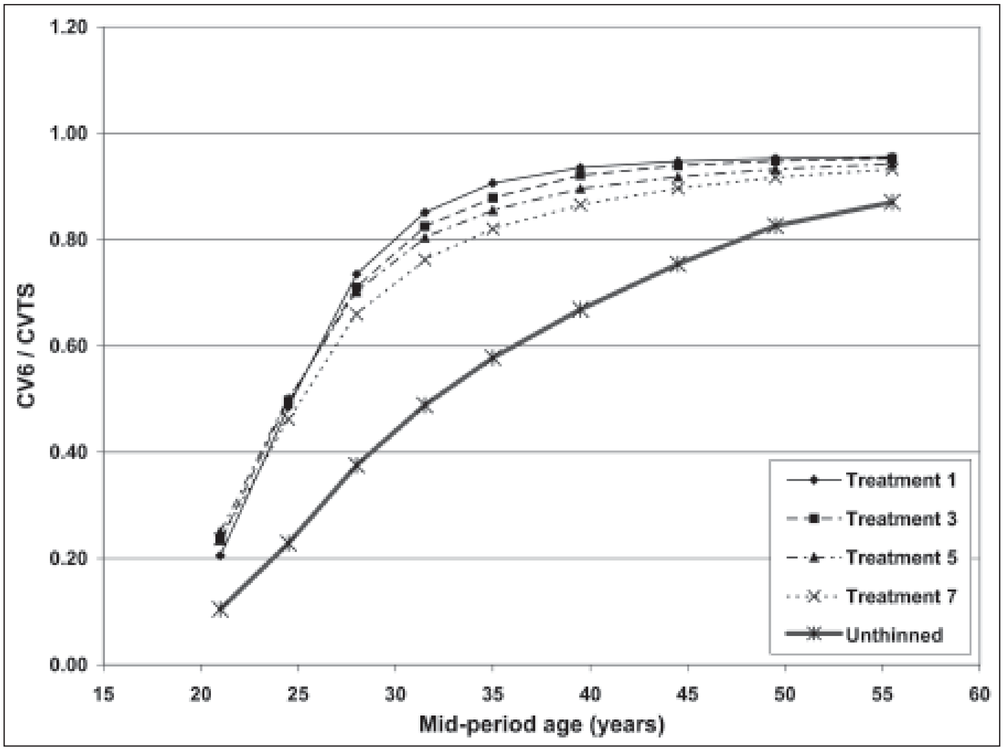


Figure 19—Change in ratios of live merchantable cubic-foot volume (CV6) to live total stem cubic-foot volume (CVTS) with age, for fixed and unthinned treatments.

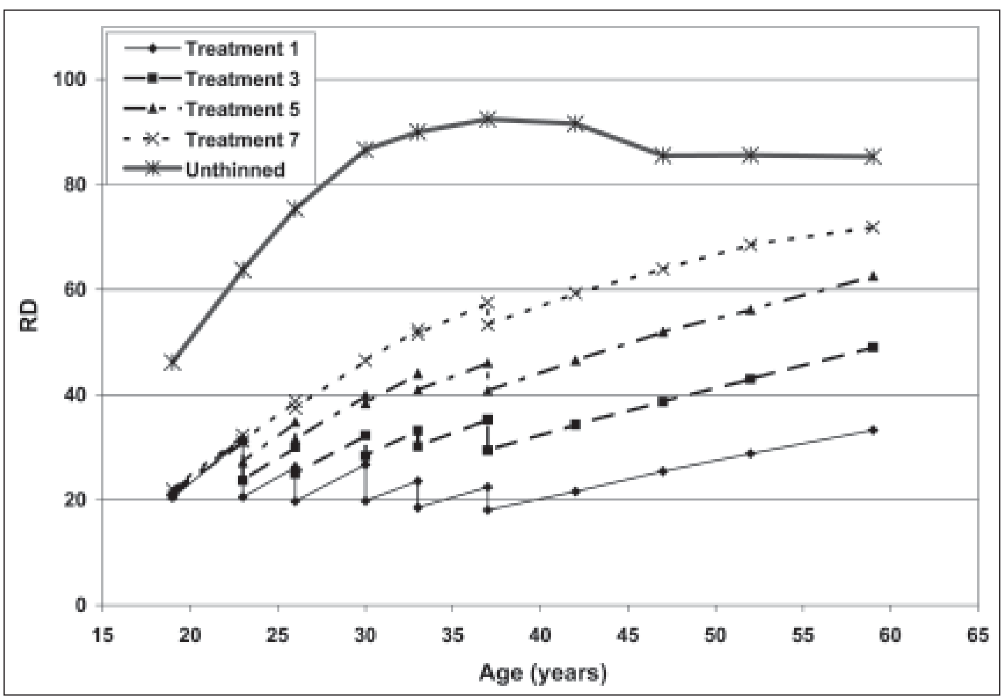


Figure 20—Trends in relative density (RD) by age, for fixed and unthinned treatments.

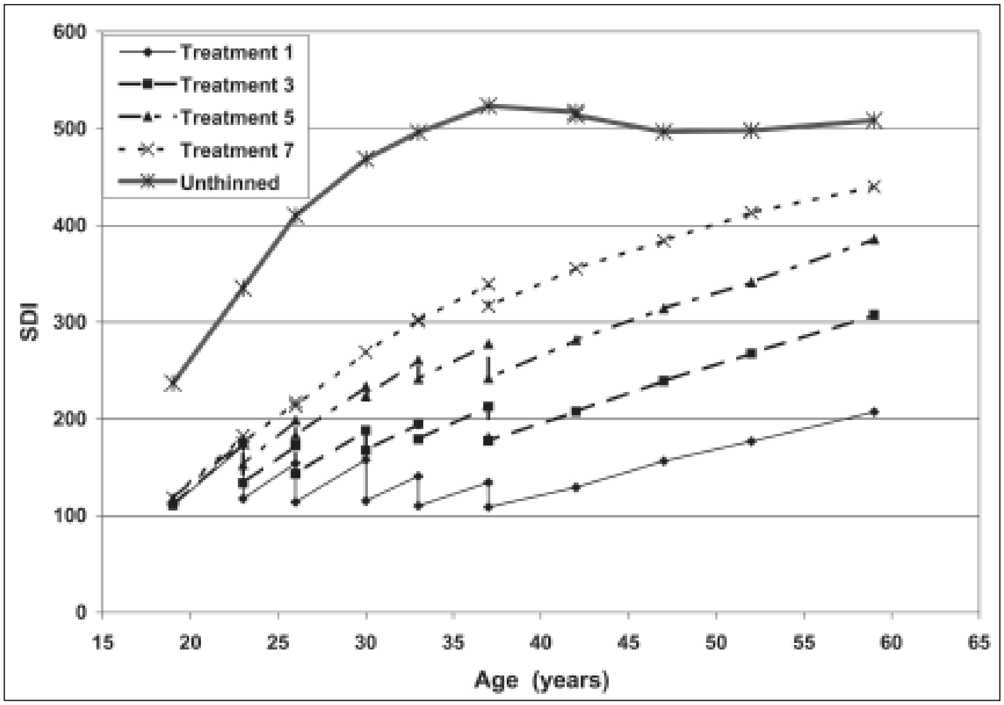


Figure 21—Trends in stand density index (SDI) by age, for fixed and unthinned treatments.

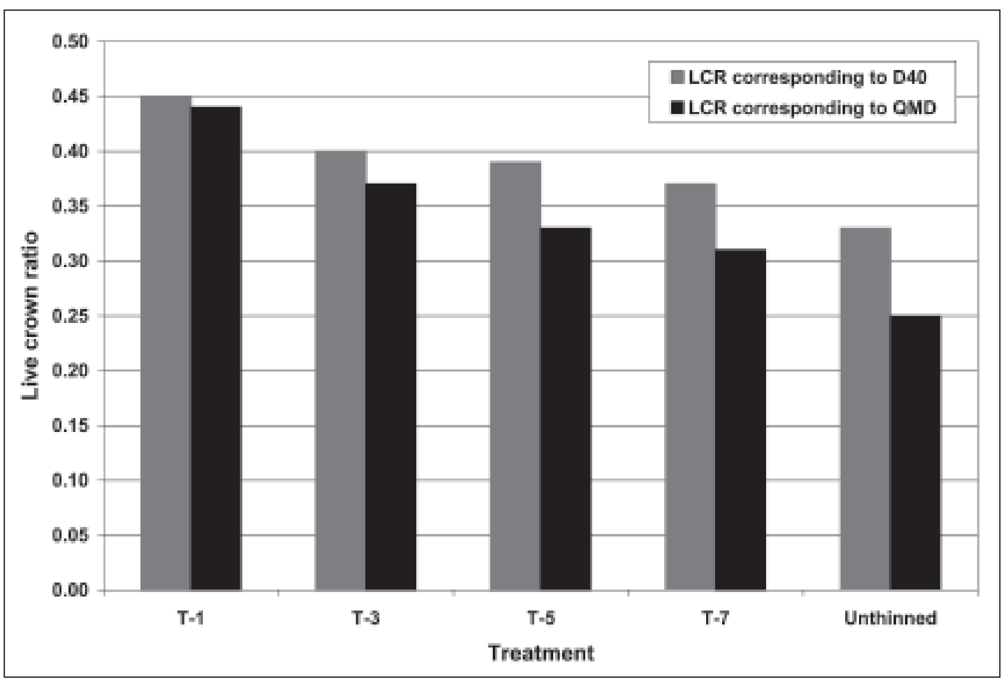


Figure 22—Live crown ratios corresponding to QMD and D40 at age 59, for fixed and unthinned treatments.

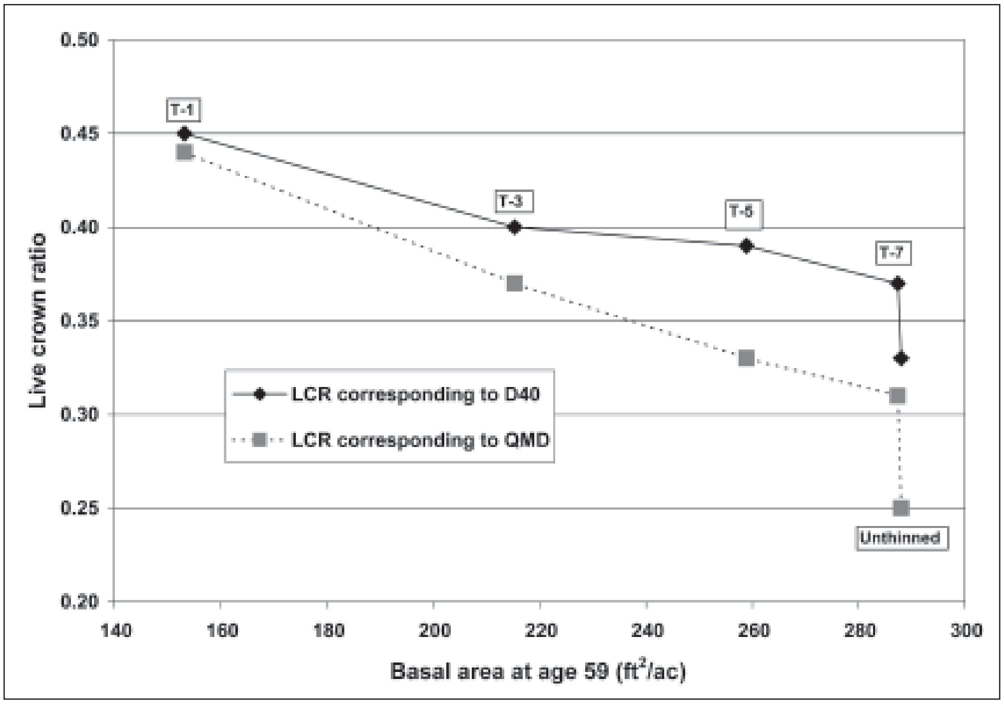


Figure 23–Live crown ratios (LCR) at age 59 in relation to basal area for (left to right) fixed treatments 1, 3, 5, and 7 and unthinned.

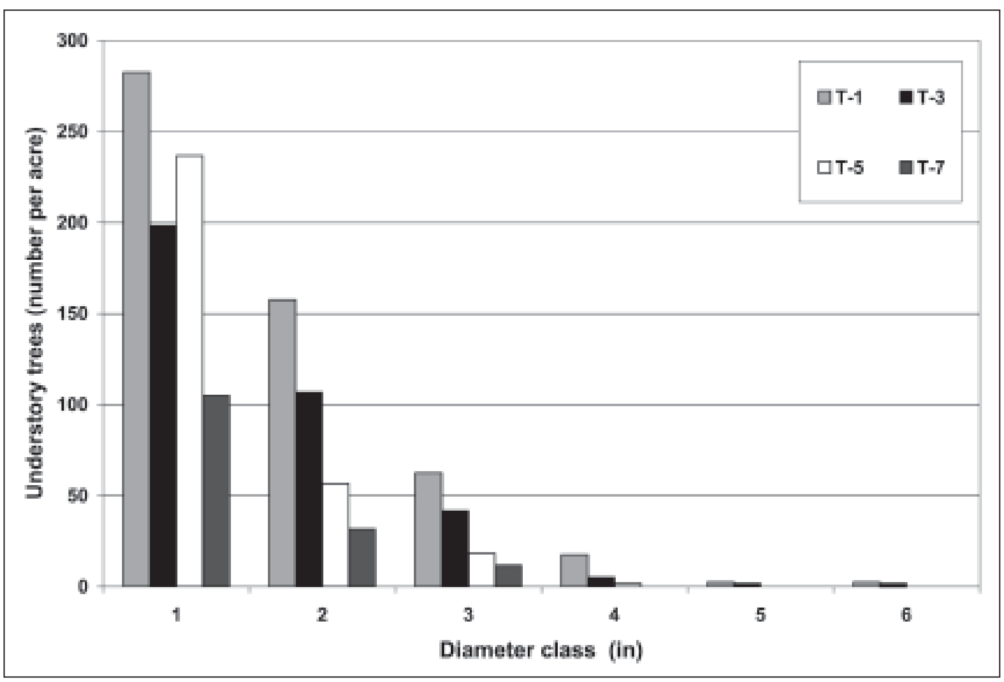


Figure 24—Distribution of understory trees by breast-high diameter class, 1994.

Figure 25–Unthinned plot in 1994, age 47.

Figure 26–Thinned plot in 1994, age 47.

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