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The Louisiana State University and Agricultural and Mechanical College, Ph.D., 1970
Agriculture, forestry and wildlife

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EFFECTS OF THINNING ON YIELD OF LOBLOLLY PINE (*PINUS TAEDA* L.) IN CENTRAL LOUISIANA

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree
Doctor of Philosophy

in

The School of Forestry and Wildlife Management

by
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B.S.F., University of Michigan, 1939
M.S., Louisiana Polytechnic Institute, 1960
May, 1970

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The author is especially thankful to Lloyd P. Blackwell, who made Professor Chapman's original records and those of the Louisiana Tech Department of Forestry available for this study, for the use of his clerical staff, and for his support through funds from the McIntire-Stennis Cooperative Forestry Research Program Project MRP-1.

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ABSTRACT

Growth and yield of a thinning experiment initiated in 1930 in a 17-year-old natural loblolly pine (Pinus taeda L.) stand near Urania, Louisiana, were studied. Two thinning treatments (normal thinning and delayed thinning) and a control (unthinned) were compared on 16 1/4-acre plots. The normal thinning treatment included eight plots, the delayed thinning treatment included five, and the control included three plots. Individual tree measurements were taken periodically on all plot trees until they were 47 to 50 years old.

Thinnings began on the normal thinning plots at age 17 to 19. These plots were thinned four or five times. The delayed thinning plots were first thinned at stand age 35 to 38 and some were thinned again several years later. At age 52, a sample of trees from each of the 16 plots was taken for the determination of tree form class and site index. Increment cores were obtained at age 53 for an analysis of specific gravity.

No statistically significant differences were found in gross cubic-volume increment, but net cubic-volume yield was approximately 20 percent greater on the normal thinning treatment than on the check. Cubic-volume yield on the check or control plots was slightly less than that presented in one of the standard yield tables for unmanaged loblolly pine and greater than yields given in other commonly used yield tables. No statistically significant differences in wood specific gravity were found among the treatments.

The number of trees per acre at the end of the study was about four times greater on the check plots than on the normal thinning plots.

Crown ratio of the dominant pines declined with age to not less than 40 percent in the normal thinning treatment but declined to about 33 percent before increasing to 36 percent in both the delayed thinning and check treatments.

Although height growth was not significantly different among treatments by age 50 based on a sampling of the five tallest trees in each plot, differences in mean annual diameter increment were highly significant. The trees in thinned stands grew larger in diameter and at a more uniform rate than those in the check plots. The average diameter in the normal thinning treatment exceeded by about 5 inches that of the check plots.

Mortality was greatest on the check plots. First thinnings as late as age 35 in the delayed thinning treatment reduced loss by mortality substantially. There was practically no mortality in the normal thinning treatment.

The thinned plots yielded slightly higher form class values than the check plots.

Understory hardwoods increased in abundance following thinnings. The progress of ecological succession on the experimental site was toward a hardwood climax.

The profit margin of the stands in the normal thinning treatment was about three times greater per acre at age 47 than that of the check plot stands. The delayed thinning treatment produced stands having about twice as much profit margin at age 47 than did the check.

In general the results of this experiment confirm accepted silvicultural theories of the development of unthinned and thinned loblolly pine stands.

INTRODUCTION

The trend in present day management of southern pines is toward maximum production of merchantable wood in the shortest period of time. Large diameter trees and quality are factors becoming less important than in the past, and rotation lengths are being adjusted to coincide with the time of the culmination of mean annual increment. Dependent on site, this usually occurs in loblolly pine (*Pinus taeda* L.) stands between age 30 and age 40.

With such rotations, the question arises whether or not thinnings are justified, and if so, when, how heavy, and what type of thinning should be used. Professor H. H. Chapman of Yale University initiated a study at Urania, Louisiana, in 1930, with a primary objective of demonstrating the value of repeated thinnings versus no thinnings in even-aged stands of loblolly pine. This paper is a detailed report on the results of the original experiment established by Chapman.

The author's objective was to compare the growth and development of plots which were considered to be thinned normally with plots first thinned at an advanced stand age and with unthinned plots. It was expected that some guides for thinnings, rotation length for the production of various products, and economic advantages of certain practices over others might be derived from the results of the analysis.

The study is unique in that continuous records of height and diameter growth over a period of 30 years to stand age 50 are available. The experimental plots are probably the oldest of their kind in the South. Although they were not installed according to sophisticated statistical design, they afford a study of growth and development of loblolly pine over a long period of time.

Definition of Terms

Technical terms are defined in accordance with those in Forestry Terminology (Society of American Foresters 1958). Terms used frequently in this study and their definitions are listed as follows:

1. Site Index--An expression of forest site quality based on the height of the dominant stand at a chosen age (50 years in this study).

2. Diameter Breast High (d.b.h.)--The diameter of a tree outside bark at 4.5 feet above the average ground level.

3. Girard Form Class--The percentage ratio of the diameter inside the bark at the top of the first 16-foot log (17.5 feet above average ground level) to the diameter outside bark at breast height.

4. Crown Ratio--The ratio between the length of the crown and the total height of the tree, expressed in percent.

5. Net Growth--Growth, including thinnings if any, minus unsalvaged mortality.

6. Gross Growth--Growth including unsalvaged mortality and thinnings if any.

7. Mean Annual Increment (MAI)--The total growth divided by the total age.

8. Ingrowth--The volume or number of trees that have grown past an adopted lower limit of measurement during a specified period.

9. Thinning--Cutting in an immature stand to increase its rate of growth, to foster quality growth, to improve

composition, to promote sanitation, to aid in litter decomposition, to obtain greater total yield, and so recover and use material that would be lost otherwise.

10. Crown Thinning--Cutting is made in the upper crown classes by the removal of codominant and dominant trees that are competing strongly with the most promising individuals of these classes.

11. Low Thinning--Anticipates natural thinning of the stand through competition, by working upward from overtopped to dominant trees.

12. Normal Thinning--Thinnings performed four or five times at about five-year intervals on selected plots in this study.

13. Delayed Thinning--Thinnings made once or twice after stand age about 35 years on selected plots in this study.

14. Check--Control plots never thinned.

15. Dominant Crown Class--Trees with crowns extending above the general level of the crown cover and receiving full light from above and partly from the side; larger than the average trees in the stand, and with crowns well-developed but possibly somewhat crowded on the sides.

16. Codominant Crown Class--Trees with crowns forming the general level of the crown cover and receiving full light from above, but comparatively little from the sides; usually with medium-sized crowns more or less crowded on the sides.

17. Statistical Significance--A test of statistical significance is a measurement of the probability that an observed value may have arisen purely as the result of chance effects. Differences between two or more statistics are considered to be statistically significant in this study if the probability of this difference occurring by chance is five percent or less (indicated by an asterisk in tables to follow). A highly significant difference (marked by a double asterisk) is considered to be one associated with a probability of a chance difference of one percent or less.

REVIEW OF LITERATURE ON THINNING SOUTHERN PINE

Many studies on the effects of thinnings have been conducted in southern pine stands. Most of these studies were statistically unsophisticated; they aimed at description, measurement, treatment, and analysis of results for specific stands and conditions over relatively short periods of time. Modern statistically designed thinning experiments have been initiated in recent years. However, long-term results from most of these experiments are not yet available.

Soil and Light Factors

In most thinning experiments, increases in size of the remaining trees have been attributed to reduction of competition, alteration of environment, and greater availability of water and nutrients to the remaining trees (Kramer and Kozlowski 1960).

Bassett (1964) and Zahner and Whitmore (1960) found critical relationships between amounts of soil moisture, degree of thinning, and continuity of diameter growth in loblolly pine. Generally, if water supply was adequate, heavier densities of stocking could be maintained and conversely, if water was limited, a sparser stocking was necessary to maintain growth late in the summer. Responses to thinnings were most significant in diameter growth, whereas height growth was not affected. A reduction in either basal area or number of trees per acre to considered minimums provided freedom from root competition up to only five years.

Korstian and Coile (1958) used trenched plots in loblolly pine stands in North Carolina to show the importance of soil moisture as a factor in tree growth. Zahner (1960) traced the normal soil water regimes during the growing season in thinned and unthinned southern pine stands. He pointed out that while the thinned stand transpires less than the unthinned during the wet spring weather, the situation is reversed during the late summer dry period, because the thinned stand still has a moisture supply and the other does not.

Working in longleaf pine (*Pinus palustris* Mill.) stands, Chapman and Bulchis (1940) concluded that root competition is the major factor in controlling growth of residual seed trees.

Competition for light was thought by Harms (1962) to be a greater limiting factor than soil moisture in his study of 6-year-old slash pine (*Pinus elliottii* Engelm.) plantations in Georgia.

Effects of Thinning on Growth and Yield

The effect of thinning on growth and yield is important to forest managers. Findings from some southern pine thinning experiments showed a greater volume growth over various periods of time from thinned stands when compared to unthinned stands (Akerman 1928, Frothingham 1942), particularly in the case of lightly thinned stands (Stahelin and Ware 1948). Other investigators have found that unthinned southern pine stands yield more than thinned stands (Bull 1950, Roach 1958). As a general rule, however, total volume production in cubic feet is apparently little affected by thinning, provided that the comparison is not made with excessively thinned stands or with stands so dense that height growth is curtailed (Smith 1962).

The only reliable way of increasing yield in cubic volume from a stand by thinning is to use thinning as a device for anticipating losses of volume which occur through natural mortality as the stand ages. This generalization has been confirmed in southern pine experiments by Li (1923), Williston (1950), Moyle (1956), and others.

In a thinning study of shortleaf pine (Pinus echinata Mill.), Williams (1959) reported that basal area growth was greater in unthinned than in heavily thinned plots. Similar findings were reported by Livingston (1952) for loblolly and slash pine plantations. Jackson (1968) studied loblolly and slash pine basal area increment before and after thinning, finding that there was a steady decrease in growth percentage before thinning, then a rapid increase immediately after thinning, followed by a decline. Nelson (1961) indicated that cubic volume growth in thinned loblolly stands was related to basal area, as well as to stand age and site qulity.

In thinned stands, much of the potential value usually resides in the trees which have been released from competition by thinning and which form the final crop. A typical crop tree released in a series of thinnings has a diameter growth pattern in which the width of the annual rings decreases very slowly but steadily outward from the pith. The increase in final diameter of crop trees is approximately 20 percent (Smith 1962). Although diameter growth is stimulated by thinning, height growth is relatively unaffected (Limstrom and Deitschman 1953).

There are indications that loblolly responds to thinning more readily than slash pine. Adams (1936), working in loblolly pine,

found that the crop trees had a volume increment 32 percent greater in thinned stands than in unthinned stands. However, for a slash pine plantation in southeastern Louisiana, Keister (1967) reported that a series of thinnings was relatively ineffective in increasing the diameter of the largest trees at age 29, compared to an unthinned control. Although Johnson (1961) and Malac (1968) pointed out that slash pine does not respond well to release, Dell and Collicott (1968) found that yield of slash pine plantations was increased by an initial commercial thinning in a severely cankered stand.

Economic Benefits of Thinning

Thinning can be used by the forest manager to obtain benefits of earlier merchantability and income, the production of more valuable products (associated with large trees), and reduction of rotation length (Chapman 1953, 1955; Bennett 1956, 1963; and McMinn 1963). By allocating wood production to an optimum number of trees of high potential for value increase, thinning is often an effective technique for increasing the economic yield from a stand.

Several studies have shown that thinning is economically attractive. The findings of Williston (1967) for loblolly pine plantations in western Tennessee showed that thinning increased economic yields in pulpwood rotations. Keister et al. (1968) determined from results of a thinning experiment in slash pine plantations in Louisiana that thinning was financially advantagous, giving the economic assumptions made in their study.

In other experiments, thinning did not prove to be financially rewarding. For example, Wenger (1948) found that thinning did not prove profitable in a 45-year-old understocked longleaf pine stand. Malac (1968) reported that thinning is not economically attractive in slash pine plantations in Georgia managed on a 30-year pulpwood rotation. Johnson (1961), however, recommended that heavy thinnings five or ten years before harvest cutting should be given serious consideration in slash pine plantations because of the possibility of increasing the net present worth of such stands.

Methods, Frequency, and Severity of Thinnings

There are many reports on studies relating to the methods of thinning. The commonly designated low, crown, selection, and mechanical or row thinnings, along with variations and combinations of them, have been tested both for their effect on the development of the residual stand and their effect on growth and yield. There is general agreement that the severity of thinnings is correlated with frequency and that frequent light thinnings in southern pine stands beginning at early stand ages led to better yields and value than that achieved in untreated check stands (Lindgren 1948; Gruschow 1949; Mann 1952; Minckler and Deitschman 1949, 1953; Chapman 1951; and Gaines 1951).

Evans and Gruschow (1954) concluded that optimum volume growth in longleaf pine stands was possible over a wide range of stand densities.

Reductions in basal area per acre and spacings between trees are common measures for the intensities of thinnings. Various guides for thinning have been developed using such factors as spacing, diameter, height, live-crown ratio, number of trees per acre, etc. Among them are mathematical formulae designed to measure stand density after thinning and equations based on relationships between growth and measures of stand parameters (Smith 1962). Reineke (1933) presented a stand density index equation which furnished the number of trees per acre based on the diameter of a tree of average basal area and a constant for a given species. Wilson (1951) proposed that the spacing of trees be governed by tree height.

"Rules of thumb" thinning guides are represented by the well-known "diameter plus" and "diameter times" spacing guides (Davis 1935, Averell 1945, and Mitchell 1952). In general these rules related average spacing of trees left after thinning to average diameter of the stand, with or without provision for a constant basal area.

Some of the above approaches to developing guides for thinnings are based on "normal" yield tables which are measures of supposedly ideal, fully-stocked, unmanaged stands at selected ages for a given site and species. In practice in managed stands normal yield values may be unattainable or perhaps even undesirable. Morriss (1958) recommended that there should be no fixed spacing between trees or basal area per acre left after thinning but, dependent on site and age, that stand density be kept below 80 percent of normal; the frequency of thinnings would be governed by the time interval necessary for the stands to reach 80 percent of normal. Wiley (1959) maintained

that normal yield tables were useless in managed stands and that the best measure of stocking was by means of correlating crown diameter and d.b.h.

The time and intensity of thinning is governed chiefly by stand density, site, and management objective. For loblolly pine in even-aged stands Chapman (1942) recommended that first thinnings be deferred until the value of the thinned volume justified the cost of the operation. Generally most first thinnings could be made by age 20 in stands of average density and on medium sites. First thinnings at early stand ages help maintain satisfactory crown ratios and afford better control over the selection of crop trees. Benefits are substantial even if first thinnings are made in more advanced stand ages. Often a large volume of merchantable material can be salvaged, and if larger diameters are desired more quickly, overstory loblolly pines respond quite favorably (Guttenberg 1954).

Frequent light thinnings are favored in loblolly pine silviculture. A five-year cycle is popular and three to five thinnings are needed in a rotation long enough to produce sawlogs. The number of thinnings is regulated by the stand density at the time of the first thinning. More thinnings are needed if a stand is overdense in the beginning.

In a study of thinning methods applied to slash pine plantations, Keister (1966) found that light crown and selection thinning was economically more profitable than heavy crown thinning, light low thinning, or not thinning.

Bull (1934, 1935) and Chapman (1942) recommended for loblolly pine the removal of trees competing directly with selected final crop trees.

Low thinnings, at least in unmerchantable sizes, did not benefit the stand. Bassett (1966), however, found little difference in yield and size of residual loblolly trees at age 35 in stands that were thinned from above compared to those that were thinned from below. Belanger and Brender (1968) reported from a study of thinnings in loblolly pine plantations that growth in cubic feet in stands thinned selectively from below was twice that achieved by stands thinned from above.

Low and frequent thinnings were recommended by Kennedy (1961) for loblolly pine stands in order to maximize yield in dollars. Chaiken (1941) felt that low thinnings in loblolly pine were better than crown thinnings because of the mortality in small, residual trees left after crown thinnings.

Bull (1949) suggested thinning southern pine on the basis of tree vigor and quality as well as spacing between trees; he recommended heavy thinning if large diameters are desired and light thinning if maximum volume and clear length of bole is wanted.

In recent years, foresters have shown interest in row thinning for southern pine silviculture. Whipple (1962) reported that row thinning gave less volume growth than selective (individual-tree) thinning in both loblolly and slash pine plantations. However, Little and Mohr (1963) stated that growth response from row thinning loblolly pine approximates that from moderate selective thinning.

Fender (1968) compared several kinds of row thinning with conventional selective thinning in 13-year-old slash pine plantations. The row thinning treatment in which every fourth row plus poor-risk

trees in the residual rows were removed had almost identical net growth to the selective thinning.

Dyer (1968) reported that it is difficult to get selective thinning accomplished in many pine-growing areas in Georgia because of labor shortages. He recommended that Georgia landowners continue selective thinning where feasible, and where it is not, every sixth row be removed in the first thinning.

Enghardt (1968) stressed that when levels of pine growing stock are comparable, selection of individual trees is more effective than row thinning in stimulating stand growth. He felt row thinning will be the solution for large areas of closely spaced plantations that have to be thinned in a short period of time without regard for the quality of the residual stand. He also pointed out that selective thinning and row thinning can be combined.

Thinning methods are sometimes influenced by the need to protect the residual trees from damaging agencies. In areas of frequent glaze storms, Brender and Romancier (1965) recommended that pine stands should be thinned early, frequently, and from below. Where hurricanes are prevalent, the heavier the thinning in slash pine plantations, the more severe is the damage (Nelson and Stanley 1959, Enghardt 1962). Because of danger from root rot (caused by Fomes annosus (Fr.) Cke.) Powers and Boyce (1963) favored thinning only one time in loblolly and slash plantations.

Thinning for gum naval stores production in slash pine stands was recommended by Akerman (1928). He advocated choosing 200 trees per acre as crop trees and releasing them from competition.

Crow (1963) stressed the idea that the choice of thinning method and intensity for southern pine should be based primarily on the objectives and wishes of the forest owner; a pulpwood company, for example, should either thin not at all or lightly and from below; sawtimber men ought to thin heavily with the crown method; and the farmer might find the selection method best if he desired large trees for farm use and a crop of grass under the trees for grazing.

Crown Ratio and Response to Thinning

The size of the crown is influential in the response of released trees. The original crown ratio is more important than the change after release. If stands are allowed to develop to where the crown length is drastically shortened, recovery is often very slow. Bennett (1955, 1960) found that older slash pine trees (30 to 45 years of age) with short crowns were unable to respond satisfactorily after thinning.

Crown length increase is best achieved by additional height growth in young stands (Gruschow and Evans 1959). Response of suppressed slash pine trees is often prompt if spacing and crown length are adequate (McCulley 1950).

Brender (1965) recommended that first thinnings in loblolly pine be made before the live crowns shorten to 40 percent of total height, but that later a ratio of green crown to total height of 30 to 33 percent was sufficient to sustain satisfactory growth along with the need of some mutual competition for the development of quality products. Chapman (1942) recommended a crown ratio of 40 percent for

loblolly pine throughout the course of a rotation; he believed that a thinning interval of five years could maintain that ratio after the initial thinning removed 50 percent of the crown canopy. Czarnowski (1961) considered a crown ratio of about 33 percent to produce optimum stand growth for loblolly pine.

Guttenberg (1954) reported on a thinning study in 44-year-old loblolly and shortleaf pine stands; response in diameter and crown growth in residual overstory trees was good.

Wood Density and Stem Quality

The effects of spacing and thinnings on southern-pine wood density were studied, among others, by Echols (1960), Paul and Smith (1950), Paul (1958), Martin (1961), Hamilton and Matthews (1965), and Jackson (1968). Many of the results were inconclusive and little or no change in specific gravity was detected after thinnings. The study by Jackson (1968), however, showed that specific gravity decreased fairly regularly until the time of thinning and then increased rapidly in the 12 years following thinning.

The proportion of earlywood to latewood is significant in wood density, and the proportion may be influenced by the length of the growing season. The amount of water available to the stand can be regulated to some extent over a period of time by wider spacing of the trees, according to Bassett (1964), and possibly lead to the development of more latewood. This was apparently borne out by the findings of Geyer and Gilmore (1965), who found a larger latewood

percentage and associated higher specific gravity in juvenile wood of loblolly pine planted at wide spacings than at close spacings.

Wahlenberg (1960) was of the opinion that thinning treatments in loblolly pine reduced the possibility of epicormic branching in the upper bole of residual trees.

THE STUDY AREA

Location

The study plots are located in an area known as Elk Pasture, about one mile northeast of Urania, La Salle Parish, Louisiana, and on lands now owned by Georgia-Pacific Corporation. Sizteen 1/4-acre plots were established beginning in 1930 by H. H. Chapman of Yale University in a nearly pure, natural, second-growth loblolly pine stand of about 200 acres in Section 8 and 9, Township 10 North, Range 2 East (Figures 1 and 2).

Soil

The soil on all plots was examined and was determined to be a complex of Myatt fine sandy loam, Stough very fine sandy loam, and Prentiss sandy loam. These three soil types are similar, and Stough is the predominant type. A description of the average Stough profile in the plot area is presented in Appendix A. This soil is somewhat poorly drained, probably more poorly drained than a typical Stough soil. The A horizon averaged 6 inches in depth. No clear boundary between the A1 and A2 horizons was discernible. The B horizon ranged from fine sandy loam to sandy clay loam to a depth of 48 inches. The average site index for this soil in this area is reported to be 95 feet (U. S. Dep. Agr. 1969). This is about 4 feet greater than the average site index of the 16 plots, as determined at age 50 from plot records. The slight difference in site index may be the result of the

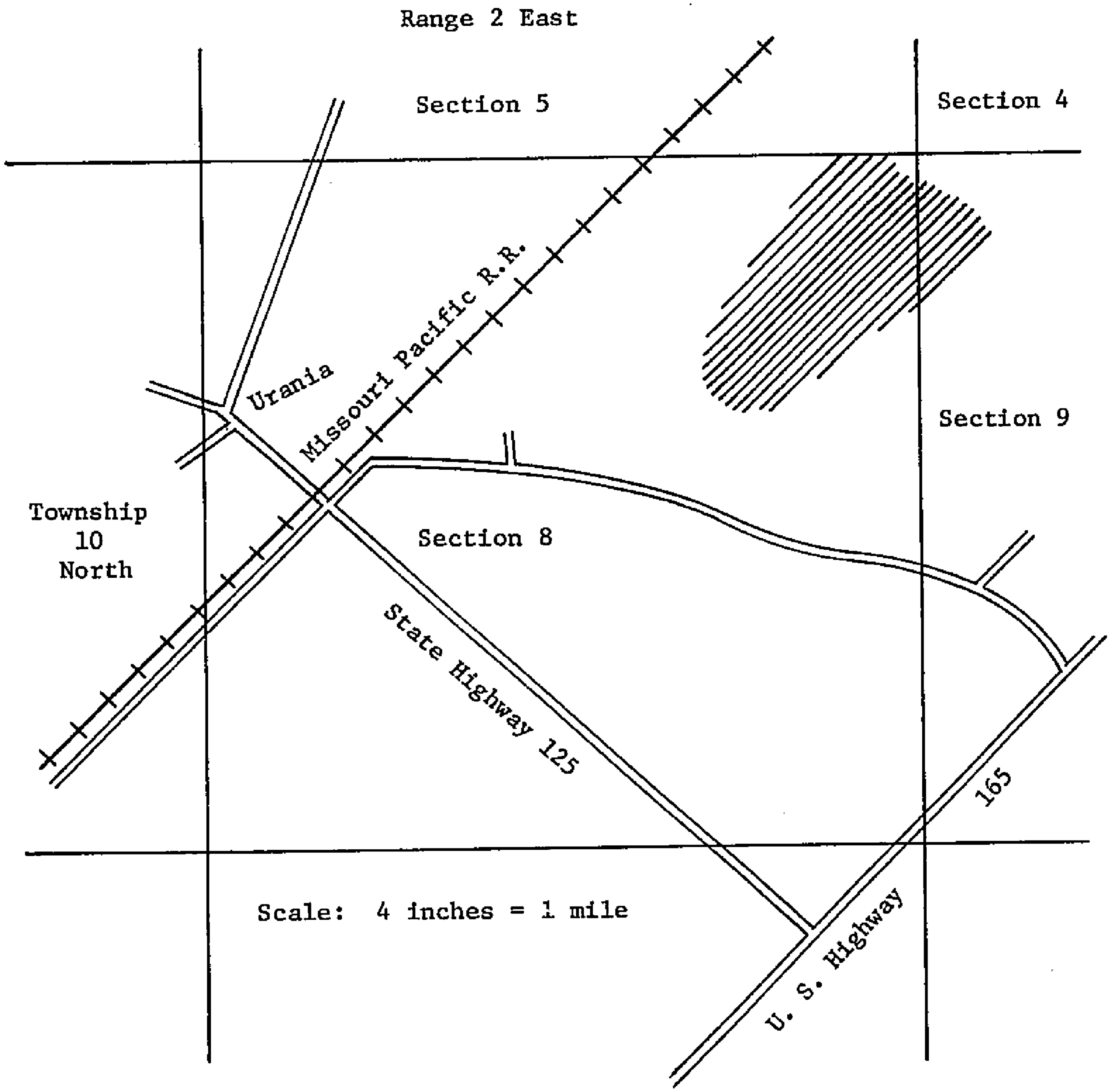

Figure 1. General study area (hatched) near Urania, Louisiana.

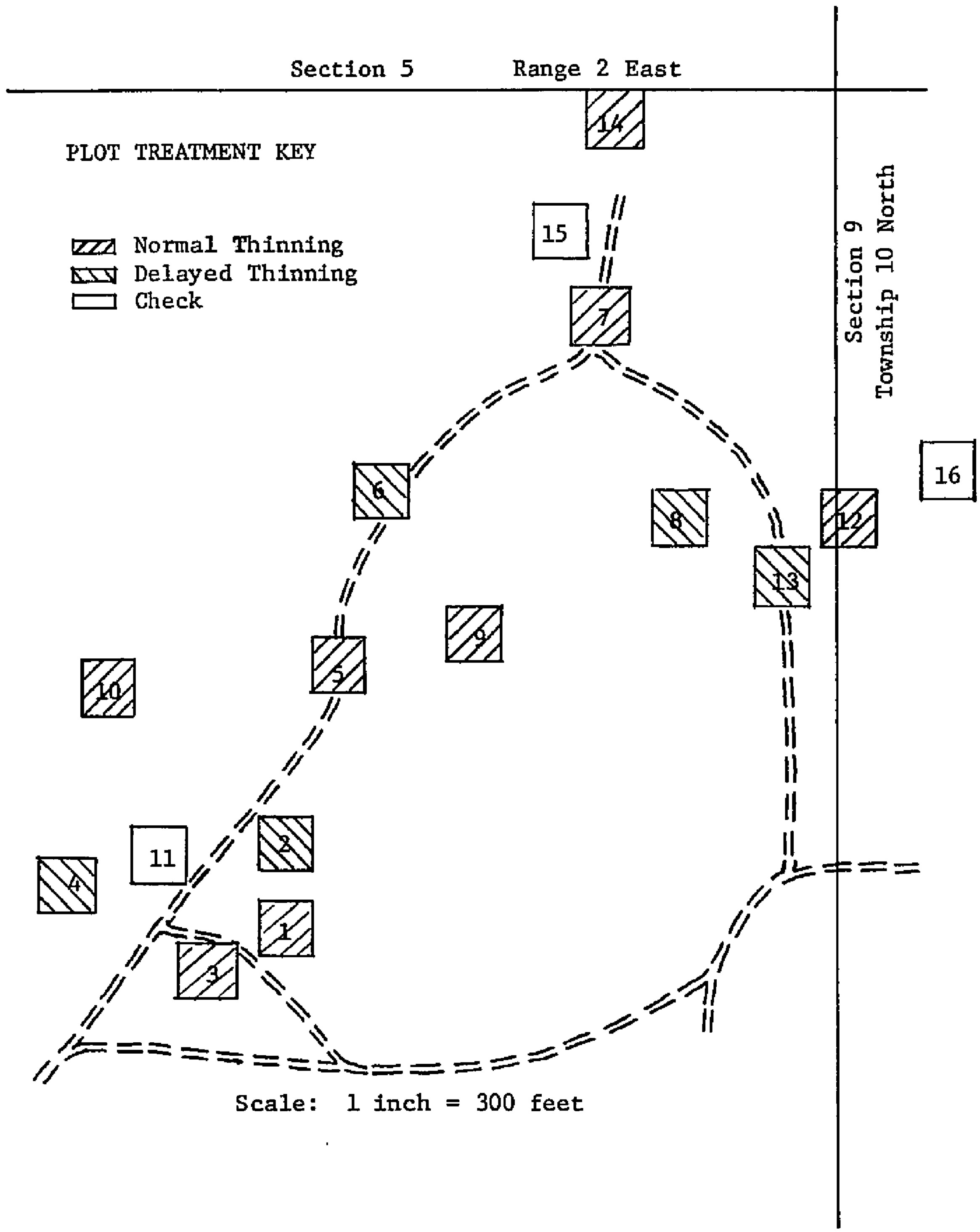

Figure 2. Location of the study plots.

poorer drainage of the soil of the plot area compared to the average Stough soil. The site index of plot 14 was about 9 feet less than the average, so the soil on this plot was reexamined. No discernible soil difference was evident to explain the lower site index.

The topography of the study area is generally flat except near the drainages. All of the plots are located on generally level areas with no slopes exceeding 2 percent.

The parent material of the soils in the study area is Coastal Plains sandy alluvium. The soil description was written by Benjamin F. Grafton of the Department of Agronomy, Louisiana Polytechnic Institute.

Climate

In general, the climate for central Louisiana is warm in summer and mild in winter. The average frost-free period is about 245 days.

From records of the U. S. Weather Bureau station less than 1 mile from the study area, the mean annual temperature for the period 1931-1963 was 66.2° Fahrenheit. July and August were the warmest months with maximum means of 82.5° Fahrenheit each and January the coldest with a mean minimum of 49.2° Fahrenheit. The average yearly rainfall for the period 1931-1963 was 58.35 inches. The most annual rainfall, 80.00 inches, occurred in 1961 and the least, 33.19 inches in 1943 and 34.22 inches in 1954 (Figure 3). Average monthly rainfall was the least during the period of August through October and was fairly well distributed throughout the rest of the year (Figure 4).

Figure 3. Average annual rainfall, Urania, Louisiana, 1931-1963.

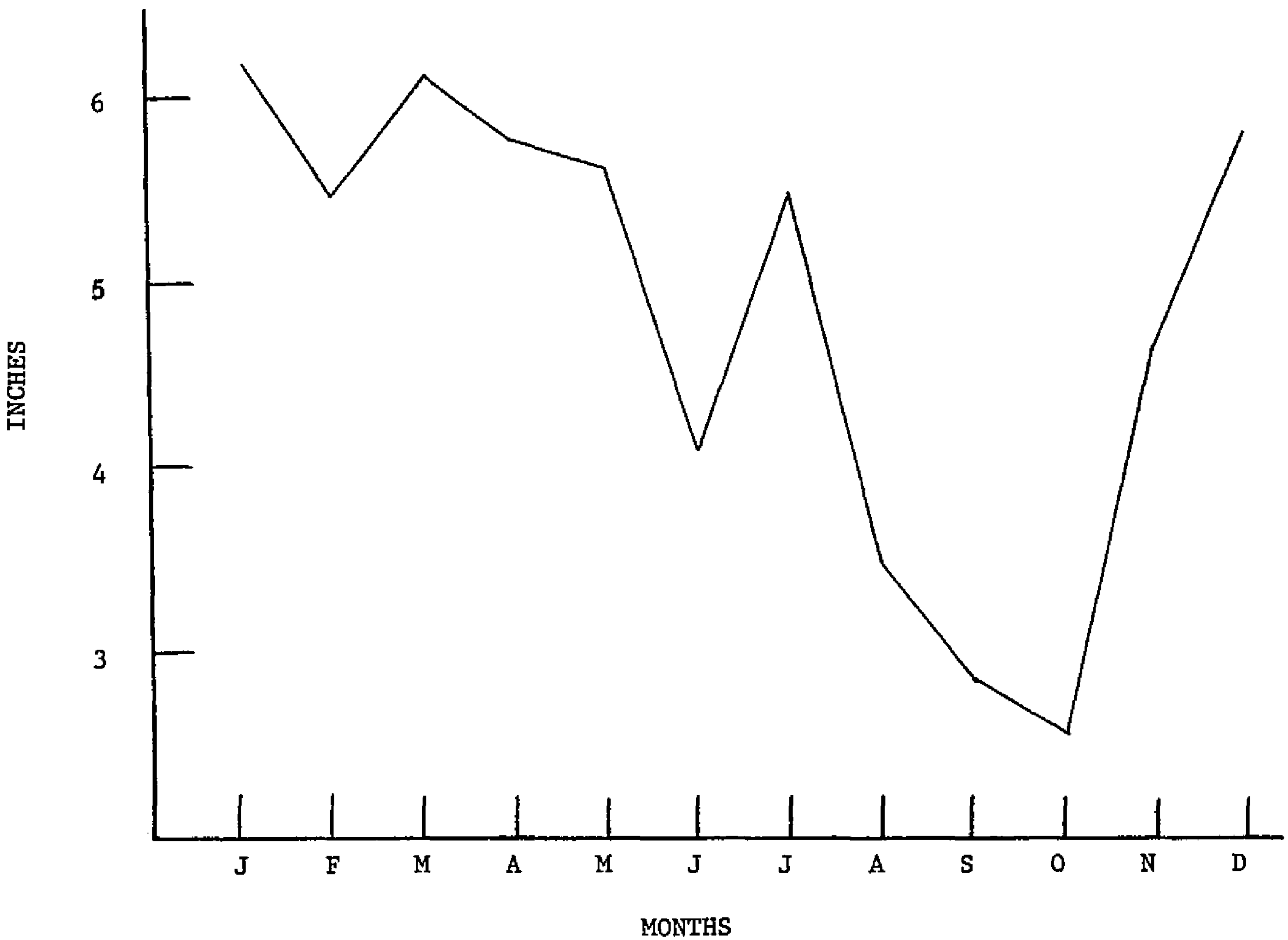

Figure 4. Average monthly rainfall, Urania, Louisiana, 1931-1963.

HISTORY OF THE EXPERIMENTAL PLOTS

Original Objectives

The objectives of this study were stated in two ways by Chapman (1942). The yield from stands originating from old fields was to be compared to that from stands originating on cutover land, and yields from thinned and unthinned were to be compared. This study was established on cutover land, and Chapman had already accumulated data from old-field stands.

History of the Area

Eight pairs of 1/4-acre plots were established during the years 1930-32. The plots were square and marked with metal pipe corners. They were established in a fenced tract of 1500 acres of longleaf pine (*P. palustris* Mill.), loblolly pine, and associated native hardwoods. The site was originally covered by virgin longleaf pine with strips of loblolly pine and hardwoods along the drainage channels. The virgin timber was commercially clearcut in 1904, and the tract was purchased in 1910 as cutover land by the Urania Lumber Company, one of the first companies in the South to practice forestry. The area burned over annually by wildfire from 1905 until the winter of 1913-14 (Chapman 1953).

After the burning ceased, a full stand of longleaf pine seedlings developed from seed originating from scattered residual trees. However, on sites close to the swales, loblolly pine seeded in during the

years 1913 to 1915 from residual seed trees. The loblolly gradually replaced the associated longleaf.

No fires occurred in the area from 1914 to 1925. A wildfire in 1925 damaged some of the timber, but there was enough undamaged loblolly for the establishment of the 16 quarter-acre plots in 1931-33. The area has not been burned since the 1925 fire.

Stand Characteristics at the Time of Plot Establishment

At this time the loblolly stand was approximately 17 years old. Stand characteristics (for trees 3.6 inches d.b.h. and up) were: 606 trees per acre, 95 square feet of basal area, average height 40 feet, and average volume 1406 cubic feet (91 percent pine and 9 percent hardwoods). All plots were located on relatively level area. The average site index, as determined by Chapman when he installed the plots, was 81. This site quality is near the average for loblolly pine throughout its range.

Pine stocking density varied from heavy to medium. Basal areas per acre on the plots before thinning varied from a low of 74 to a high of 118 square feet per acre, based on trees 3.6 inches d.b.h. and up.

Thinning Treatments

A code of 10, 12, or 15, indicating average spacing in feet between the dominant pines, was assigned to each plot by Chapman. Each thinned plot with its associated check plot was installed in areas having similar stocking. Plots 7, 8, 14, and 15 were coded 10;

plots 3, 4, 5, 6, 10, and 11 were coded 12; and plots 1, 2, 9, 12, 13, and 16 were coded 15.

The plots were numbered consecutively in the order of installation: numbers 1-4 in 1930, numbers 5-11 in 1931, and numbers 12-16 in 1932. Plots 1, 3, 5, 7, 9, 10, 12, and 14 were the original thinning plots.

An isolation strip 25 feet wide was maintained around the perimeters of the thinned plots. This strip was treated in the same manner as the plot proper in order to eliminate side effects.

The first cutting in the thinned plots was made in the year of establishment. The thinning method employed was a type of crown thinning. As described by Chapman (1953), it consisted of removing about 50 percent of the upper crown canopy. Codominants were removed to favor selected dominants which had good form and were considered to be crop trees. Openings created were approximately equal to the width of the crowns of the dominants left for crop trees. No trees 3.6 inches d.b.h. or under were cut. Basal areas per acre left after the first thinning on the original eight thinned plots ranged from 56 to 78 square feet, averaging 66 square feet for trees 3.6 inches d.b.h. and up. In later thinnings, beginning about age 30, basal area per acre was reduced to about 80 square feet on 7 of the 8 plots. Plot 14 was cut more heavily and 60 square feet per acre was left after its last thinning at age 35.

The method of thinning was the same for about the first three cuts. Potential crop trees were selected and their crowns released by removing enough trees to provide a 50 percent reduction in the crown

canopy. In later thinnings the selection and number of trees removed was based on tree vigor, crown ratio, spacing, and a decision by Chapman to leave about 80 square feet of basal area per acre in the residual stand.

In 1948-51, at ages 35 to 38, the number of check plots was reduced from eight to three by thinning five of the hitherto unthinned plots: plots 2, 4, 6, 8, and 13 were thinned and plots 11, 15, and 16 remained check plots. Thus a delayed thinning treatment was introduced into the study. The first thinning in these five plots was a medium to heavy crown thinning. Basal area per acre was reduced from an average of 155 to 90 square feet. Three of the five plots were thinned a second time at ages 43 to 44 to about 80 square feet of basal area per acre each.

Chapman's original thinning schedule, at least for the denser plots, was presumably to thin every five years for three successive thinnings, then to thin every ten years thereafter until the stand was harvested. However, for several reasons, this schedule was not followed exactly. Thinnings occurred at intervals varying from five to twelve years.

The following tabulation shows the actual thinning schedule of the plots:

Plot no.	No. of thinnings	Stand age, years, at time of thinning
	Normal thinning	
1	5	17,22,27,32,39
3	5	17,22,27,39,44
5	5	18,23,28,38,43
7	5	18,23,28,38,43
9	4	18,23,28,39
10	5	18,23,28,39,44
12	4	19,29,38,43
14	4	19,24,29,35
	Delayed thinning	
2	1	37
4	2	38,44
6	2	38,43
8	1	35
13	2	35,44
	Check	
11	0	
15	0	
16	0	

Photographs of the Plots

Plates 1, 2, and 3 show the general appearance of a typical plot of each of the three treatments at age 53 years.

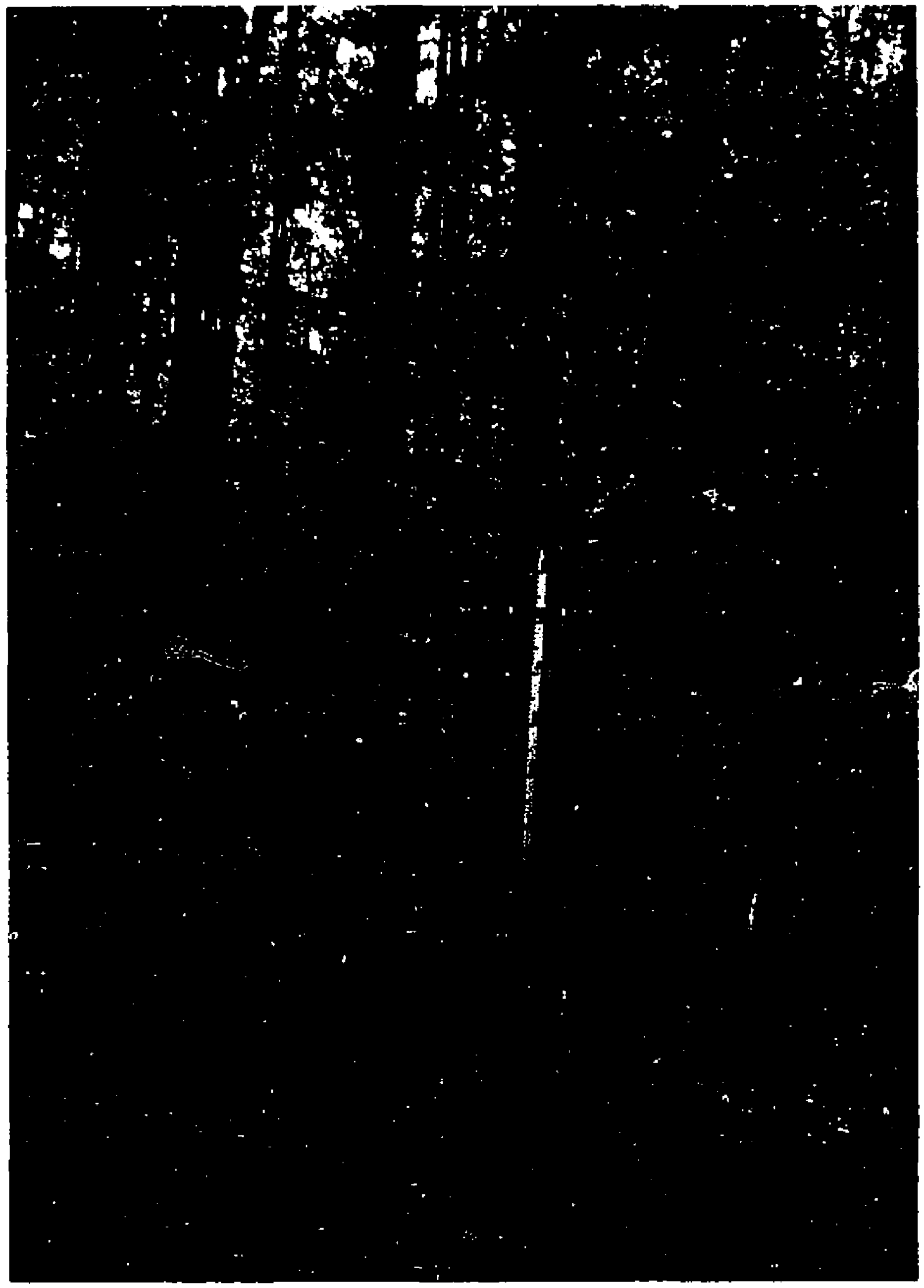

Plate 1. Plot 16, check, age 53 years.

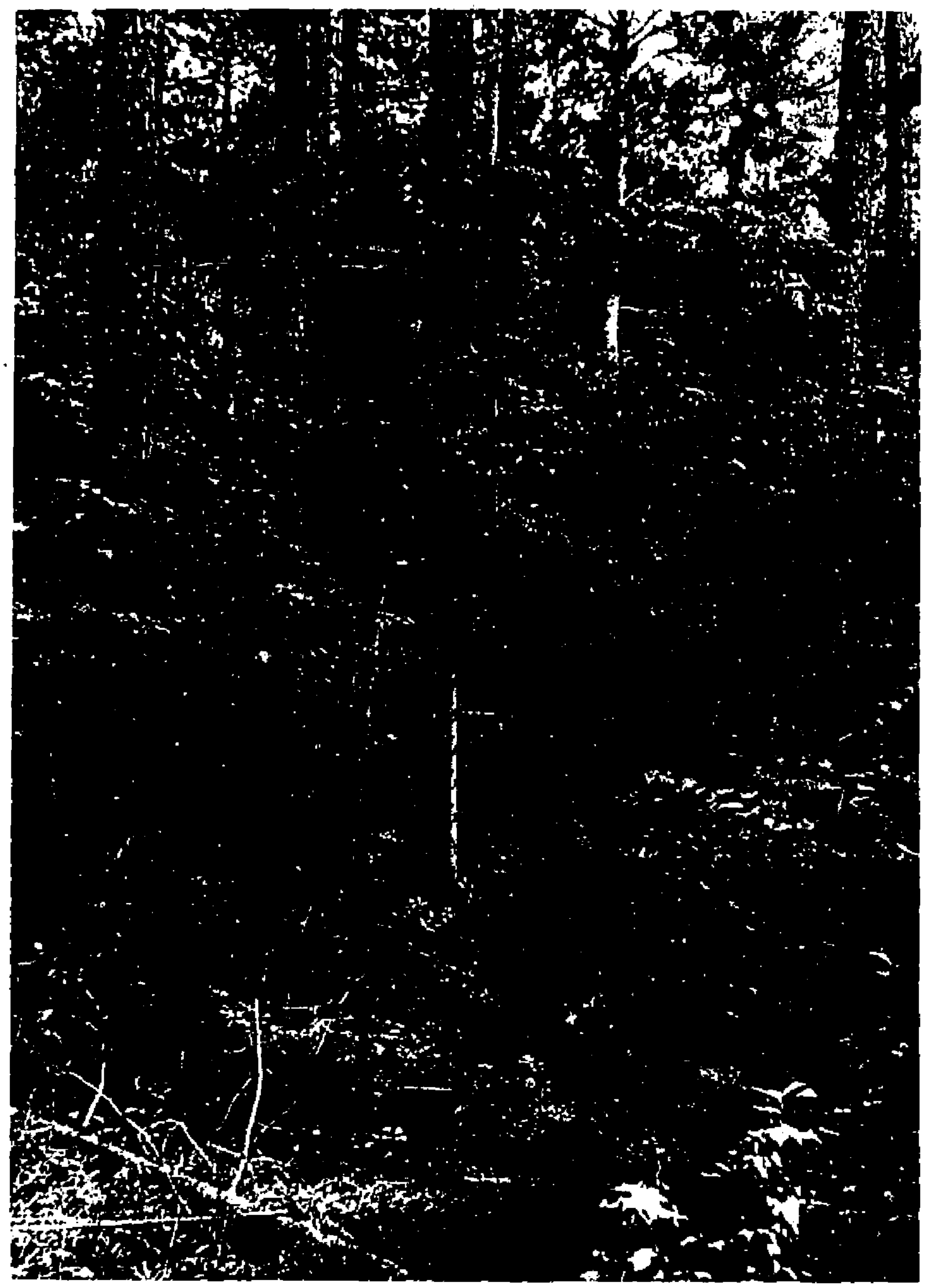

Plate 2. Plot 3, normal thinning treatment, age 53 years. Note dense hardwood understory and large diameter of residual pines.

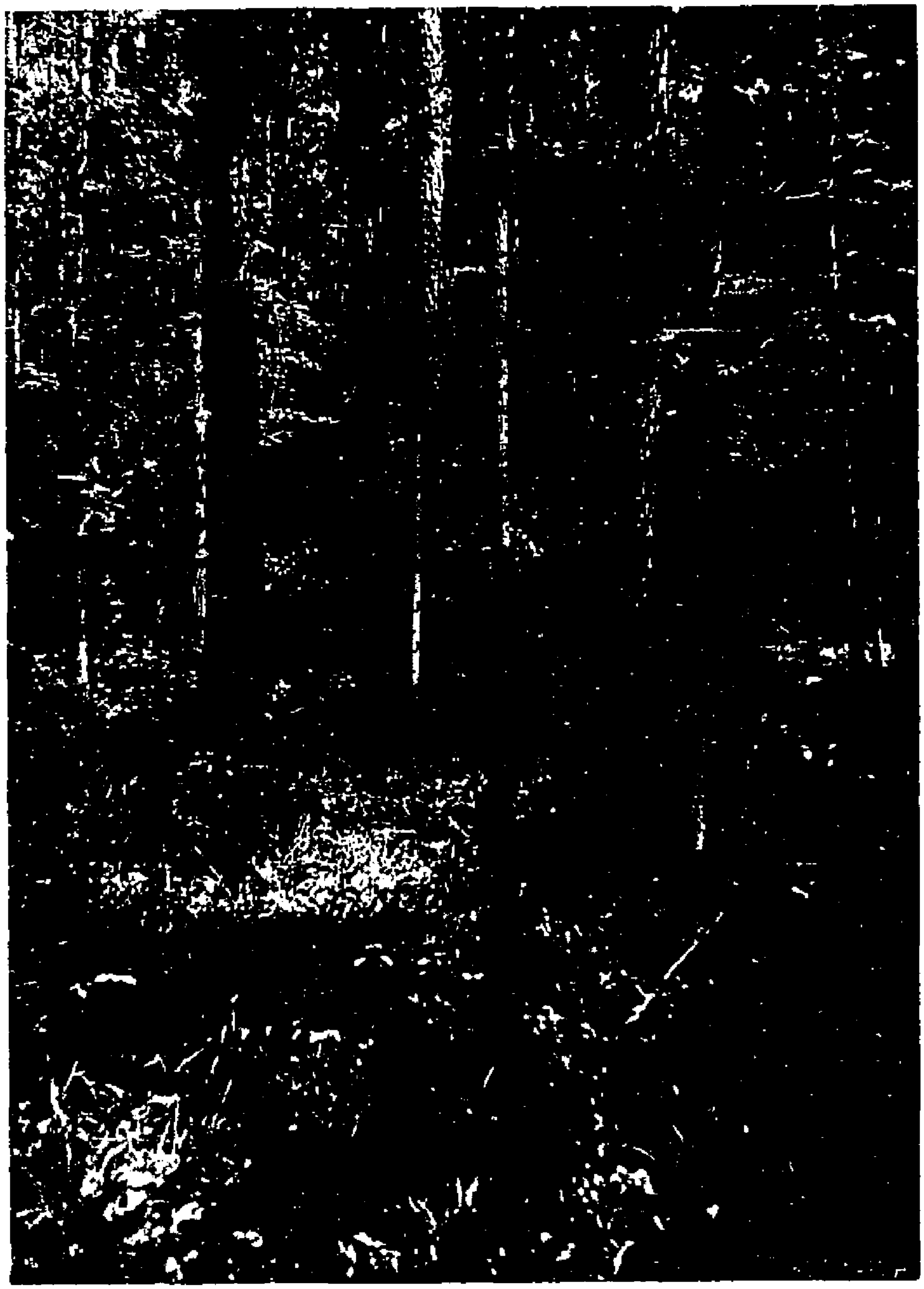

Plate 3. Plot 8, delayed thinning treatment, age 53 years.

Measurements on the Plots

Until 1948, and while the plots were under the supervision of Professor H. H. Chapman, measurements were made in the early spring on those plots scheduled for measurement by Yale University student crews. After 1948, student crews from Louisiana Polytechnic Institute measured the trees in late fall, winter, or early spring. The author participated in the plot measurements during the period 1956-1963. The original records of Professor Chapman up to 1948 were obtained to supplement the Louisiana Polytechnic Institute data.

All trees 3.6 inches d.b.h. and larger were tagged at the time of installation, and ingrowth was tagged when it reached this diameter throughout the course of the remeasurements. The measurements made on each tree were d.b.h. to the nearest 0.1 inch, total height to the nearest foot, and crown length on pines to the nearest foot. Trees which died between measurements were recorded as "mortality" at the time they were first discovered to be dead.

Thinnings were made soon after the measurements. Height and crown length measurements were verified by taping felled trees.

All living stems under 3.6 inches d.b.h. were counted and recorded by 1-inch d.b.h. classes and by species groups.

Remeasurements were made every five years after the year of installation until the period 1945 to 1948 when difficulties with manpower and transportation prevented the maintenance of the original schedule. From 1949 to 1963, the five-year interval between measurements was maintained. The last measurements used for volume determination were made in 1960 (age 47) in plot 2; in 1961 (age 48)

in plots 5, 6, 7, and 12; in 1962 (age 49) in plots 1, 3, 4, 9, 10, 11, and 13; and in 1963 (age 50) in plots 8, 14, 15, and 16.

The record is complete for diameter measurement, but only a sample of heights and crown ratios was taken in many of the earlier measurement years.

In 1965 (age 52) data were obtained to determine tree taper, expressed as Girard form class, and to determine site index.

All pines on plots having fewer than 20 trees were measured. Twenty pines in those plots having more than 20 were randomly selected for measurement. The measurements taken were total height, crown length, d.b.h., and diameter outside bark and bark thickness at 17.5 feet above the ground. The form class data from plot 1, and for 12 of the 20 trees from plot 3, were lost. Average form class for the normal thinning treatment is based on the remaining data.

In 1966 (age 53) five pine trees per plot were randomly selected. An increment core 0.5 inch in diameter was extracted from each of the selected trees at breast height for the determination of specific gravity.

Trees Accidentally Cut

Some of the plots are astride or adjacent to land lines. Single trees were inadvertently cut by surveyors on plots 2, 7, and 8, and two trees were cut on plot 4. In addition, a large post oak was girdled on plot 6 in 1933 for an unknown reason. These accidental losses were not significant and did not have a serious effect on the results of the study. The losses were treated as "mortality" in the analysis of the data.

Previously Published Reports on the Plots

The first report on these plots was made by Chapman (1942). He compared the development of thinned plots to check plots after two thinnings, at age 22 years. He concluded that growth in thinned stands could equal or exceed that in unthinned stands five years after thinning, provided that stands were not thinned too drastically.

In a second report Chapman (1953) analyzed the performance of the treated and check plots in terms of yield, diameter growth, and value at stand age of about 35 years. As expected, thinned stands and those having wider initial spacing grew at a greater rate in diameter than the trees in the check plots and those having closer initial spacing. Diameter growth was studied in relation to crown ratio; an optimum crown ratio of 40 percent was associated with a regular increment in diameter, together with an acceptable clear bole length. The average total net yield in volume was greater in thinned plots than in check plots.

COMPUTATIONAL PROCEDURE

Stand Characteristics through Age 50

It was necessary to supply estimated values for missing heights. For this purpose, equations for total tree height based on d.b.h. as the independent variable were derived by quadratic regression analysis for each plot (Table 1). These equations were used to estimate each missing tree-height.

The basic data were punched in computer cards. Analyses were programmed and processed by an IBM 360 computer system.

The same volume tables and methods of computation used by Chapman for his reports (Chapman 1942, 1953) were employed for the volume determinations. These analyses are presented in summary tables for each plot in Appendix B. Per-acre volumes in cubic feet, board feet, and cords are listed by stand age at each measurement year as volume before cut, cut, and after cut. Additionally, per-acre values of basal area, number of trees, and crown ratio are summarized in the same manner.

Tables 1, 2, 3, and 5, Miscellaneous Publication 50 (U. S. Dep. Agr. 1929), were entered into the computer programs as look-up tables for the volume analyses. The values in Table 5 in M.P. 50 were converted from International 1/8-inch rule to International 1/4-inch rule.

Table 1. Regression equations for height over diameter at breast height (x) by plots

Plot number	Equation	r^2	Number of observations
1	Height = $9.98 + 5.50x - 0.051x^2$	0.88	139
2	" = $5.64 + 7.81x - 0.174x^2$	0.82	130
3	" = $-3.50 + 8.42x - 0.180x^2$	0.93	138
4	" = $12.59 + 6.33x - 0.118x^2$	0.86	119
5	" = $12.40 + 6.04x - 0.075x^2$	0.87	129
6	" = $8.58 + 8.75x - 0.210x^2$	0.84	136
7	" = $16.18 + 5.18x - 0.065x^2$	0.95	131
8	" = $6.47 + 9.41x - 0.297x^2$	0.85	138
9	" = $7.41 + 6.92x - 0.128x^2$	0.89	103
10	" = $10.58 + 5.66x - 0.058x^2$	0.91	127
11	" = $-3.79 + 10.43x - 0.301x^2$	0.78	117
12	" = $10.74 + 6.11x - 0.112x^2$	0.81	128
13	" = $7.50 + 6.70x - 0.115x^2$	0.80	101
14	" = $10.60 + 6.72x - 0.155x^2$	0.88	135
15	" = $1.71 + 10.62x - 0.393x^2$	0.67	123
16	" = $4.54 + 8.45x - 0.227x^2$	0.62	124

For comparisons of the development of the eight normal thinning plots, five delayed thinning plots, and three check plots, regression equations for predicting basal area, volume, number of trees, crown ratio, and diameter and height growth, all at a given age, were computed. In all cases, stand age was used as the independent variable. The method of analysis was by a program for polynomial regression which tested increasing number of polynomials and printed the equation for the highest degree polynomial yielding the smallest residual sum of squares. The equations and tables of predicted values are presented in Appendix C, and some are presented graphically in Appendix D.

Covariance Analyses

Because of the varying ages (47 to 50 years) of the plots when last measured, analysis of covariance was employed to test differences between treatments in the production of basal area, cubic-foot volume and board-foot volume. Crown ratio and crown length were also analyzed in this manner. Stand age was used as the independent variable in all cases. Basal area, including thinnings if any, cubic-foot and board-foot volume, including thinnings if any, crown ratio, and crown length were the dependent variables. In addition to the comparisons between treatments, comparisons were also made between plots thinned different numbers of times.

Form Class and Site Index

Form classes for the treatments were determined on the basis of the five largest-diameter trees of the 20 randomly selected on each

plot at stand age 52, except plot 1, for which the data were lost. Diameter inside bark at 17.5 feet height was divided by d.b.h. outside bark for the form class values, and the averages of the five trees on each plot furnished the data for the test of significance by analysis of variance.

Site index was based on the mean height of the five tallest trees on each plot. Each tree's height, except those measured at age 50, was adjusted by interpolation between its height below 50 and its height above 50 years of age. The mean site indices by treatments were tested for significance by analysis of variance.

Specific Gravity at Age 53

The cores from the five randomly selected trees on each plot were trimmed to include the growth from age 18 through age 52. After oven drying and weighing, each of the cores was immersed in water in a graduated cylinder and the amount of water displaced was recorded in cubic centimeters. Specific gravity values were computed by dividing the oven-dry weight in grams by the number of cubic centimeters of water displaced.

The differences among treatment means were tested by analysis of variance.

Analysis of Average Height and Crown Ratio for the Dominant Stand

The average crown ratio of the ten largest-diameter pine trees per plot, which were considered to represent the dominant stand, was computed at various ages. In some cases fewer than ten heights or crowns were measured per plot, so the average was computed on the

number of trees for which height and crown data were available. These data were subjected to regression analysis in order to indicate the change in height and crown ratio over time and at stand densities resulting from thinning or not thinning.

A second analysis was made using the height and crown data of the ten largest-diameter trees measured at the last measurement year and adjusting these data, if necessary, by interpolation to stand age 50 on all of the plots. Mean crown ratios of the treatments were tested by analysis of variance.

Economic Analysis

For this analysis, the portion of the stand in the d.b.h. range of 3.6 to 9.6 inches was computed in units of standard cords, outside bark, and the remainder, 9.6 inches d.b.h. and over, was calculated in board feet (International 1/4-inch rule). Pine cordwood was valued at $5.00 per cord, hardwood cordwood at $2.00 per cord, pine sawtimber at $50.00 per thousand board feet, and hardwood sawtimber at $20.00 per thousand board feet. A compound interest rate of 6 percent annually was used to determine the age-47 values of the initial stand at ages 17 to 19 and of the thinnings. A charge of five cents per tree was assessed to cover the cost of marking for thinning.

Except for one plot, which was last measured at age 47, the volumes were adjusted to age 47 by interpolation of the growth between the last and next to last measurements. It was then possible to make value comparisons of the treatments at a common stand age.

Spacing Analysis

The normal thinning treatment included sufficient replications of the 10, 12, and 15 spacing codes for statistical analysis. Differences in net mean annual cubic-foot growth, average board-foot volume at age 47, average d.b.h. at age 47, and number of trees per acre at age 47 were tested by analysis of variance. The mean diameters per plot, number of trees per plot, and board feet per plot were adjusted by interpolation to furnish values for stand age 47.

GROWTH AND YIELD

Volume and Basal Area

Gross mean annual increments of the entire stands of all treatments to the last measurement period were almost identical (Table 3). The difference in averages of the net mean annual increment of the thinning treatments compared to the check was significant at the P = 0.01 level (Table 2).

Table 2. Analysis of variance of net mean annual increment in cubic feet per acre, ages 47 to 50

Source of Variation	d.f.	Sum of squares	Mean square	F
Total	15	2351.0		
Normal thinning vs delayed thinning	1		23.3	0.22
Normal and delayed thinning vs check	1		977.5	9.41**
Within	13	1350.2	103.9	

Net mean annual increment of the normal thinnings plots, including the volume of thinnings, was 21.4 percent higher than that from the check plots. The net mean annual increment of the delayed thinning treatment exceeded that of the check by 18.4 percent. The greater net yield produced in the thinned stands is attributed to less loss by mortality.

Table 3. Volume of cut, mortality, gross and net mean annual increment per acre

Plot no.	No. of thinnings	Stand age when thinned	Total volume cut	Total mortality	Gross MAI	Net MAI
		- - Years - -	- - - - - - Cubic feet[1]			- - - -
		Normal Thinning Plots				
1	5	17,22,27,32,39	2097	119	118	115
3	5	17,22,27,39,44	2754	93	125	121
5	5	17,23,28,38,43	2840	77	135	133
7	5	18,23,28,38,43	2428	126	120	118
9	4	18,23,28,39	2207	171	125	121
10	5	18,23,28,39,44	2460	41	126	125
12	4	19,29,38,43	2205	0	117	117
14	4	19,24,29,35	2198	65	101	100
	Average		2399	86	121	119
		Delayed Thinning Plots				
2	1	37	489	470	132	122
4	2	38,44	2433	530	123	120
6	2	38,43	2559	624	138	125
8	1	35	1685	274	115	109
13	2	35,44	1889	111	106	104
	Average		1811	402	123	116
		Check Plots				
11	0		0	1197	137	113
15	0		0	1300	111	85
16	0		0	1094	119	95
	Average		0	1097	122	98

[1] All trees 3.6 inches d.b.h. and up, inside bark, including stump and tip.

Differences in net yields in cubic feet and basal area were tested by covariance analyses (Tables 4 and 5). Where yields for pine only were used, the differences were highly significant for both the regression coefficient and the means in the comparison of normal thinning treatment versus check. Differences were also significant for pine growth in the comparison of the delayed thinning treatments versus check. In these analyses, thinning yields exceeded check yields.

In the analyses using all species combined, the differences were highly significant in all comparisons of the normal thinning treatment versus check for both cubic feet and basal area. The regression coefficient was significant at the 5 percent level in the basal area comparison of the delayed thinning versus check.

There was little difference between cubic-volume production of the normal thinning and delayed thinning treatments by age 50 (Table 3). The cutting in the delayed thinning treatment, even at advanced stand ages, prevented the large losses to mortality such as that which occurred on the check plots from about age 35 and later.

Within the normal thinning treatment there was no significant difference in volume production for plots thinned four times and those thinned five times. In the delayed thinning treatment there was also no significant difference between plots thinned once and those thinned twice.

A comparison of some of the average yield values for all species in the check plots to normal yields for site index 90 (the average site index for the check plots) and age 50 in Miscellaneous Publication

Table 4. Covariance analyses of pine volume and basal-area increment, ages 17-50

Source of variation	d.f.	Volume (cu. ft.) Sum squares	Volume (cu. ft.) Mean square	Volume (cu. ft.) F	Basal area (sq. ft.) Sum squares	Basal area (sq. ft.) Mean square	Basal area (sq. ft.) F
		Normal thinning plots vs check plots					
Treatment	56	6,333,451			7,641		
Check	19	2,159,974			4,667		
Within	75	8,493,425	113,246		12,308	164	
Reg. coef.	1		2,203,453	19.5**		4,009	24.4**
Common	76	10,696,878	140,748		16,317	215	85.8**
Adj. mean	1		7,269,981	51.65**		18,447	
Total	77	17,966,859			24,764		
		Delayed thinning plots vs check plots					
Treatment	34	9,164,590			11,825		
Check	19	2,159,974			4,666		
Within	53	11,324,564	213,671		16,491	311	
Reg. coef.	1		1,247,772	5.84*		2,505	8.05**
Common	54	12,572,336	233,821		18,996	352	
Adj. mean	1		1,407,634	6.05*		1,463	6.16*
Total	55	13,979,970			20,459		

Table 5. Covariance analyses of cubic-foot and basal-area increment, all species, ages 17-50

Source of		Volume (cu. ft.)			Basal area (sq. ft.)		
variation	d.f.	Sum squares	Mean square	F	Sum squares	Mean square	F
			Normal thinning plots vs check plots				
Treatment	56	6,828,791			7,373		
Check	19	4,510,248			6,248		
Within	75	11,339,039	151,187		13,621	182	
Reg. coef.	1		1,319,262	8.73**		2,786	15.3**
Common	76	12,658,301	166,556		16,407	216	
Adj. mean	1		4,000,258	24.02**		11,973	55.4**
Total	77	16,658,559			28,380		
			Delayed thinning plots vs check plots				
Treatment	34	10,645,938			14,410		
Check	19	4,510,540			6,248		
Within	53	15,156,478	285,971		20,658	390	
Reg. coef.	1		1,005,109	3.69		2,096	5.37*
Common	54	16,211,587	300,214		22,754	421	
Adj. mean	1		1,007,711	3.36		1,356	2,98
Total	55	17,219,298			24,010		

50 (U. S. Dep. Agr. 1929), and to those in Meyer (1942) and Schumacher and Coile (1960), is presented below.

	Check plots	Misc. Pub. 50	Meyer	Schumacher and Coile
	- - - - - - -	per acre	- - - - - - -	
No. of trees	296	220	155	165
Basal area, $ft.^2$	161	167	136	155
Volume, cubic feet	4789	6150	4740	5210

Ingrowth, which amounted to about 40 trees per acre of small-sized hardwoods, was not included in the check plot values.

The lower cubic-foot yield of the check plots compared to the Miscellaneous Publication 50 yield value is possibly due to the hardwood component in the stand. At age 50, the hardwoods averaged shorter in height and smaller in diameter than the pines. The yields by Meyer (1942) and Schumacher and Coile (1960) are based on pine only and on fewer trees and less basal area per acre.

Differences in the net cubic-foot mean annual increments of pine in the 10-, 12-, and 15-foot spacing categories in the normal thinning treatment were tested by analysis of variance and there were no significant differences. Plots having wider initial spacing had fewer trees per acre at age 47, but they were larger in diameter than those on the plots that began with closer spacings.

Mean board-foot volumes at age 47 for the 10-, 12-, and 15-foot spacings in the normal thinning treatments were 16.5, 21.0, and 21.8 thousand board feet per acre, respectively. The numerical difference

between the 10-foot and 15-foot spacings is large but was not statistically significant when the means of all spacings were tested by analysis of variance.

Plot summaries of per-acre yields of basal area, cubic feet, and cords and board feet by merchantability class are presented in Tables 20 to 22 (Appendix B). Basal area and volume production of the treatments, based on regression analysis, are presented in Tables 25 to 28 (Appendix C), and in Figures 8 to 11 (Appendix D).

Number of Trees

The codes 10, 12, and 15 were related to the average spacing in feet between presumed crop trees at the time of the establishment of the plots. The following tabulation shows the average number per acre at the beginning of the study and the number remaining at age 47, not including ingrowth.

	Spacing			Spacing: Age 17–20			Spacing: Age 47		
Treatment	10	12	15	10	12	15	10	12	15
	No. of plots			--- Number of trees ---					
Normal thinning	2	3	3	836	648	403	86	77	72
Delayed thinning	1	2	2	688	684	458	128	108	142
Check	1	1	1	772	680	440	368	348	280
Total plots and average number	4	6	6	783	665	427	167	131	129

In general, those plots beginning with the largest number of trees per acre had more trees per acre at age 47. An exception is in the age-47 average in the delayed thinning treatment for the 15-foot spacing. This average was influenced by the large number of trees

left on plot 2, where in the one thinning, only hardwoods were removed at age 37.

The reduction in number of trees in the thinnings was governed by the crown width of the trees in the dominant stand. The plots with trees more closely spaced had narrower crowns and consequently more stems per acre remained after thinning to leave the 50 percent crown canopy. The slight differences in numbers between the spacing categories in the normal thinning treatment at age 47 were not significant.

The average number of stems per acre remaining after thinnings and mortality and based on regression analysis for selected ages is presented in Table 6 and Figure 5.

In the check plots which may be considered to represent "normal" stands, the average number of pine stems was 541 per acre at age 19. At age 50, the average number was 256 per acre (Table 18, Appendix B), which is comparable to the 220 listed for site index 90 and age 50 in Table 42, Miscellaneous Publication 50. Hardwood stems averaged 89 per acre at age 19 and 55 per acre at age 50. The average natural loss in stems was 53 percent for pines and 38 percent for the hardwoods over the 31-year period.

Crown Ratio for the Dominant Stand of Pines

The difference in crown ratios of trees in the normal thinning treatment and in the check was highly significant (Table 7); the normal thinning crown ratios were consistently higher than the check crown ratios. No significance was found in the comparison of the crown ratios in the delayed thinning treatment and the check. Similar

results were obtained for crown lengths (Table 7) except for the lack of significance for the regression coefficient in the comparison of the normal thinning treatment versus check.

Table 6. Average number of trees per acre 3.6 inches d.b.h. and up, all species, after treatment and mortality, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years	- - - - - - - - - - -	Number	- - - - - - - - - - -
15	409	607	694
20	305	575	646
25	221	551	598
30	156	533	547
35	110	306	496
40	84	193	443
45	77	135	388
50	90	131	332

Normal thinning number = $836 - 34.3x + 0.38x^2$

Delayed thinning number (to age 35) = $744.4 - 1128x + 0.1415x^2$

Delayed thinning number (over age 35) = $2612.6 - 103.92x + 1.086x^2$

Check number = $827.9 - 8.51x - 0.028x^2$

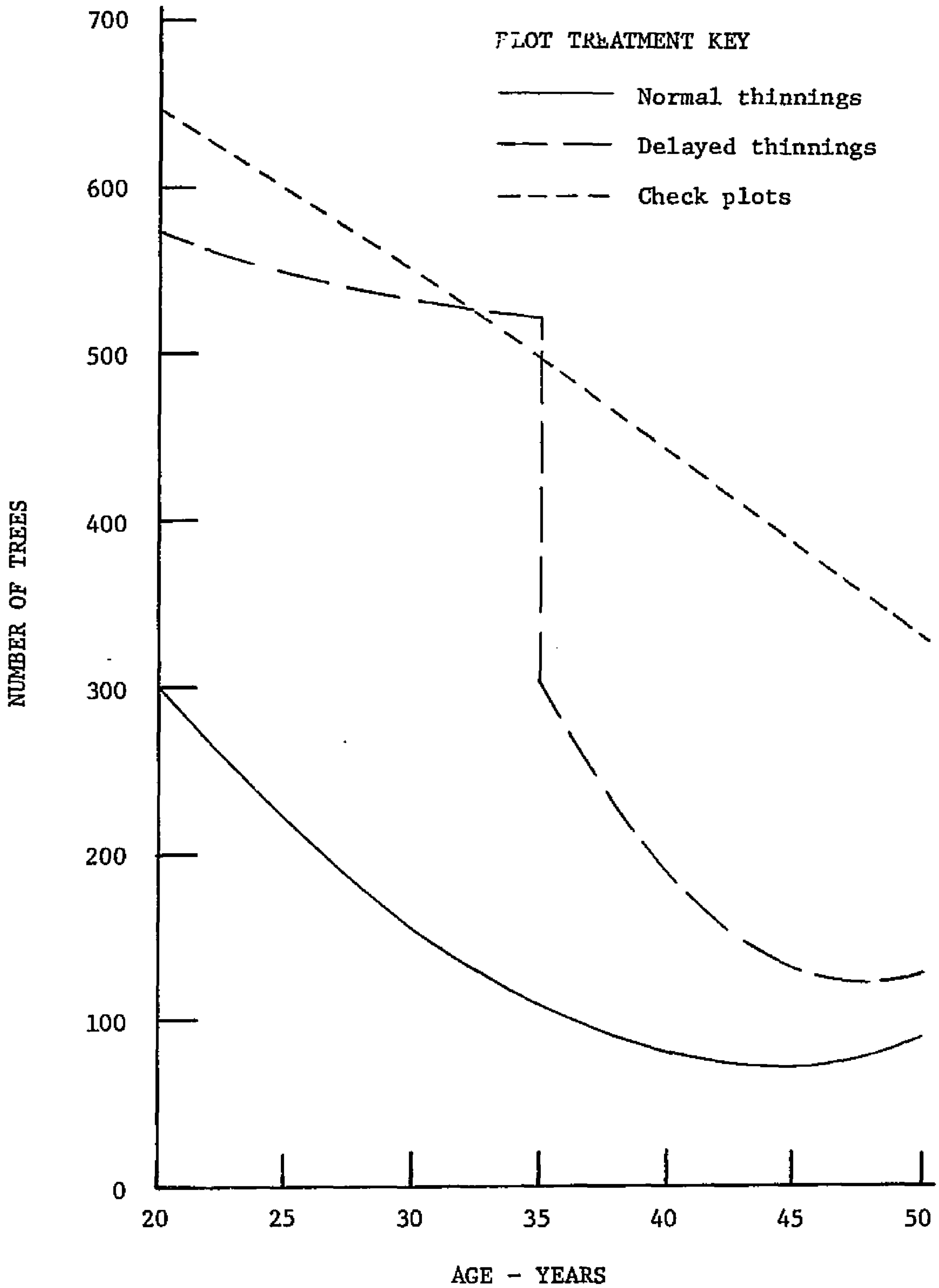

Figure 5. Average number of trees per acre after treatment and mortality (from Table 6).

Table 7. Covariance analyses of pine crown ratio and crown length, ages 22-50

Source of variation	d.f.	Crown ratio (percent)			Crown length (feet)		
		Sum squares	Mean square	F	Sum squares	Mean square	F
				Normal thinning plots vs check plots			
Treatment	403	16,526			10,699		
Check	136	7,121			5,029		
Within	539	23,647	43.9		15,728	29	
Reg. coef.	1		368.0	8.38**		16	0.55
Common	540	24,015	44.5		15.744	29	
Adj. mean	1		5,278.0	118.6**		4,782	164.9**
Total	541	29,293			20,526		
				Delayed thinning plots vs check plots			
Treatment	235	13,267			7,771		
Check	136	7,121			5,029		
Within	371	20,388	54.95		12,800	34.5	
Reg. coef.	1		55.00	1.0		5.0	0.14
Common	372	20,443	54.95		12,805	34.4	
Adj. mean	1		12.00	0.2		67.0	1.95
Total	373	20,445			12,872		

The covariance analyses were based on the heights and crown lengths of up to ten of the largest-diameter trees per plot from age 22 to age 50. An analysis of variance of the mean crown ratios of the ten largest-diameter trees on all of the plots at age 50 showed a highly significant difference in the comparison of the normal thinning and delayed thinning treatments (Table 8); the mean crown ratio was higher in the normal thinning plots.

Table 8. Analysis of variance of the average pine crown ratios of the 10 largest-diameter trees on each plot at age 50

Source of variation	d.f.	Sum of squares	Mean square	F
Total	15	158.4		
Normal thinning vs delayed thinning	1		87.2	20.8**
Normal and delayed thinning vs check	1		16.4	3.9
Within	13	54.8	4.2	

A comparison of the predicted values of crown ratios in the treatments (Table 9 and Figure 6) showed almost no difference between the delayed thinning treatment and the check, which confirms the results of the covariance analysis. The slight increase in crown ratio on the check plots after age 40 is attributed to heavy mortality in the understory, which afforded some release to the remaining trees in addition to removing many of the shortest-crowned trees from the stand.

Table 9. Average crown ratio[1/] for the dominant stand of pine, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Percent	
20	54.5	52.6	46.7
25	47.8	41.7	39.4
30	43.9	36.0	35.3
35	41.5	33.3	33.3
40	40.6	32.6	33.0
45	40.1	33.7	33.8
50	40.6	36.1	35.8

[1/]Percent that crown length is of heights from Table 10

Normal thinning crown length = $28.33 - 0.19x + 0.0068x^2$

Delayed thinning crown length = $484.77 - 39.16x + 1.07x^2 - 0.0094x^3$

Check crown length = $32.92 - 0.86x + 0.016x^2$

Dominant trees in all plots tended to maintain their superior position, had longer crowns, and had larger than average diameters.

In the normal thinning treatment, although the crown ratio of the dominant stand declined from its initial value of 54 percent, a crown ratio of at least 40 percent was maintained on the plots, which was the objective of Chapman (1942).

Height of the Dominant Stand of Pines

Heights of the dominant stand (ten largest-diameter pines per plot) in the delayed thinning treatment and check were about the same until age 35, when the treated plots were first cut (Table 10). After age 35 the delayed thinning average dominant height was slightly

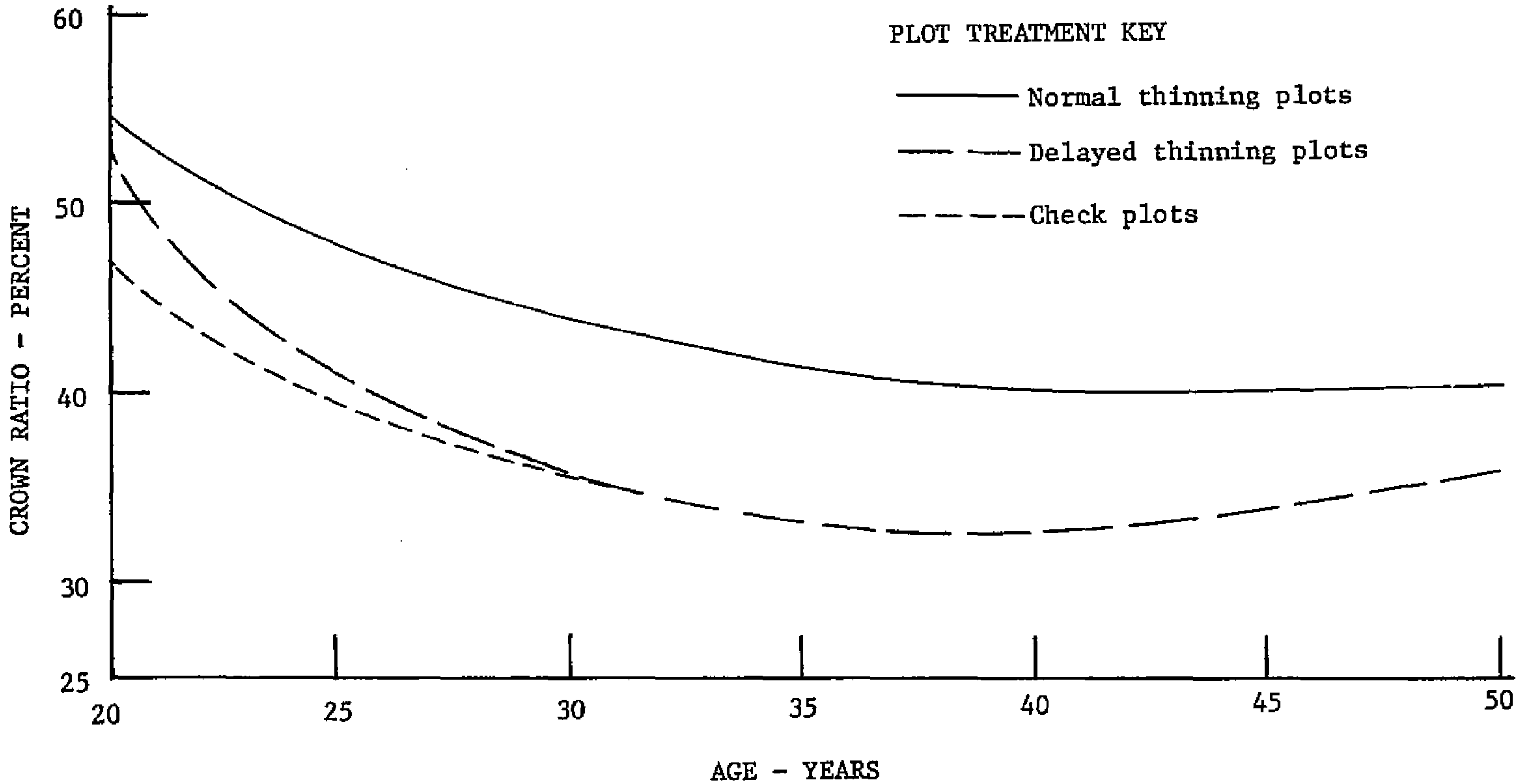

Figure 6. Average crown ratio for the dominant stand of pine (from Table 9).

more than the check, primarily because the trees selected for removal were shorter than those left.

Table 10. Average height of the dominant stand of pine

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Feet	
15	40.7	35.6	39.7
20	49.9	45.6	47.3
25	58.1	54.7	54.4
30	65.6	62.8	61.2
35	72.3	70.0	67.5
40	78.3	76.3	73.3
45	83.7	81.7	78.8
50	88.5	86.2	83.7

$$\text{Normal thinning height} = 6.535 + 2.629x - 0.025x^2 + 0.0001x^3$$

$$\text{Delayed thinning height} = 0.254 + 2.633x - 0.018x^2$$

$$\text{Check height} = 14.278 + 1.828x - 0.0088x^2$$

An analysis of variance of the height-means of the five tallest trees on each plot at age 50 showed no significant difference between treatments (Table 11). Average height at age 50 was 92.3 feet on the normal thinning plots, 89.5 feet on the delayed thinning plots, and 89.7 feet on the check plots.

Heights were most variable on the check plots. The average height for all trees on the check plots was about 14 feet less at age 50 than for the dominant stand. Many small-diameter pines and most of the hardwoods were in the understory. However, the number of trees in the

overstory was substantial, with about 60 trees per acre exceeding 80 feet in height at age 50. This compares quite favorably with the stands in both the normal thinning and delayed thinning treatments.

Table 11. Analysis of variance of the average height of the five tallest trees on each plot at age 50

Source of variation	d.f.	Sum of squares	Mean square	F
Total	15	376.4		
Among treatments	2	29.2	14.6	0.55
Within treatments	13	347.2	26.7	

Diameter growth

Plot summaries of diameters for all species at different stand ages are presented in Table 18 (Appendix B), and average diameters at selected stand ages, based on regression analyses, in Table 12 and Figure 7. As expected, average diameters were larger in those treatments leaving fewer trees per acre. Average d.b.h. at the last measurement period, ages 47 to 50, for the normal thinning, delayed thinning, and check plots was 15.6, 12.9, and 10.2 inches, respectively. The differences in mean annual diameter increment for pine were found to be highly significant (Table 13).

Table 12. Average diameter for all trees 3.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years	- - - - - - - - - - -	Inches	- - - - - - - - - - - -
15	4.72	5.10	5.06
20	6.20	5.54	5.52
25	7.74	6.23	6.18
30	9.32	7.18	6.94
35	10.95	8.39	7.74
40	12.63	9.86	8.51
45	14.37	11.58	9.18
50	16.15	13.57	9.67

$$\text{Normal thinning diameter} = 0.553 + 0.263x + 0.0098x^2$$

$$\text{Delayed thinning diameter} = 5.337 - 0.093x + 0.005x^2$$

$$\text{Check diameter} = 5.458 - 0.145x + 0.0093x^2 + 0.000095x^3$$

Table 13. Analysis of variance of mean annual diameter increment of pine, ages 47-50

Source of variation	d.f.	Sum of squares	Mean square	F
Total	15	.03628		
Normal thinning vs delayed thinning	1		.00889	18.14**
Normal and delayed thinning vs check	1		.02097	42.80**
Within	13	.00642		

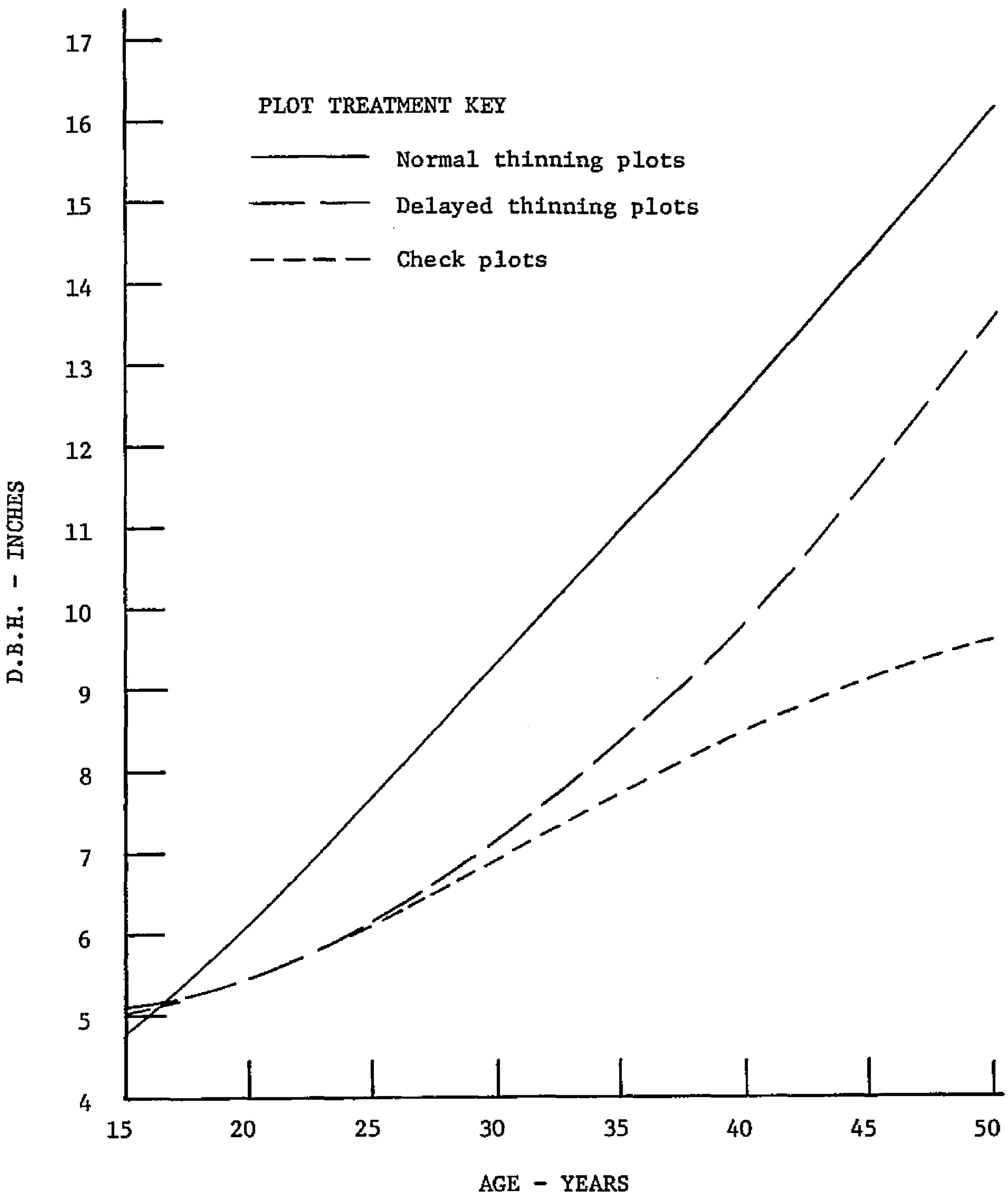

Figure 7. Average d.b.h. (from Table 12).

Mean diameters adjusted to age 47 in the spacing categories of 10, 12, and 15 in the normal thinning treatment were 13.9, 15.1 and 16.0 inches. The differences were not significant. Average diameters in the beginning for the normal thinning plots in the codes 10, 12, and 15 were 4.8, 5.6, and 6.3 inches at ages 17 to 19. Plots in all treatments with fewer stems per acre at the start of the study had trees with larger average diameters throughout the course of the study than did the denser plots.

Specific Gravity of Pines

The results of the analysis of specific gravity of the wood from trees in the three treatments were similar to other southern pine thinning studies conducted in the past.

The average specific gravity ranged from a low of 0.584 for plot 15, a check plot, to 0.643 for plot 2, a delayed thinning plot. The means were 0.615 for the normal thinning plots, 0.627 for the delayed thinning plots, and 0.615 for the check plots. The differences were not significant. Much of the variability in wood specific gravity may be due to heredity (Zobel 1960).

Photographs of the cores from each plot are presented in Plates 4, 5, and 6.

Mortality

Throughout the development of the stands in this study, some trees were recorded dead in most of the measurement years. The cause of death was not recorded except for two trees which died from windthrow and lightning. As there is no record of insect or disease

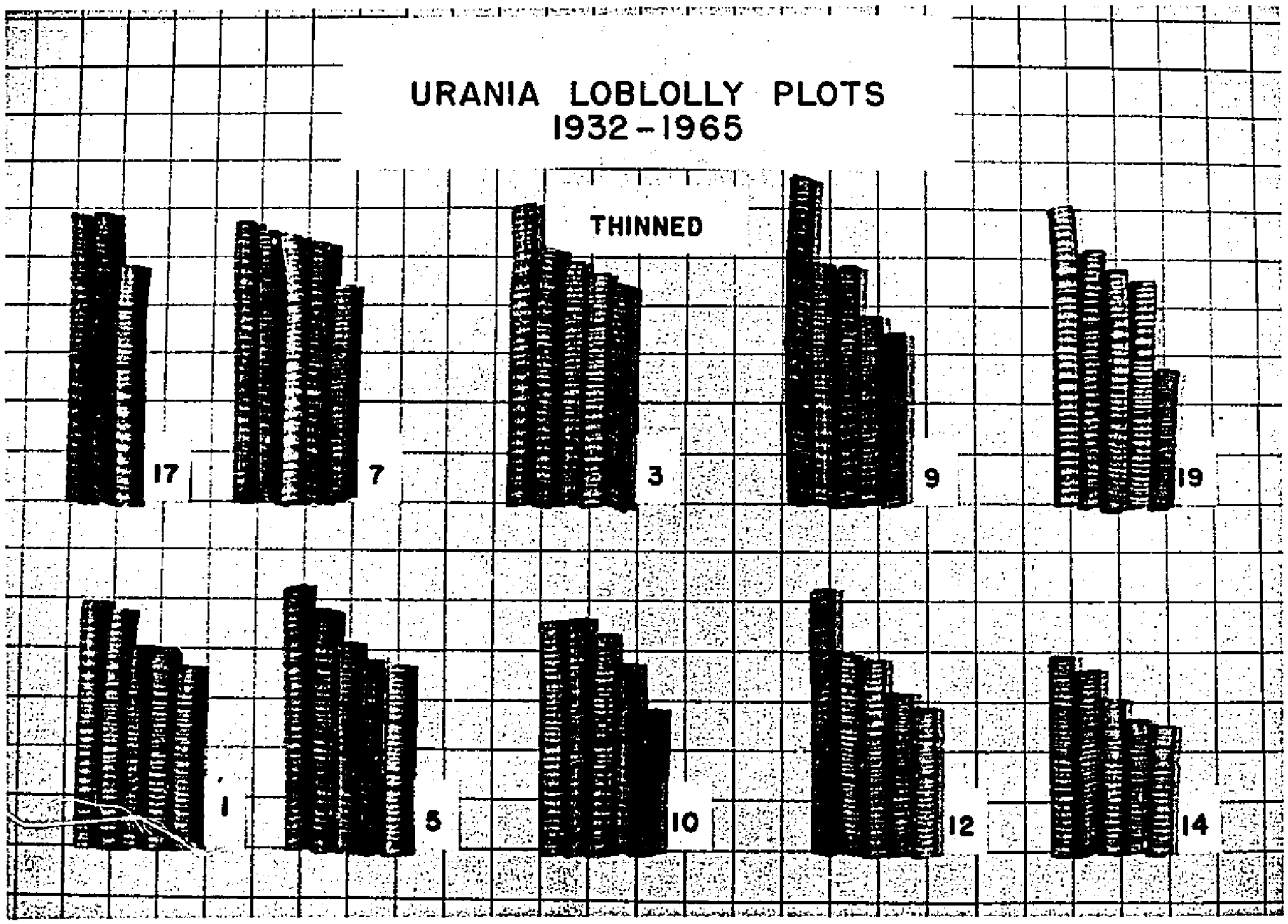

Plate 4. Increment cores taken at breast height from trees in normal thinning plots. Represented is 33 years of radial growth. The last 20 years' growth is indicated by cross lines ten rings apart counting from the top of the core. Numbers 17 and 19 are from plots not included in this study. One-inch squares.

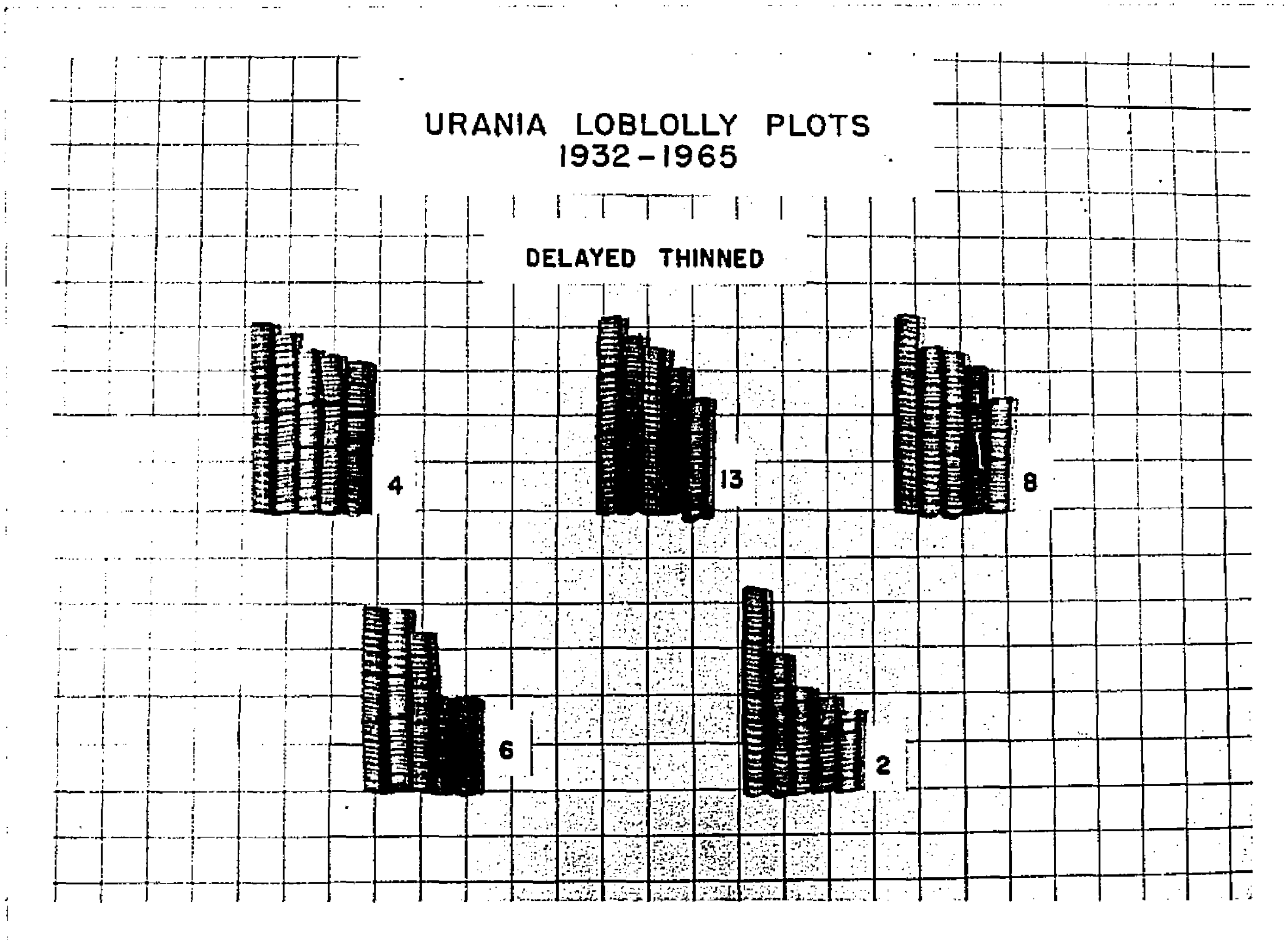

Plate 5. Increment cores taken at breast height from trees in the delayed thinning plots. Represented is 33 years of radial growth. The last 20 years' growth is indicated by cross lines ten rings apart counting from the top of the core. One-inch squares.

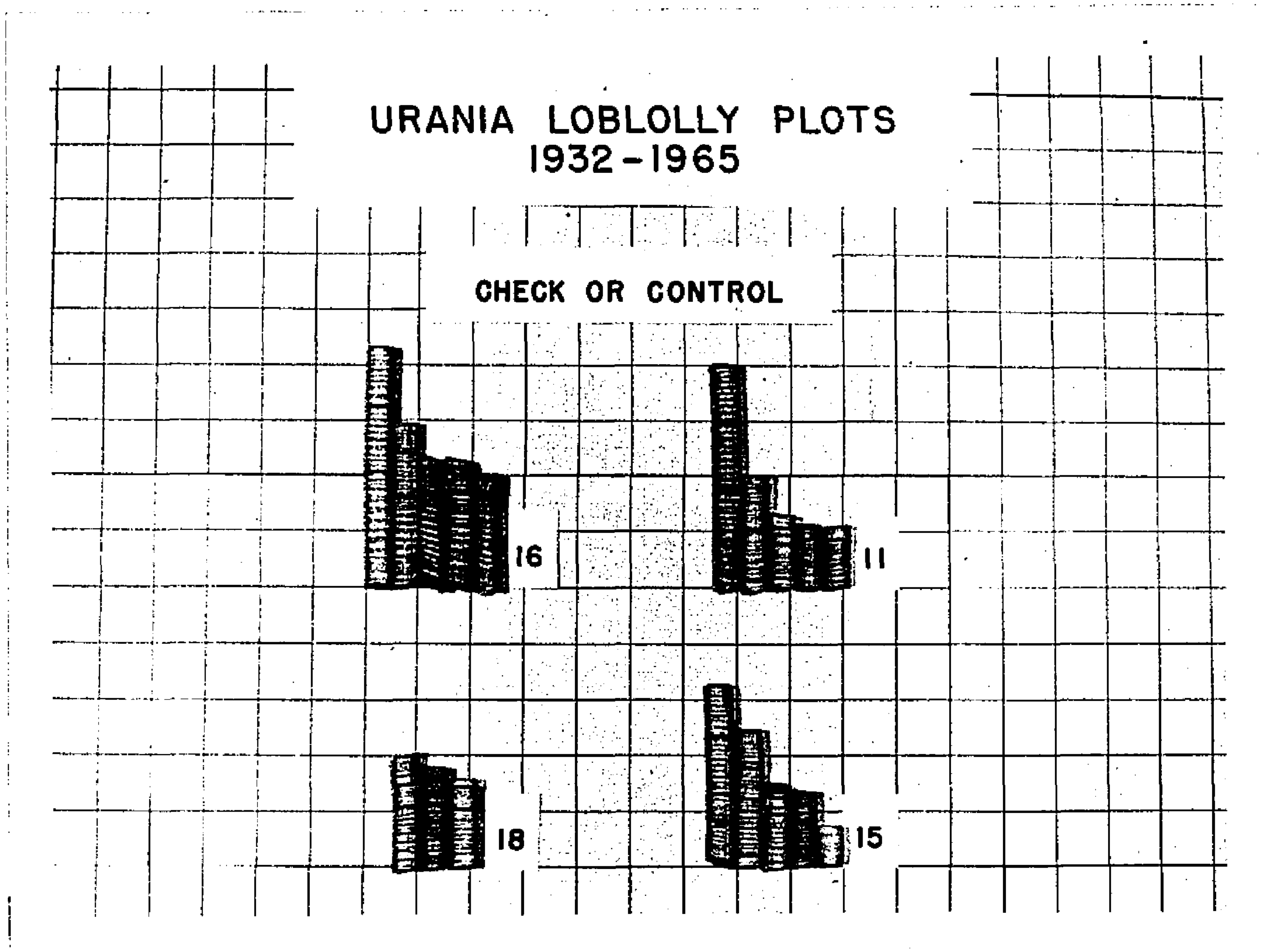

Plate 6. Increment cores taken at breast height from trees in the check plots. Represented is 33 years of radial growth. The last 20 years' growth is indicated by cross lines ten rings apart counting from the top of the core. Number 18 is from a plot not included in this study. One-inch squares.

outbreaks in the area during the course of the study, most of the mortality, particularly in the delayed thinning and check treatment, can probably be attributed to the overcroded condition of the stands. Relatively more pines died than did hardwoods.

Mortality was greatest on the check plots, less on the delayed thinning plots, and least on the normal thinning plots. Trees on the check plots began dying in substantial numbers, mostly in the understory, at about age 30 and continued to die at a fairly high rate to age 50. Heaviest mortality in the delayed thinning plots occurred at the same time as in the check plots but decelerated rapidly after the first thinning. Death of trees in the normal thinning plots was minimal. The losses in number of trees per acre and in units of basal area and cubic volume per acre are summarized by plots in Table 24 (Appendix B), and in cubic feet by treatments in Table 3. Averages of 2, 8, and 24 cubic feet per acre per year were lost in dead trees in the normal thinning, delayed thinning, and check plots respectively.

Periodic annual rainfall and periodic annual mortality for the check plots are tabulated below.

Period	Stand age	Periodic annual rainfall	Periodic annual mortality, trees per acre
	Years	Inches	Number
1937-1942	24.29	63.39	6.3
1943-1947	30-34	58.74	15.4
1948-1953	35-40	61.38	12.7
1954-1958	41-45	54.74	7.8
1959-1963	46-50	53.25	13.0

A comparison of the mortality with the rainfall data shows no discernible correlation. The lowest yearly rainfall occurred in 1943 and in 1954 (Figure 3), which were followed by periods of relatively high average rainfall. Mortality was high for the period beginning in 1943 and low for the period beginning in 1954. Presumably, the pattern of rainfall had little effect on the amount and distribution of mortality over time. There is no evidence that the death of the trees in the check plots can be attributed to any cause other than to the natural thinning process in developing, fully-stocked stands.

Form Class of Pines

A significant difference was found in the comparisons of mean form classes among the treatments at age 52 (Table 14).

The ten largest-diameter trees from the randomly selected sample of 20 trees in each plot, excepting plot 1, were used for the analysis. Form classes averaged 84 for the normal and delayed thinning plots and 80 for the check plots. A reason for the lower value for the check plots may be that the sample of 20 was drawn from stands averaging about 90 trees per quarter-acre plot, whereas most or all of the trees were samples on the plots in the normal and delayed

Table 14. Analysis of variance of form class at age 52

Source of variation	d.f.	Sum of squares	Mean square	F
Total	14	51.03		
Normal thinning vs delayed thinning	1		0.06	
Normal and delayed thinning vs check	1		30.97	18.54**
Within	12	20.00	1.67	

thinning treatments. Consequently, the check plot samples included some trees that were not in the dominant or codominant crown class and which had smaller diameters. The smaller trees in a stand ordinarily have a lower form class than do the larger trees. In spite of an apparent or real increase in taper in large trees, diameter increase will more than offset an increase in taper, except in extraordinary cases, yielding higher form class values for larger trees. The dominant trees in the check plot stands have much larger diameters than the average and have equally as good form as the best in the treated plots.

Development of Hardwoods on the Plots

Many hardwoods, mostly of tolerant species, were present both in the overstory and understory of the plots at the time of establishment. At the times of installation of the plots, 1930-1932, and after cutting in the thinned plots, the average hardwood component in trees 3.6 inches d.b.h. and up was 7 percent of the total basal area on the

normal thinning plots, 15 percent on the delayed thinning plots, and 14 percent on the check plots.

In the last measurement period, 1961-1963, hardwoods amounted to 0.8 percent of the basal area on the normal thinning plots, 1.7 percent on the delayed thinning plots, and 15.7 percent on the check plots. Most of the large hardwoods were cut in the first thinnings on the plots, and hardwood ingrowth was also cut in the course of the thinnings. A few sweetgums (*Liquidambar styraciflua* L.) were allowed to remain in some of the delayed thinning plots if their removal would have created large openings in the crown canopy. Hardwoods in the check plots maintained about the same proportion of the total basal area throughout the period of time in this study.

Seedling and sprout hardwoods developed rapidly in size and number after thinnings in the treated plots. The small understory hardwoods were cut back at least once on all of the plots in the normal thinning treatment by age 38, and on plots 2, 4, and 13 in the delayed thinning treatment when they were first thinned. This cutting did not reduce the number of stems of small hardwoods because of sprouting, but it prevented most of the stems from becoming ingrowth during the earlier stand ages. The structure of the understory was altered somewhat by the cutting of small hardwoods. A more even-sized understory developed in the uncut plots. Compare the even height of the understory in Plate 7, a photograph of plot 6 in which the small hardwoods were not cut, to the irregular height of the understory displayed in Plate 8, a photograph of a plot where small hardwoods were cut.

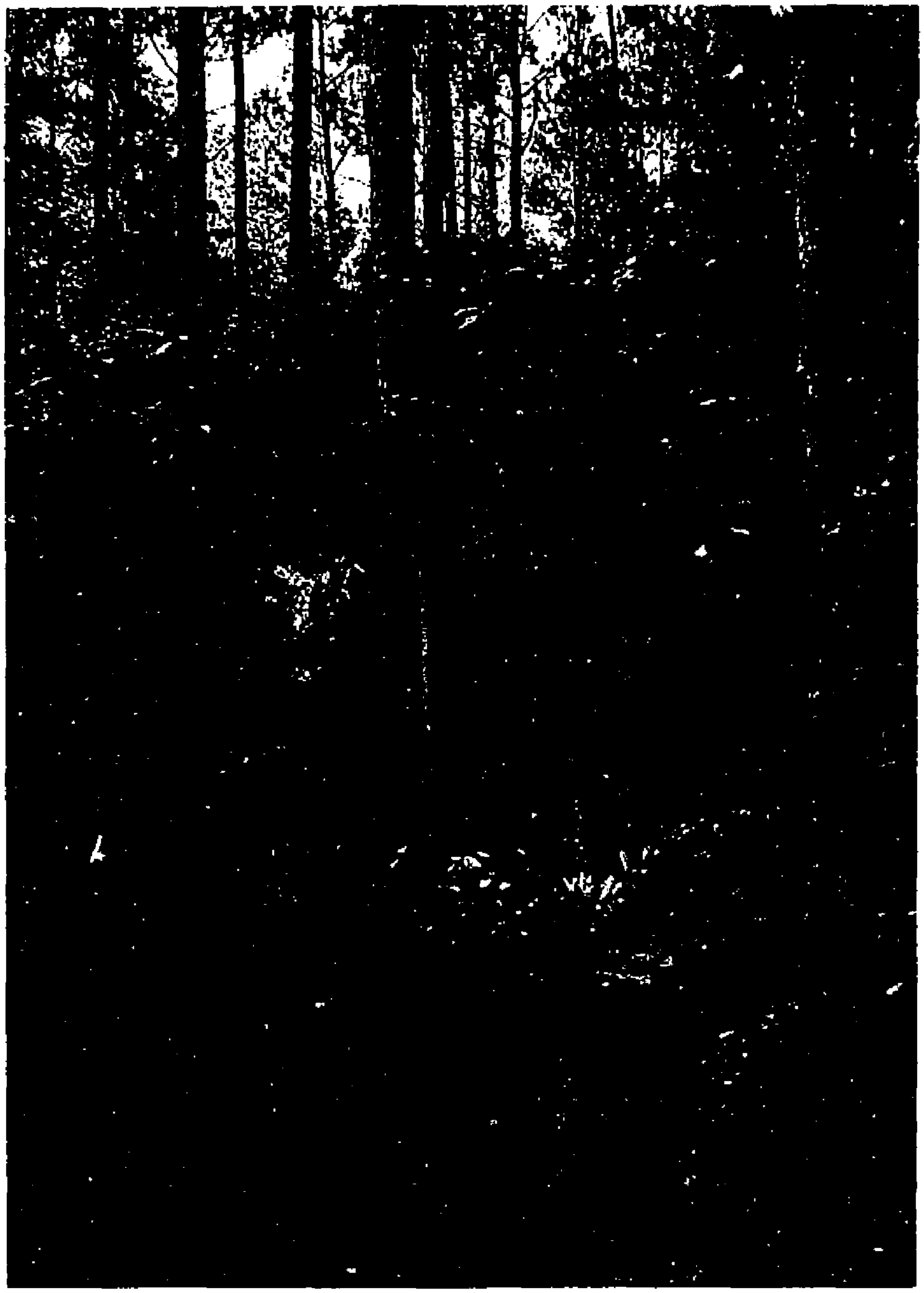

Plate 7. Plot 6, delayed thinning treatment, age 53 years. Note the uniformity of the height of the hardwood brush as a result of not cutting understory hardwoods.

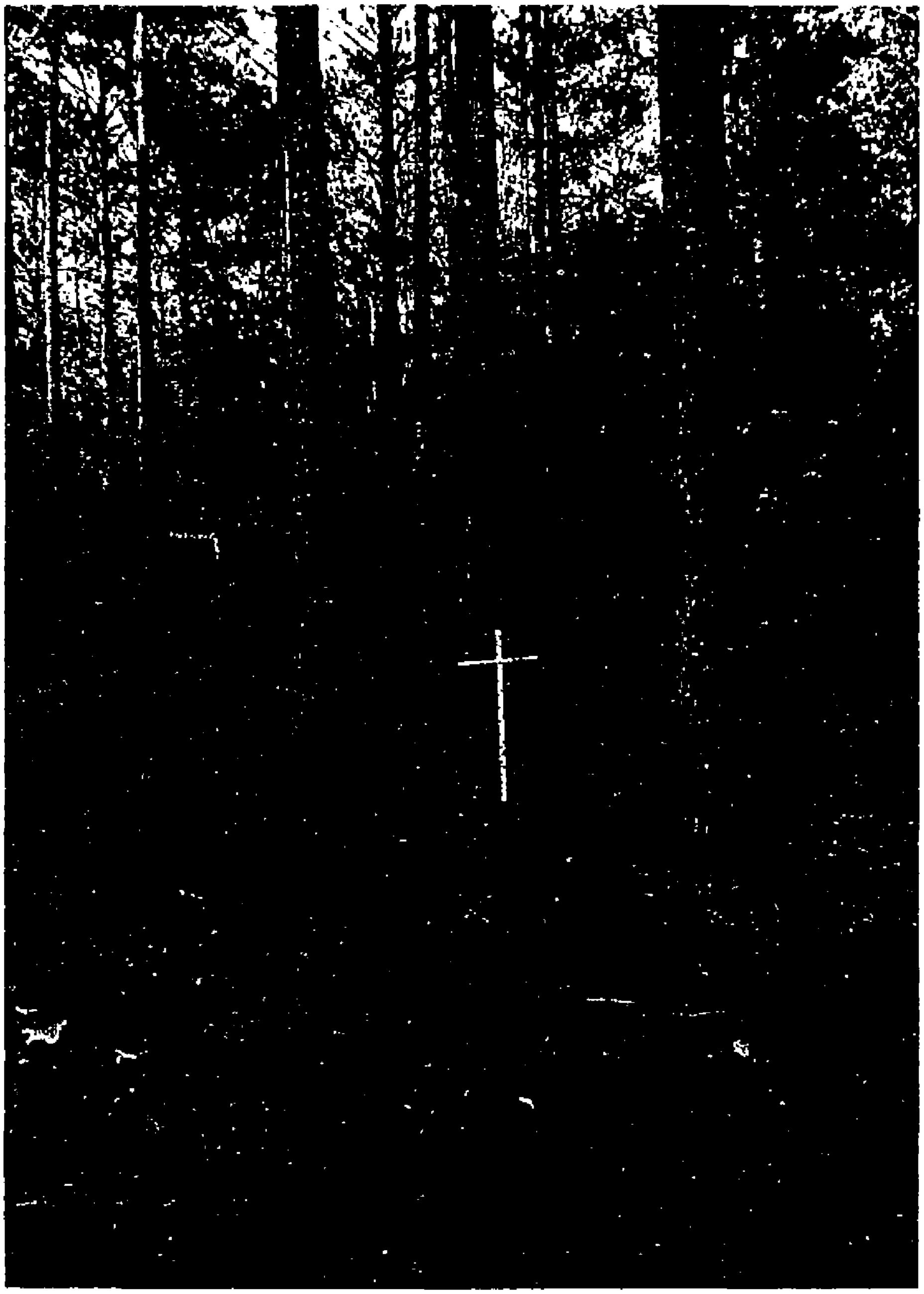

Plate 8. Plot 13, delayed thinning treatment, age 53 years. Note the irreuglar height of the understory sprouts as a result of cutting the small hardwoods.

The average number of stems of hardwoods 0.6-3.6 inches d.b.h. in the last measurement years (1960-1963) was 516 per acre in the normal thinning plots, 371 in the delayed thinning plots, and 221 in the check plots. On the check plots many hardwoods, especially the smaller ones, died as the stand grew older; there was an average of 520 small hardwood stems per acre at age 19 and an average of 221 per acre at age 50. The larger-sized hardwoods, 3.6 inches d.b.h. and up, constituted 28 percent of the number of trees in the check plots at age 50. Some of the hardwoods had reached the dominant and codominant crown positions, and those in the understory are expected to eventually replace the less tolerant and more or less suppressed pines.

Although most of the overstory hardwoods were removed in the thinning treatments, understory hardwoods developed in abundance on thinned plots, speeding up the trend toward dominance of the area by the hardwoods.

The species representing most of the hardwoods at stand age 50 are listed below:

white oak	_Quercus alba_ L.
post oak	_Quercus stellata_ Wang.
southern red oak	_Quercus falcata_ Michx.
water oak	_Quercus nigra_ L.
sweetgum	_Liquidambar styraciflua_ L.
blackgum	_Nyssa sylvatica_ Marsh.
red maple	_Acer rubrum_ L.
American holly	_Ilex opaca_ Ait.
yaupon	_Ilex vomitoria_ Ait.
winged elm	_Ulmus alata_ Michx.
black cherry	_Prunus serotina_ Ehrh.
white ash	_Fraxinus americana_ L.
red mulberry	_Morus rubra_ L.
shining sumac	_Rhus copallina_ L.
bitternut hickory	_Carya cordiformis_ (Wang.) Koch.
witch hazel	_Hamamelis virginia_ L.

The composition of the species was about the same in each treatment: 12-16 percent in oaks, 58-67 percent in the gums, and 17-30 percent in all other species combined. There appeared to be a tendency for sweetgum to increase in abundance compared to other hardwoods.

The results in this study confirm the conclusion of Wenger (1969) that the progress of plant succession on this kind of site is toward a hardwood climax. Since the species grouping was not done consistently over the many years of data collection, analysis of successional trends among the various hardwood species was not possible.

Economic Analysis

Possibly the greatest returns from thinnings is the stimulation and maintenance of diameter growth in rotations long enough to produce poles, sawlogs, and plywood bolts. By about age 30 in the normal thinning treatment after three thinnings, diameters were large enough to furnish substantial values for these products (Table 15). From age 30 to age 50 the increase in board feet per acre was extremely rapid on the normal and delayed thinning plots (Tables 16 and 17). On sites similar to the average site in this study, the culmination of mean annual increment in cubic feet occurs about age 35 (Wahlenberg 1960), and just at the time when board-foot increment is increasing.

In the financial analysis, summarized in Table 15, trees up to 9.6 inches d.b.h. were valued as cordwood and trees over 9.6 inches d.b.h. as sawtimber. The "margin of profit" is the difference between (1) the value of the timber on a plot at the beginning of the study, compounded at the rate of 6 percent to age 47, and (2) the market value

Table 15. Financial analysis of thinning treatments at age 47

Thinning treatment	Standing age 47	Thinnings compounded to age 47[1]	Standing, age 47, plus compounded thinnings	Standing, age 17-19 compounded to age 47[2]	Margin of profit[3]
			Dollars per acre		
Normal thinning					
Plot 1	1077	772	1849	418	1431
Plot 3	959	812	1771	504	1267
Plot 5	1120	646	1766	569	1197
Plot 7	968	508	1476	417	1059
Plot 9	1132	738	1870	422	1448
Plot 10	1084	747	1831	450	1381
Plot 12	1058	655	1713	391	1322
Plot 14	691	359	1050	430	620
Average	1011	655	1666	450	1216
Delayed thinning					
Plot 2	1530	31	1551	313	1238
Plot 4	883	420	1303	366	937
Plot 6	939	334	1273	557	716
Plot 8	950	146	1096	325	771
Plot 13	848	321	1169	309	860
Average	1030	248	1278	374	904
Check					
Plot 11	955	0	955	524	431
Plot 15	671	0	671	420	251
Plot 16	1146	0	1146	386	760
Average	924	0	924	443	481

1/ Cash value of all thinnings, compounded at 6.0% from the year of thinning to age 47.
2/ Cash value of standing timber at ages 17-19, before thinning, compounded at 6.0% to age 47.
3/ Amount by which the compounded ages 17-19 value is exceeded by the value of standing timber at age 47 plus the value of compounded thinnings.

Table 16. Average sawtimber production per acre, all species 9.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years	- - -Board feet (International 1/4-inch rule)- - -		
15	0	0	0
20	424	0	0
25	3,007	1,393	1,213
30	7,594	4,601	3,586
35	13,185	8,535	7,705
40	18,777	13,196	11,097
45	23,369	18,584	15,067
50	25,962	25,697	18,402

Normal thinning board feet = $30149.11 - 3755.99x + 140.18x^2 - 1.335x^3$

Delayed thinning board feet = $-3752.47 - 157.39x + 14.53x^2$

Check board feet = $26517.64 - 2834.93x + 92.37x^2 - 0.778x^3$

Table 17. Average sawtimber production of pine per acre, trees 9.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years	- - -Board feet (International 1/4-inch rule)- - -		
15	0	0	0
20	346	0	0
25	2,889	1,271	906
30	7,441	3,592	2,948
35	13,003	7,943	6,188
40	18,575	13,267	10,036
45	23,155	18,505	13,900
50	25,743	22,600	17,190

Normal thinning board feet = $30278.78 - 3767.68x + 140.23x^2 - 1.334x^3$

Delayed thinning board feet = $57150.58 - 5542.49x + 167.55x^2 - 1.41x^3$

Check board feet = $29368.52 - 3018.69x + 94.91x^2 - 0.788x^3$

of the standing timber on the plots at age 47, plus the value of the thinning incomes compounded from the age when received to age 47.

A comparison of the average margins of profit shows that by age 47, the normal thinning plots were about three times as valuable as the check and that the delayed thinning plots were about twice as valuable.

Analyses using other interest rates and stumpage values would yield other results, but there would still be a substantial difference between the treatments simply because of the greater amount of the more valuable sawtimber on the treated plots.

The difference between the margin of profit between the averages for the normal thinning and delayed thinning treatments is not great in this valuation. The real difference might be much greater if the comparison were based on the value of the final products obtained from the sawtimber-size trees after conversion. There are fewer trees per thousand board feet and the maximum diameters are larger on the normal thinning plots than on the delayed thinning plots. These differences ordinarily mean superiority for the normal thinning treatment in log quality, which was not measured in this study.

SUMMARY AND CONCLUSIONS

A study of growth and yield in thinned and unthinned, evenaged, second-growth loblolly pine was begun in 1930 in a 17-year-old stand near Urania, Louisiana. Three treatments designated as normal thinning, delayed thinning, and check were installed. Originally there were eight replications each of normal thinning and check treatments, paired by crop-tree spacing classes. Five of the check plots were thinned at stand ages 35 to 38 and became the delayed thinning treatment.

Treatments were applied on the normal thinning plots at about five-year intervals for a total of four or five thinnings. The delayed thinning plots were thinned once or twice. The selection of trees for cutting was done in accordance with Chapman's rules for crown thinning, which aimed to maintain a 40-percent crown ratio on the residual or crop trees by periodic reductions in the crown canopy of up to 50 percent. Measurements were made on each tree at the time of treatment and at about five-year intervals.

Analyses were made on an IBM computer. Stand parameters were determined for each plot at various ages. Regression analyses were used for predicting growth and yield for each of the treatment categories. Differences were tested statistically by analysis of variance and covariance.

Results and conclusions of the study are as follows:

1. No differences due to treatment were found in gross cubic-volume increment. In general this supports the general silvicultural principle that the gross production of wood is not influenced by thinnings provided that stands are not thinned drastically. In short rotations (up to 35 years) designed to produce small-diameter products, there is possibly no benefit in terms of merchantable volume to be derived from thinning.

2. Net cubic-volume yield was approximately 20 percent greater on the thinned plots than on the check. There was little difference between normal thinning and delayed thinning. Large losses to mortality, such as those in the check plots beginning about age 35, were apparently prevented by the thinnings in the delayed and normal thinning treatments. The utilization of nearly all merchantable material is possible by repeated thinnings in stands managed for any rotation length. The yield of larger-sized products is increased and rotation length for the production of these products may be shortened by judicious selection of the crop trees at early stand ages. Growing space can be reserved for a limited number of trees per acre, thereby concentrating increments of volume and value on a chosen portion of the stand.

3. Yields in cubic volume on the check plots were slightly less than those presented in Miscellaneous Publication 50 (U. S. Dep. Agr. 1929) and greater than in some of the other commonly used yield tables for unmanaged loblolly pine stands. These tables contain estimates of various parameters for unmanaged stands and are of limited use in present-day forestry practice.

4. The number of trees per acre at age 47 was about four times greater on the check plots than on the normal thinning plots. Plots beginning with a greater number of trees per acre generally had more trees per acre at age 47 irrespective of treatments.

Overdensity in even-aged loblolly pine stands often retards diameter growth and prolongs the time before economically justifiable first thinnings of merchantable material can be made.

A stand density whereby about 400 or fewer trees were left per acre after a first thinning at about age 18 produced the largest average-diameter (about 17 inches d.b.h.) stand in the study at age 50. The more dense stands had smaller average diameters throughout the course of the study even though they were thinned as frequently and by the same method. If growing space is to be best distributed among trees throughout a thinning regime, more thinnings or heavier thinnings are needed in the originally more dense stands than in those with wider spacings in order to obtain the same number and size of trees per acre at harvest age.

5. Pine crown ratio of the dominant stand declined from its initial value of about 50 percent but remained above 40 percent in the normal thinning plots. On the delayed thinning and check plots, the crown ratio declined to about 33 percent at age 40 and then rose to about 36 percent by age 50.

Crown length is correlated with crown width in loblolly pine and can be regulated by the frequency and intensity of thinnings. If a long, clear bole is desired, it can be achieved by light thinning but with some reduction in diameter growth rate. A 40-percent crown

ratio is apparently a good compromise between a satisfactory clear-bole length and diameter growth for the production of sawlogs and sawlog-size products.

6. Differences in the mean heights of pines in the dominant stand were not significant among treatments. The site averaged about the same for all treatments and the result was as expected. There was little variation among heights of trees on the normal thinning plots, more on the delayed thinning plots, and considerable on the check plots. Fewer trees develop large diameters in unthinned stands and often some of the largest are of poorer quality than those of comparable size in treated stands.

7. Average d.b.h. at ages 47 to 50 was highest on the normal thinning treatment and lowest on the check plots. The differences in mean annual diameter increment were highly significant. Average d.b.h. on the normal thinning treatment was about 5 inches larger than that on the check plots.

8. No significant difference was found in the specific gravity of cores from wood in each treatment. Apparently the average proportion of late wood to early wood was the same in all treatments regardless of ring width. There is much variability in specific gravity among individual trees in a wild stand like the one in this study. The specific gravity of wood produced by a tree may be a genetic characteristic and inheritable. A forest producing wood of uniform specific gravity might be attainable by regeneration with selected stock.

9. Mortality was greatest on the check plots, less on the delayed thinning plots, and practically nil on the normal thinning plots. The cause of death was attributed to overcrowding in the stands, as there was no record of attacks by insects or disease. No correlation was found between periods of heavy mortality and periods of low rainfall. Heavy mortality on the check plots began at about age 30, indicating that there may be little gain in net volume production by thinning in short rotations. Relatively more pines died than did hardwoods. The hardwoods were more able than the pines to persist for a long period of time in suppressed positions in the stand.

10. Form class for the average tree did not differ significantly between the two thinning treatments. It was significantly lower in the check plots. From observation of these stands, thinning neither increased nor decreased dominant-pine form class values; the dominant pines in the check stands, although fewer in number per acre, had equally as good form as the trees in the thinned stands.

11. Understory hardwoods increased in number and size following thinnings and developed to a condition of high understory, 30 to 50 percent of the height of the dominant stand, by age 50 in spite of being cut one or more times. Unless hardwoods are eliminated or controlled so that they do not develop to large size, thinnings on this and similar sites tend to hasten the succession from pine type to hardwood type over relatively long rotations. Hardwoods decreased in number on the check plots but many of the survivors were establishing positions of dominance by age 50. The large amount of mortality in the check plots, beginning about age 35, may have the

same effect in the future as thinnings on the increase of hardwood reproduction.

12. The normal thinning showed a margin of profit about three times greater than the average value of the check plots. The delayed thinning plots averaged about twice the profit margin of the check plots. The difference is due principally to the larger amount of sawtimber present on the treated plots at age 47 and to the compounded value to age 47 of the thinnings on these plots. Products such as sawlogs, veneer bolts, poles, and piling can be produced in larger amounts and over a shorter period of time if stands are thinned.

13. The results of this experiment confirm generally accepted silvicultural theories of the development of unthinned and thinned loblolly pine stands.

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APPENDIX A - DESCRIPTION OF PREDOMINANT SOIL FOUND ON THE CHAPMAN LOBLOLLY THINNING PLOTS

STOUGH VERY FINE SANDY LOAM

Location: LaSalle Parish, Louisiana, Chapman loblolly thinning plots - Georgia-Pacific Corporation - Sections 8 and 9, Township 10 North, Range 2 East.

Vegetation: Second-growth, even-aged, loblolly pine.

Slope and Land Form: Level.

Drainage and Permeability: Somewhat poorly drained. Surface runoff and internal drainage moderate to slow. Permeability is moderate in upper profile and slow in fragipan.

Parent Material: Coastal Plains, sandy alluvium. Local stream terrace.

Average Profile Described By: Benjamin F. Grafton, June 21, 1967.

HORIZON	DEPTH	DESCRIPTION
01	0.1"	Undecomposed pine needles, leaves and twigs, lower 1/4 inch partially decomposed organic material.
A1[1]	1-6"	Dark gray (10YR 4/1) very fine sandy loam; medium granular structure; very friable; few brown concretions; many roots; abrupt smooth boundary. pH 5.2.
B1	6-11"	Light yellowish brown (10YR 6/4) very fine sandy loam; weak subangular blocky structure; friable; few roots; few brown and yellow concretions; clear smooth boundary. pH 4.9.
B2	11-30"	Brownish yellow (10YR 6/6) sandy clay loam with distinct, light gray (10YR 6/1) and yellowish brown (10YR 5/4) mottles; moderate sub-angular blocky structure; friable; few mottling stronger in lower part of this layer. pH 4.9.

[1] A2 horizon not well defined.

HORIZON	DEPTH	DESCRIPTION
BX	30-48"	Light brownish gray (10YR 6/2) fine sandy loam to very fine sandy clay loam with distinct brownish yellow (10YR 6/6) and yellowish brown (10YR 5/6) mottles; moderate medium sub-angular blocky structure; firm, many brown and black concretions; clear smooth boundary; pH 5.1.
C	48+"	Mottled light gray (10YR 7/1) yellowish brown (10YR 5/6) and yellow (10YR 7/6) sandy clay loam; very weak sub-angular to massive structure; friable; brown concretions. pH 5.3.

Remarks: Colors given for moist soil.
Profile described from soil pits.
Analyses by LPI soils laboratory.

APPENDIX B

PLOT SUMMARIES OF STAND CHARACTERISTICS

AT VARIOUS STAND AGES

Table 18. Number of trees per acre 3.6" d.b.h. and up and average d.b.h. at various stand ages

	Pine						Hardwood					
	Before cut		Cut		After cut		Before cut		Cut		After cut	
Stand age	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
Plot 1 (Normal thinning)												
17	336	6.29	100	4.65	236	6.37	76	4.52	24	4.52	52	4.52
22	236	7.64	24	5.33	212	7.85	56	5.06	8	4.37	48	5.16
27	212	9.09	76	7.44	136	9.89	48	5.62	24	5.25	24	5.97
32	136	10.86	8	12.28	128	10.77	24	6.50	8	7.16	16	6.14
37	120	12.37	0	0.00	120	12.37	4	9.50	0	0.00	4	9.50
39	120	12.68	52	10.68	68	14.02	4	9.40	4	9.40	0	0.00
44	68	15.23	0	0.00	68	15.23	0	0.00	0	0.00	0	0.00
49	68	16.31	0	0.00	68	16.31	0	0.00	0	0.00	0	0.00
Plot 2 (Delayed thinning)												
17	304	6.24	0	0.00	304	6.24	132	4.76	0	0.00	132	4.76
22	300	7.19	0	0.00	300	7.19	132	5.39	0	0.00	132	5.39
27	292	8.10	0	0.00	292	8.10	128	5.82	0	0.00	128	5.82
32	272	8.84	0	0.00	272	8.84	112	6.19	0	0.00	112	6.19
37	248	9.94	0	0.00	248	9.94	104	6.70	100	6.51	4	10.30
42	200	11.25	0	0.00	200	11.25	4	11.00	0	0.00	4	11.00
47	180	12.22	0	0.00	180	12.22	4	11.50	0	0.00	4	11.50

Table 18. Continued

Stand age	Pine: Before cut: Trees	Pine: Before cut: Av. d.b.h.	Pine: Cut: Trees	Pine: Cut: Av. d.b.h.	Pine: After cut: Trees	Pine: After cut: Av. d.b.h.	Hardwood: Before cut: Trees	Hardwood: Before cut: Av. d.b.h.	Hardwood: Cut: Trees	Hardwood: Cut: Av. d.b.h.	Hardwood: After cut: Trees	Hardwood: After cut: Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
Plot 3 (Normal thinning)												
17	700	5.31	332	4.76	368	5.76	20	4.80	16	5.04	4	3.70
22	352	6.79	132	5.87	220	7.29	4	4.70	4	4.70	0	0.00
27	216	8.77	48	8.11	168	8.95	0	0.00	0	0.00	0	0.00
32	152	10.31	0	0.00	152	10.31	0	0.00	0	0.00	0	0.00
37	148	11.65	0	0.00	148	11.65	0	0.00	0	0.00	0	0.00
39	148	11.98	45	10.80	92	12.64	0	0.00	0	0.00	0	0.00
44	92	13.86	12	13.96	80	13.84	0	0.00	0	0.00	0	0.00
49	80	15.11	0	0.00	80	15.11	0	0.00	0	0.00	0	0.00
Plot 4 (Delayed thinning)												
17	564	5.06	0	0.00	564	5.06	72	4.50	0	0.00	72	4.50
22	560	5.91	0	0.00	560	5.91	68	4.92	0	0.00	68	4.92
27	540	6.63	0	0.00	540	6.63	68	5.21	0	0.00	68	5.21
32	480	7.39	0	0.00	480	7.39	68	5.52	0	0.00	68	5.52
37	372	8.63	0	0.00	372	8.63	68	5.97	0	0.00	68	5.97
38	348	8.88	220	7.61	128	10.71	68	6.03	68	6.03	0	0.00
44	120	12.33	32	10.66	88	12.89	0	0.00	0	0.00	0	0.00
49	88	14.40	0	0.00	88	14.40	0	0.00	0	0.00	0	0.00

Table 18. Continued

Stand age	Pine: Before cut Trees	Pine: Before cut Av. d.b.h.	Pine: Cut Trees	Pine: Cut Av. d.b.h.	Pine: After cut Trees	Pine: After cut Av. d.b.h.	Hardwood: Before cut Trees	Hardwood: Before cut Av. d.b.h.	Hardwood: Cut Trees	Hardwood: Cut Av. d.b.h.	Hardwood: After cut Trees	Hardwood: After cut Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
Plot 5 (Normal thinning)												
18	632	5.56	208	5.24	424	5.72	24	5.57	8	6.51	16	5.03
23	416	6.57	180	5.71	236	7.16	16	5.95	8	5.01	8	6.77
28	228	8.33	100	6.06	128	9.74	8	7.75	4	5.10	4	9.70
33	128	10.94	0	0.00	128	10.94	4	11.30	0	0.00	4	11.30
38	128	12.04	40	10.43	88	12.70	84	5.55	80	4.92	4	12.80
43	84	13.95	12	11.61	72	14.30	4	13.60	4	13.60	0	0.00
48	72	15.63	0	0.00	72	15.63	0	0.00	0	0.00	0	0.00
Plot 6 (Delayed thinning)												
18	648	5.45	0	0.00	648	5.45	84	5.38	0	0.00	84	5.38
23	636	6.04	0	0.00	636	6.04	80	5.17	0	0.00	80	5.17
28	572	6.70	0	0.00	572	6.70	68	5.66	0	0.00	68	5.66
33	488	7.48	0	0.00	488	7.48	68	6.18	0	0.00	68	6.18
38	392	8.41	196	7.27	196	9.42	68	6.54	60	6.12	8	9.09
43	192	10.15	64	8.68	128	10.80	8	9.87	8	9.87	0	0.00
48	128	11.84	0	0.00	128	11.84	0	0.00	0	0.00	0	0.00

Table 18. Continued

Stand age	Pine: Before cut Trees	Pine: Before cut Av. d.b.h.	Pine: Cut Trees	Pine: Cut Av. d.b.h.	Pine: After cut Trees	Pine: After cut Av. d.b.h.	Hardwood: Before cut Trees	Hardwood: Before cut Av. d.b.h.	Hardwood: Cut Trees	Hardwood: Cut Av. d.b.h.	Hardwood: After cut Trees	Hardwood: After cut Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
					Plot 7 (Normal thinning)							
18	740	4.78	304	4.48	436	4.97	92	4.31	36	4.47	56	4.21
23	436	5.81	120	5.19	316	6.03	56	4.84	44	4.93	12	4.49
28	284	7.69	128	6.41	156	8.60	4	3.60	0	0.00	4	3.60
33	148	10.17	0	5.40	144	10.27	0	0.00	0	0.00	0	0.00
38	140	11.64	40	9.83	100	12.29	0	0.00	0	0.00	0	0.00
43	96	13.53	20	12.32	76	13.83	0	0.00	0	0.00	0	0.00
48	76	15.24	0	0.00	76	15.24	0	0.00	0	0.00	0	0.00
					Plot 8 (Delayed thinning)							
18	580	4.81	0	0.00	580	4.81	112	4.32	0	0.00	112	4.32
23	584	5.45	0	0.00	584	5.45	112	4.63	0	0.00	112	4.63
28	560	6.31	0	0.00	560	6.31	112	5.00	0	0.00	112	5.00
35	448	7.21	316	6.14	132	9.28	112	5.34	108	5.22	4	7.80
40	124	11.02	0	0.00	124	11.02	4	8.80	0	0.00	4	8.80
45	124	12.11	0	0.00	124	12.11	4	9.50	0	0.00	4	9.50
50	124	12.92	0	0.00	124	12.92	4	10.00	0	0.00	4	10.00

Table 18. Continued

	Pine						Hardwood					
	Before cut		Cut		After cut		Before cut		Cut		After cut	
Stand age	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
					Plot 9 (Normal thinning)							
18	336	6.18	132	5.80	204	6.35	76	6.37	28	6.02	48	6.57
23	204	7.75	40	5.45	164	8.21	48	7.25	0	0.00	48	7.25
28	164	9.78	64	7.98	100	10.78	48	7.89	48	7.89	0	0.00
34	100	12.61	0	0.00	100	12.61	0	0.00	0	0.00	0	0.00
39	96	13.99	28	12.23	68	14.65	0	0.00	0	0.00	0	0.00
44	64	15.84	0	0.00	64	15.84	0	0.00	0	0.00	0	0.00
49	64	16.91	0	0.00	64	16.91	72	4.01	0	0.00	72	4.01
					Plot 10 (Normal thinning)							
18	508	5.80	192	5.29	316	6.09	60	4.54	20	4.62	40	4.50
23	304	7.19	132	5.72	172	8.14	40	5.02	16	4.98	24	5.05
28	172	9.67	52	9.49	120	9.75	24	5.55	24	5.55	0	0.00
34	120	11.54	0	0.00	120	11.54	0	0.00	0	0.00	0	0.00
39	116	12.56	32	10.74	84	13.19	0	0.00	0	0.00	0	0.00
44	84	14.52	12	12.54	72	14.83	0	0.00	0	0.00	0	0.00
49	72	16.15	0	0.00	72	16.16	0	0.00	0	0.00	0	0.00

Table 18. Continued

	Pine						Hardwood					
	Before cut		Cut		After cut		Before cut		Cut		After cut	
Stand age	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
					Plot 11 (Check)							
18	580	5.52	0	0.00	580	5.52	100	5.66	0	0.00	100	5.66
23	572	6.03	0	0.00	572	6.03	100	5.96	0	0.00	100	5.96
28	528	6.77	0	0.00	528	6.77	100	6.42	0	0.00	100	6.42
34	432	7.84	0	0.00	432	7.84	96	7.18	0	0.00	96	7.18
39	368	8.60	0	0.00	368	8.60	84	7.68	0	0.00	84	7.68
44	324	9.33	0	0.00	324	9.33	108	7.30	0	0.00	108	7.30
49	284	9.95	0	0.00	284	9.95	116	7.23	0	0.00	116	7.23
					Plot 12 (Normal thinning)							
19	324	6.37	88	5.26	236	7.74	60	5.34	24	5.32	36	5.35
24	236	8.26	0	0.00	236	8.26	36	5.90	0	0.00	36	5.90
29	236	9.15	116	6.91	120	10.89	36	6.29	36	6.29	0	0.00
35	120	12.48	0	0.00	120	12.48	0	0.00	0	0.00	0	0.00
38	120	13.04	28	11.21	92	13.55	0	0.00	0	0.00	0	0.00
43	92	14.61	20	14.28	72	14.71	0	0.00	0	0.00	0	0.00
48	72	15.96	0	0.00	72	15.96	0	0.00	0	0.00	0	0.00

Table 18. Continued

Stand age	Pine: Before cut Trees	Pine: Before cut Av. d.b.h.	Pine: Cut Trees	Pine: Cut Av. d.b.h.	Pine: After cut Trees	Pine: After cut Av. d.b.h.	Hardwood: Before cut Trees	Hardwood: Before cut Av. d.b.h.	Hardwood: Cut Trees	Hardwood: Cut Av. d.b.h.	Hardwood: After cut Trees	Hardwood: After cut Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
					Plot 13 (Delayed thinning)							
19	436	5.53	0	0.00	436	5.53	44	4.64	0	0.00	44	4.64
24	436	6.51	0	0.00	436	6.51	44	5.21	0	0.00	44	5.21
28	432	7.06	0	0.00	438	7.06	44	5.44	0	0.00	44	5.44
35	376	8.06	236	6.85	140	9.78	36	6.63	36	6.63	0	0.00
39	140	10.62	0	0.00	140	10.62	0	0.00	0	0.00	0	0.00
44	140	11.51	40	9.63	100	12.19	0	0.00	0	0.00	0	0.00
49	100	13.27	0	0.00	100	13.27	0	0.00	0	0.00	0	0.00
					Plot 14 (Normal thinning)							
19	804	4.81	332	4.55	472	5.16	36	4.56	32	4.52	4	4.90
24	472	6.23	108	6.32	364	6.20	4	5.00	4	5.00	0	0.00
29	360	7.09	188	5.97	172	8.13	0	0.00	0	0.00	0	0.00
35	176	9.16	60	7.88	116	9.76	0	0.00	0	0.00	0	0.00
40	96	11.51	0	0.00	96	11.51	0	0.00	0	0.00	0	0.00
45	96	12.53	0	0.00	96	12.53	0	0.00	0	0.00	0	0.00
53	96	13.52	0	0.00	96	13.32	0	0.00	0	0.00	0	0.00

Table 18. Continued

Stand age	Pine						Hardwood					
	Before cut		Cut		After cut		Before cut		Cut		After cut	
	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.	Trees	Av. d.b.h.
Years	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches	No.	Inches
						Plot 15 (Check)						
19	716	4.87	0	0.00	716	4.87	56	4.78	0	0.00	56	4.78
24	716	5.57	0	0.00	716	5.57	56	5.26	0	0.00	56	5.26
29	692	6.08	0	0.00	692	6.08	56	5.58	0	0.00	56	5.58
34	596	6.81	0	0.00	596	6.81	56	6.11	0	0.00	56	6.11
40	424	7.72	0	0.00	424	7.72	40	7.39	0	0.00	40	7.39
45	368	8.42	0	0.00	368	8.42	80	6.18	0	0.00	80	6.18
50	300	9.28	0	0.00	300	9.28	64	5.90	0	0.00	64	5.90
						Plot 16 (Check)						
19	328	5.92	0	0.00	328	5.92	112	4.29	0	0.00	112	4.29
24	328	7.16	0	0.00	328	7.16	104	4.73	0	0.00	104	4.73
29	296	8.20	0	0.00	296	8.20	96	5.17	0	0.00	96	5.17
35	272	9.12	0	0.00	272	9.12	96	5.53	0	0.00	96	5.53
40	244	9.99	0	0.00	244	9.99	76	6.12	0	0.00	76	6.12
45	232	10.71	0	0.00	232	10.71	140	5.57	0	0.00	140	5.57
50	184	11.48	0	0.00	184	11.48	124	5.87	0	0.00	124	5.87

Table 19. Number of trees per acre by size and product classes at various stand ages

	Before cut						Cut						After cut					
	Pulpwood[1/]			Sawtimber[2/]			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
							Plot 1 (Normal thinning)											
17	328	76	404	8	0	8	100	24	124	0	0	0	228	52	280	8	0	8
22	212	562	268	24	0	24	24	8	32	16	0	16	188	48	236	24	0	24
27	120	48	168	92	0	92	60	24	84	4	0	4	60	24	84	76	0	76
32	36	24	60	100	0	100	4	8	12	0	0	0	32	16	48	96	0	96
37	16	4	20	104	0	104	0	0	0	36	0	36	16	4	20	104	0	104
39	16	4	20	104	0	104	16	4	20	0	0	0	0	0	0	68	0	68
44	0	0	0	68	0	68	0	0	0	0	0	0	0	0	0	68	0	68
49	0	0	0	68	0	68	0	0	0	0	0	0	0	0	0	68	0	68
							Plot 2 (Delayed thinning)											
17	304	132	436	0	0	0	0	0	0	0	0	0	304	132	436	0	0	0
22	272	132	404	28	0	28	0	0	0	0	0	0	272	132	404	28	0	28
27	232	128	360	60	0	60	0	0	0	0	0	0	232	128	360	60	0	60
32	180	108	288	92	4	96	0	0	0	0	0	0	180	108	288	92	4	96
37	136	96	232	112	8	120	0	96	96	0	4	4	136	0	136	112	4	116
42	72	0	72	128	4	132	0	0	0	0	0	0	72	0	72	128	4	132
47	48	0	48	132	4	136	0	0	0	0	0	0	48	0	48	132	4	136

[1/] Trees 3.6 inches to 9.6 inches d.b.h.

[2/] Trees 9.6 inches d.b.h. and up.

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
							Plot 3 (Normal thinning)											
17	700	20	720	0	0	0	332	16	348	0	0	0	368	4	372	0	0	0
22	340	4	344	12	0	12	132	4	136	0	0	0	208	0	208	12	0	12
27	144	0	144	72	0	72	44	0	44	4	0	4	100	0	100	68	0	68
32	52	0	52	100	0	100	0	0	0	0	0	0	52	0	52	100	0	100
37	12	0	12	136	0	136	0	0	0	0	0	0	12	0	12	136	0	136
39	16	0	16	132	0	132	12	0	12	44	0	44	4	0	4	88	0	88
44	4	0	0	88	0	88	0	0	0	12	0	12	4	0	4	76	0	76
49	4	0	0	76	0	76	0	0	0	0	0	0	4	0	4	76	0	76
							Plot 4 (Delayed thinning)											
17	564	72	636	0	0	0	0	0	0	0	0	0	564	72	636	0	0	0
22	556	68	624	4	0	4	0	0	0	0	0	0	556	68	624	4	0	4
27	512	68	580	28	0	28	0	0	0	0	0	0	512	68	580	28	0	28
32	416	68	484	64	0	64	0	0	0	0	0	0	416	68	484	64	0	64
37	260	60	320	112	8	120	0	0	0	0	0	0	260	60	320	112	0	112
38	228	60	288	120	8	128	200	60	260	20	8	28	28	0	28	100	0	100
44	8	0	8	112	0	112	8	0	8	24	0	24	0	0	0	88	0	88
49	0	0	0	88	0	88	0	0	0	0	0	0	0	0	0	88	0	88

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
							Plot 5 (Normal thinning)											
18	628	24	652	4	0	4	208	8	216	0	0	0	420	16	436	4	0	4
23	296	16	412	20	0	20	180	8	188	0	0	0	216	8	224	20	0	20
28	168	4	172	60	4	64	100	4	104	0	0	0	68	0	68	60	4	64
33	44	0	44	84	4	88	0	0	0	0	0	0	44	0	44	84	4	88
38	16	80	96	112	4	116	12	80	92	28	0	28	4	0	4	84	4	88
43	4	0	4	80	4	84	0	0	0	12	4	16	4	0	4	68	0	68
48	0	0	0	72	0	72	0	0	0	0	0	0	0	0	0	72	0	72
							Plot 6 (Delayed thinning)											
18	648	84	732	0	0	0	0	0	0	0	0	0	648	84	732	0	0	0
23	632	80	712	4	0	4	0	0	0	0	0	0	632	80	712	4	0	4
28	552	68	620	20	0	20	0	0	0	0	0	0	552	68	620	20	0	20
33	428	64	492	60	4	64	0	0	0	0	0	0	428	64	492	60	4	64
38	300	64	364	92	4	96	184	60	244	12	0	12	116	4	120	80	4	84
43	96	4	100	96	4	100	52	4	56	12	4	16	44	0	44	84	0	84
48	12	0	12	116	0	116	0	0	0	0	0	0	12	0	12	116	0	116

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Plot 7 (Normal thinning)																		
18	740	92	832	0	0	0	304	36	340	0	0	0	436	56	492	0	0	0
23	436	56	492	4	0	4	120	44	164	0	0	0	316	12	328	0	0	0
28	252	4	256	32	0	32	128	0	128	0	0	0	124	4	128	32	0	32
33	40	0	40	104	0	104	0	0	0	0	0	0	40	0	40	104	0	104
38	20	0	20	120	0	120	16	0	16	24	0	24	4	0	4	96	0	96
43	0	0	0	96	0	96	0	0	0	20	0	20	0	0	0	76	0	76
48	0	0	0	76	0	76	0	0	0	0	0	0	0	0	0	76	0	76
Plot 8 (Delayed thinning)																		
18	580	112	692	0	0	0	0	0	0	0	0	0	580	112	692	0	0	0
23	584	112	696	0	0	0	0	0	0	0	0	0	584	112	696	0	0	0
28	544	112	656	16	0	16	0	0	0	0	0	0	544	112	656	16	0	16
35	400	108	508	48	4	52	316	104	420	0	4	4	84	4	88	48	0	48
40	28	4	32	96	0	96	0	0	0	0	0	0	28	4	32	96	0	96
45	12	4	16	112	0	112	0	0	0	0	0	0	12	4	16	112	0	112
50	0	0	0	124	4	128	0	0	0	0	0	0	0	0	0	124	4	128

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
							Plot 9 (Normal thinning)											
18	332	72	404	4	4	8	132	28	160	0	0	0	200	44	244	4	4	8
23	160	40	200	44	8	52	40	0	40	0	0	0	120	40	160	44	8	52
28	68	40	108	96	8	104	48	40	88	16	8	22	20	0	20	80	0	80
34	12	0	12	88	0	88	0	0	0	0	0	0	12	0	12	88	0	88
39	0	0	0	96	0	96	0	0	0	28	0	28	0	0	0	68	0	68
44	0	0	0	64	0	64	0	0	0	0	0	0	0	0	0	64	0	64
49	0	72	72	64	0	64	0	0	0	0	0	0	0	72	72	64	0	64
							Plot 10 (Normal thinning)											
18	508	60	568	0	0	0	192	20	212	0	0	0	316	40	356	0	0	0
23	292	40	332	12	0	12	132	16	148	0	0	0	160	24	184	12	0	12
28	76	24	100	96	0	96	52	24	76	20	0	20	24	0	24	96	0	96
34	20	0	20	100	0	100	0	0	0	0	0	0	20	0	20	100	0	100
39	4	0	4	112	0	112	4	0	4	28	0	28	0	0	0	84	0	84
44	0	0	0	84	0	84	0	0	0	12	0	12	0	0	0	72	0	72
49	0	0	0	72	0	72	0	0	0	0	0	0	0	0	0	72	0	72

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Plot 11 (Check)																		
18	580	92	672	0	8	8	0	0	0	0	0	0	580	92	672	0	8	8
23	560	92	652	12	8	20	0	0	0	0	0	0	560	92	652	12	8	20
28	512	92	604	16	8	24	0	0	0	0	0	0	512	92	604	16	8	24
34	368	84	452	64	12	76	0	0	0	0	0	0	368	84	452	64	12	76
39	272	72	344	96	12	108	0	0	0	0	0	0	272	72	344	96	12	108
44	200	92	292	124	16	140	0	0	0	0	0	0	200	92	292	124	16	140
49	152	96	248	132	20	152	0	0	0	0	0	0	152	96	248	132	20	152
Plot 12 (Normal thinning)																		
19	308	60	368	16	0	16	88	24	112	0	0	0	220	36	256	16	0	16
24	204	36	240	32	0	32	0	0	0	0	0	0	204	36	240	32	0	32
29	160	32	192	76	4	80	112	32	144	4	4	8	48	0	48	76	0	76
35	24	0	24	96	0	96	0	0	0	0	0	0	24	0	24	96	0	96
38	16	0	16	104	0	104	4	0	4	24	0	24	12	0	12	80	0	80
43	4	0	4	88	0	88	4	0	4	16	0	16	0	0	0	72	0	72
48	0	0	0	72	0	72	0	0	0	0	0	0	0	0	0	72	0	72

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
							Plot 13 (Delayed thinning)											
19	436	4	480	0	0	0	0	0	0	0	0	0	436	44	480	0	0	0
24	420	44	464	16	0	16	0	0	0	0	0	0	420	44	464	16	0	16
28	400	44	444	32	0	32	0	0	0	0	0	0	400	44	444	32	0	32
35	308	32	340	68	4	72	232	32	264	4	4	8	76	0	76	64	0	64
39	44	0	44	96	0	96	0	0	0	0	0	0	44	0	44	96	0	96
44	20	0	20	120	0	120	16	0	16	24	0	24	4	0	4	96	0	96
49	0	0	0	100	0	100	0	0	0	0	0	0	0	0	0	100	0	100
							Plot 14 (Normal thinning)											
19	804	36	840	0	0	0	332	32	364	0	0	0	472	4	476	0	0	0
24	456	4	460	16	0	16	100	4	104	8	0	8	356	0	356	8	0	8
29	340	0	340	20	0	20	188	0	188	0	0	0	152	0	152	20	0	20
35	116	0	116	60	0	60	56	0	56	4	0	4	60	0	60	56	0	56
40	12	0	12	84	0	84	0	0	0	0	0	0	12	0	12	84	0	84
45	0	0	0	96	0	96	0	0	0	0	0	0	0	0	0	96	0	96
50	0	0	0	96	0	96	0	0	0	0	0	0	0	0	0	96	0	96

Table 19. Continued

	Before cut						Cut						After cut					
	Pulpwood			Sawtimber			Pulpwood			Sawtimber			Pulpwood			Sawtimber		
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
								Plot 15 (Check)										
19	716	56	772	0	0	0	0	0	0	0	0	0	716	56	772	0	0	0
24	716	56	772	0	0	0	0	0	0	0	0	0	716	56	772	0	0	0
29	688	56	744	4	0	4	0	0	0	0	0	0	688	56	744	4	0	4
34	580	52	632	16	4	20	0	0	0	0	0	0	580	52	632	16	4	20
40	372	36	408	52	4	56	0	0	0	0	0	0	372	36	408	52	4	56
45	276	76	352	92	4	96	0	0	0	0	0	0	276	76	352	92	4	96
50	196	64	260	104	0	104	0	0	0	0	0	0	196	64	260	104	0	104
								Plot 16 (Check)										
19	316	112	428	12	0	12	0	0	0	0	0	0	316	112	428	12	0	12
24	304	104	408	24	0	24	0	0	0	0	0	0	304	104	408	24	0	24
29	236	96	332	60	0	60	0	0	0	0	0	0	236	96	332	60	0	60
35	188	96	284	84	0	84	0	0	0	0	0	0	188	96	284	84	0	84
40	144	72	216	100	0	104	0	0	0	0	0	0	144	72	216	100	4	104
45	112	132	244	120	8	128	0	0	0	0	0	0	112	132	244	120	8	128
50	64	116	180	120	8	128	0	0	0	0	0	0	64	116	180	120	8	128

Table 20. Basal area per acre of all species 3.6 inches d.b.h. and up at various stand ages

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Square feet								
Plot 1 (Normal thinning)									
17	72.53	8.48	81.01	20.33	2.68	23.01	52.20	5.80	58.00
22	75.06	7.80	82.86	3.72	0.83	4.55	71.34	6.97	78.31
27	95.50	8.26	103.76	22.91	3.60	26.51	72.59	4.66	77.25
32	87.54	5.52	93.06	6.57	2.23	8.80	80.97	3.29	84.26
37	100.19	1.96	102.15	0.00	0.00	0.00	100.19	1.96	102.15
44	86.07	0.00	87.07	0.00	0.00	0.00	86.07	0.00	86.07
49	98.69	0.00	98.69	0.00	0.00	0.00	98.69	0.00	98.69
Plot 2 (Delayed thinning)									
17	64.50	16.34	80.84	0.00	0.00	0.00	64.50	16.34	80.84
22	86.29	20.93	107.22	0.00	0.00	0.00	86.29	20.93	107.22
27	104.40	22.97	127.37	0.00	0.00	0.00	104.40	22.97	127.37
32	115.86	23.38	139.24	0.00	0.00	0.00	115.86	23.38	139.24
37	132.62	25.44	158.06	0.00	23.12	23.12	132.62	2.32	134.94
42	138.08	2.63	140.71	0.00	0.00	0.00	138.08	2.63	140.71
47	146.70	2.88	149.58	0.00	0.00	0.00	146.70	2.88	149.58

Table 20. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	- - - - - - - - - - - - - - - - - -			- - Square feet - -			- - - - - - - - - - - - - - - - - -		
				Plot 3 (Normal thinning)					
17	107.78	2.51	110.29	41.11	2.22	43.33	66.67	0.29	66.96
22	88.64	0.48	89.12	24.69	0.48	25.27	63.85	0.00	63.85
27	90.60	17.23	90.60	17.23	0.00	17.23	73.37	0.00	73.37
32	88.08	0.00	88.08	0.00	0.00	0.00	88.08	0.00	88.08
37	109.55	0.00	109.55	0.00	0.00	0.00	109.55	0.00	109.55
39	115.82	0.00	115.82	35.62	0.00	35.62	80.20	0.00	80.20
44	96.33	0.00	96.33	12.75	0.00	12.75	83.58	0.00	83.58
49	99.56	0.00	99.56	0.00	0.00	0.00	99.56	0.00	99.56
				Plot 4 (Delayed thinning)					
17	78.87	9.75	88.62	10.00	0.00	0.00	77.87	9.75	88.62
22	106.54	8.97	115.51	0.00	0.00	0.00	106.54	8.97	115.51
27	129.36	10.05	139.41	0.00	0.00	0.00	129.36	10.05	139.41
32	143.06	11.30	154.36	0.00	0.00	0.00	143.06	11.30	154.36
37	151.12	13.23	164.35	0.00	0.00	0.00	151.12	13.23	164.35
38	152.40	13.50	165.90	72.25	13.50	85.75	80.15	0.00	80.15
44	99.54	0.00	99.54	19.85	0.00	19.85	79.69	0.00	79.69
49	99.50	0.00	99.50	0.00	0.00	0.00	99.50	0.00	99.50

Table 20. Continued

Stand	Before cut			Cut			After cut		
age	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years					Square feet				
				Plot 5 (Normal thinning)					
18	106.73	4.06	110.79	31.19	1.85	33.04	75.54	2.21	77.75
23	97.91	3.09	101.00	32.00	1.09	33.09	65.91	2.00	67.91
28	86.29	2.62	88.91	20.01	0.56	20.57	66.28	2.06	68.34
33	83.55	2.78	86.33	0.00	0.00	0.00	83.55	2.78	86.33
38	101.20	14.12	115.32	23.74	10.55	34.29	77.46	3.57	81.03
43	89.16	4.03	93.19	8.82	4.03	12.85	80.34	0.00	80.34
48	95.91	0.00	95.91	0.00	0.00	0.00	95.91	0.00	95.91
				Plot 6 (Delayed thinning)					
18	104.84	13.23	118.07	0.00	0.00	0.00	104.84	13.23	118.07
23	126.66	11.67	138.33	0.00	0.00	0.00	126.66	11.67	138.33
28	140.24	11.90	152.14	0.00	0.00	0.00	140.24	11.90	152.14
33	148.83	14.14	162.97	0.00	0.00	0.00	148.83	14.14	162.97
38	151.28	15.86	167.14	56.49	12.26	68.75	94.79	3.60	98.39
43	107.79	4.25	112.04	26.29	4.25	30.54	81.50	0.00	81.50
48	97.78	0.00	97.78	0.00	0.00	0.00	97.78	0.00	97.78

Table 20. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Square feet								
Plot 7 (Normal thinning)									
18	92.11	9.33	101.44	33.29	3.92	37.21	58.82	5.41	64.23
23	80.30	7.14	87.44	17.61	5.82	23.43	62.69	1.32	64.01
28	91.98	0.23	92.21	29.06	0.00	29.06	62.92	0.23	63.15
33	83.51	0.00	83.51	0.00	0.00	0.00	83.51	0.00	83.51
38	103.50	0.00	103.50	21.06	0.00	21.06	82.44	0.00	82.44
43	95.83	0.00	95.83	16.56	0.00	16.56	79.27	0.00	79.27
48	96.27	0.00	96.27	0.00	0.00	0.00	96.27	0.00	96.27
Plot 8 (Delayed thinning)									
18	73.27	11.38	84.65	0.00	0.00	0.00	73.27	11.38	84.65
23	94.57	13.10	107.67	0.00	0.00	0.00	94.57	13.10	107.67
28	121.66	15.24	136.90	0.00	0.00	0.00	121.66	15.24	121.66
35	127.01	17.40	144.41	65.02	16.07	81.09	61.99	1.33	63.32
40	83.34	1.68	85.02	0.00	0.00	0.00	83.34	1.68	85.02
45	99.13	1.96	101.09	0.00	0.00	0.00	99.13	1.96	101.09
50	112.85	2.18	115.03	0.00	0.00	0.00	112.85	2.18	115.03

Table 20. Continued

Stand age	Before cut Pine	Before cut Hwd	Before cut Total	Cut Pine	Cut Hwd	Cut Total	After cut Pine	After cut Hwd	After cut Total
Years				Square feet					
				Plot 9 (Normal thinning)					
18	69.06	16.82	85.88	24.24	5.54	29.78	44.82	11.28	56.10
23	66.75	13.75	80.50	6.48	0.00	6.48	60.27	13.75	74.02
28	85.62	16.30	101.92	22.24	16.30	38.54	63.38	0.00	63.38
34	86.74	0.00	86.74	0.00	0.00	0.00	86.74	0.00	86.74
39	102.47	0.00	102.47	22.85	0.00	22.85	79.62	0.00	79.62
44	87.63	0.00	87.63	0.00	0.00	0.00	87.63	6.32	87.63
49	99.79	6.32	106.11	0.00	0.00	0.00	99.79	6.32	106.11
				Plot 10 (Normal thinning)					
18	93.13	6.74	9.87	29.28	2.33	31.61	63.85	4.41	68.26
23	85.70	5.49	91.19	23.56	2.16	25.72	62.14	3.33	65.47
28	87.70	4.02	91.72	25.53	4.02	29.55	62.17	0.00	62.17
34	86.84	0.00	86.84	0.00	0.00	0.00	86.84	0.00	86.84
39	99.81	0.00	99.81	20.12	0.00	20.12	79.69	0.00	79.69
44	96.63	0.00	96.63	10.28	0.00	10.28	86.35	0.00	86.35
49	102.39	0.00	102.39	0.00	0.00	0.00	102.39	0.00	102.39

Table 20. Continued

Stand age	Before cut Pine	Before cut Hwd	Before cut Total	Cut Pine	Cut Hwd	Cut Total	After cut Pine	After cut Hwd	After cut Total
Years	Square feet								
				Plot 11 (Check)					
18	96.43	17.28	113.71	0.00	0.00	0.00	96.43	17.28	113.71
23	113.28	19.11	132.39	0.00	0.00	0.00	113.28	19.11	132.39
28	132.09	22.04	154.13	0.00	0.00	0.00	132.09	22.04	154.13
34	144.75	26.39	171.14	0.00	0.00	0.00	144.75	26.39	171.14
39	148.41	25.69	174.10	0.00	0.00	0.00	148.41	25.69	174.10
44	153.74	29.94	183.68	0.00	0.00	0.00	153.74	29.94	183.68
49	153.36	31.53	184.89	0.00	0.00	0.00	153.36	31.53	184.89
				Plot 12 (Normal thinning)					
19	71.74	9.32	81.06	13.28	3.70	16.98	58.46	5.62	64.08
24	87.72	6.84	99.56	0.00	0.00	0.00	87.72	6.84	94.56
29	107.82	7.75	115.57	30.20	7.75	37.95	77.62	0.00	77.62
35	101.91	0.00	101.91	0.00	0.00	0.00	101.91	0.00	101.91
38	111.30	0.00	111.30	19.19	0.00	10.19	92.11	0.00	92.11
43	107.18	0.00	107.18	22.24	0.00	22.24	84.94	0.00	84.94
48	100.00	0.00	100.00	0.00	0.00	0.00	100.00	0.00	100.00

Table 20. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Square feet								
Plot 13 (Delayed thinning)									
19	72.83	5.17	78.00	0.00	0.00	0.00	72.83	5.17	78.00
24	100.70	6.52	107.22	0.00	0.00	0.00	100.70	6.52	107.22
28	117.51	7.09	124.60	0.00	0.00	0.00	117.51	7.09	124.60
35	133.33	8.62	141.95	60.35	8.62	68.97	72.98	0.00	72.98
39	86.08	0.00	86.08	0.00	0.00	0.00	86.08	0.00	86.08
44	101.22	0.00	101.22	20.21	0.00	20.21	81.01	0.00	81.01
49	96.08	0.00	96.08	0.00	0.00	0.00	96.08	0.00	96.08
Plot 14 (Normal thinning									
19	106.15	4.09	110.24	37.53	3.57	41.10	68.62	0.52	69.14
24	99.94	0.54	100.48	23.55	0.54	24.09	76.39	0.00	76.39
29	98.58	0.00	98.94	32.02	0.00	32.02	66.56	0.00	66.56
35	80.58	0.00	80.58	20.33	0.00	20.33	60.25	0.00	60.25
40	69.42	0.00	69.42	0.00	0.00	0.00	69.42	0.00	69.42
45	82.26	0.00	82.26	0.00	0.00	0.00	82.26	0.00	82.26
50	92.89	0.00	92.89	0.00	0.00	0.00	92.89	0.00	92.89

Table 20. Continued

Stand	Before cut			Cut			After cut		
age	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Square feet								
				Plot 15 (Check)					
19	92.66	6.96	99.62	0.00	0.00	0.00	92.66	6.96	99.62
24	120.97	8.43	129.40	0.00	0.00	0.00	120.97	8.43	129.40
29	139.33	9.49	148.82	0.00	0.00	0.00	139.33	9.49	148.82
34	150.58	11.41	161.99	0.00	0.00	0.00	150.58	11.41	161.99
40	137.75	11.92	149.67	0.00	0.00	0.00	137.75	11.92	149.67
45	142.36	16.66	159.02	0.00	0.00	0.00	142.36	16.66	159.02
50	140.79	12.15	152.94	0.00	0.00	0.00	140.79	12.15	152.94
				Plot 16 (Check)					
19	62.78	11.26	74.04	0.00	0.00	0.00	62.78	11.26	74.04
24	91.82	12.69	104.51	0.00	0.00	0.00	91.82	12.69	104.51
29	108.67	14.00	122.67	0.00	0.00	0.00	108.67	14.00	122.67
35	123.31	16.03	139.34	0.00	0.00	0.00	123.31	16.03	139.34
40	132.84	15.54	148.38	0.00	0.00	0.00	132.84	15.54	148.38
45	145.18	23.67	168.85	0.00	0.00	0.00	145.18	23.67	168.85
50	132.19	23.27	155.46	0.00	0.00	0.00	132.19	23.27	155.46

Table 21. Volume per acre at various stand ages of all species 3.6 inches d.b.h. and up inside bark, including stump, stem, and tip

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
Plot 1 (Normal thinning)									
17	1060.0	96.1	1156.1	294.6	31.6	326.2	765.4	64.5	829.9
22	1429.6	112.4	1542.0	57.4	10.7	68.1	1372.2	101.7	1473.9
27	2202.0	131.5	2333.5	483.2	56.0	539.2	1718.8	75.5	1794.3
32	2286.5	95.7	2382.2	163.5	40.7	204.2	2123.0	55.0	2178.0
37	2957.3	52.7	3010.0	0.0	0.0	0.0	2957.3	52.7	3010.0
39	3190.3	40.9	3231.2	917.9	40.9	958.8	2272.4	0.0	2922.8
44	2922.8	0.0	2922.8	0.0	0.0	0.0	2922.8	0.0	2922.8
49	3554.4	0.0	3554.4	0.0	0.0	0.0	2554.4	0.0	2554.4
Plot 2 (Delayed thinning)									
17	995.3	2219.5	1214.8	0.0	0.0	0.0	995.3	219.5	1214.8
22	1632.2	341.6	1973.8	0.0	0.0	0.0	1632.2	341.6	1973.8
27	2399.7	424.4	2824.1	0.0	0.0	0.0	2399.7	424.4	2824.1
32	2936.1	459.3	3395.4	0.0	0.0	0.0	2936.1	459.3	3395.4
37	3726.3	513.6	4239.9	0.0	454.1	454.1	3726.3	59.5	3785.8
42	4263.5	76.5	4340.0	0.0	0.0	0.0	4263.5	76.5	4340.4
47	5165.6	89.6	5255.2	0.0	0.0	0.0	5165.6	89.6	5255.2

Table 21. Continued

Stand	Before cut			Cut			After cut		
Age	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 3 (Normal thinning)					
17	1497.7	34.1	1531.8	535.8	30.0	565.8	961.9	4.1	966.0
22	1642.9	8.7	1651.6	428.9	8.7	437.6	1214.0	0.0	1214.0
27	2034.1	0.0	2034.1	359.6	0.0	359.6	1674.5	0.0	1674.5
32	2288.3	0.0	2288.3	0.0	0.0	0.0	2288.3	0.0	2288.3
37	3246.3	0.0	3246.3	0.0	0.0	0.0	3246.3	0.0	3246.3
39	3384.6	0.0	3384.6	965.0	0.0	965.0	2419.6	0.0	2419.6
44	3228.4	0.0	3228.4	426.4	0.0	426.4	2802.0	0.0	2802.0
49	3291.2	0.0	3291.2	0.0	0.0	0.0	3291.2	0.0	3291.2
				Plot 4 (Delayed thinning)					
17	1092.2	92.8	1185.0	0.0	0.0	0.0	1092.2	92.8	1185.0
22	1858.3	131.3	1989.6	0.0	0.0	0.0	1858.3	131.3	1989.6
27	2672.6	165.2	2837.8	0.0	0.0	0.0	2672.6	165.2	2837.8
32	3146.6	193.3	3339.9	0.0	0.0	0.0	3146.3	193.3	3339.9
37	3636.7	254.6	3891.3	0.0	0.0	0.0	3636.7	254.6	3891.3
38	3764.7	256.7	4021.4	1591.3	256.7	1848.0	2173.4	0.0	2173.4
44	3144.4	0.0	3144.4	585.1	0.0	585.1	2559.3	0.0	2559.3
49	3197.8	0.0	3197.8	0.0	0.0	0.0	3197.8	0.0	3197.8

Table 21. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 5 (Normal thinning)					
18	1732.7	67.1	1799.8	514.8	32.6	547.4	1217.9	34.5	1252.4
23	1983.2	59.1	2043.3	605.1	18.7	623.8	1378.1	40.4	1418.5
28	2046.4	65.5	2111.9	385.8	8.3	394.1	1660.6	57.2	1717.8
33	2317.9	80.8	2398.7	0.0	0.0	0.0	2317.9	80.8	2398.7
38	3093.2	281.4	3374.6	655.2	166.2	821.4	2438.0	115.2	2553.2
43	3105.8	154.0	3259.8	299.2	154.0	453.2	2806.6	0.0	2806.6
48	3547.4	0.0	3547.4	0.0	0.0	0.0	3547.4	0.0	3547.4
				Plot 6 (Delayed thinning)					
18	1703.4	134.5	1857.9	0.0	0.0	0.0	1703.4	134.5	1837.9
23	2515.5	212.9	2728.4	0.0	0.0	0.0	2515.5	212.9	2728.4
28	3089.4	244.2	3333.6	0.0	0.0	0.0	3089.4	244.2	3333.6
33	3667.2	318.4	3985.6	0.0	0.0	0.0	3667.2	318.4	3985.6
38	4156.8	350.1	4506.9	1407.9	247.5	1655.4	2748.9	102.6	2851.5
43	3402.1	124.4	3526.5	779.5	124.4	903.9	2622.6	0.0	2622.6
48	3443.3	0.0	3443.3	0.0	0.0	0.0	3443.3	0.0	3443.3

Table 21. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 7 (Normal thinning)					
18	1299.8	124.0	1423.8	450.3	53.0	503.3	849.5	71.0	920.5
23	1365.0	107.6	1472.6	281.6	89.8	371.4	1083.4	17.8	1101.2
28	1947.2	0.0	1947.2	554.5	0.0	554.5	1392.7	0.0	1392.7
33	2061.7	0.0	2061.7	0.0	0.0	0.0	2061.7	0.0	2061.7
38	2763.8	0.0	2763.8	515.1	0.0	515.1	2248.7	0.0	2248.7
43	2970.3	0.0	2970.3	483.2	0.0	483.2	2487.1	0.0	2487.1
48	3232.0	0.0	3232.0	0.0	0.0	0.0	3232.0	0.0	3232.0
				Plot 8 (Delayed thinning)					
18	1104.8	135.2	1240.0	0.0	0.0	0.0	1104.8	135.2	1240.0
23	1626.0	189.7	1815.7	0.0	0.0	0.0	1626.0	189.7	1815.7
28	2545.2	239.2	2784.4	0.0	0.0	0.0	2545.2	239.2	2784.4
35	3044.9	335.5	3380.4	1389.7	295.2	1684.9	1655.2	40.3	1695.5
40	2399.0	40.8	2439.8	0.0	0.0	0.0	2399.0	40.8	2439.8
45	3101.7	43.2	3144.9	0.0	0.0	0.0	3101.7	43.2	3144.9
50	3703.1	63.4	3766.5	0.0	0.0	0.0	3703.1	63.4	3766.5

Table 21. Continued

Stand	Before cut			Cut			After cut		
age	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 9 (Normal thinning)					
18	1127.7	278.3	1406.0	388.4	95.2	483.6	739.3	183.1	922.4
23	1472.7	289.7	1762.4	118.1	0.0	118.1	1354.6	289.7	1644.3
28	2220.4	360.2	2580.6	556.3	360.2	916.5	1664.1	0.0	1664.1
34	2653.7	0.0	2653.7	0.0	0.0	0.0	2653.7	0.0	2653.7
39	3364.4	0.0	3364.4	689.2	0.0	689.2	2675.2	0.0	2675.2
44	3052.0	0.0	3052.0	0.0	0.0	0.0	3052.0	0.0	3052.0
49	3658.8	71.3	3730.1	0.0	0.0	0.0	3658.8	71.3	3730.1
				Plot 10 (Normal thinning)					
18	1447.4	87.3	1534.7	433.4	31.2	464.6	1014.0	56.1	1070.1
23	1637.0	76.3	1713.3	397.5	30.5	428.0	1239.5	45.8	1285.3
28	2181.3	77.1	2258.4	624.7	77.1	701.8	1556.6	0.0	1556.6
34	2440.6	0.0	2400.6	0.0	0.0	0.0	2400.6	0.0	2400.6
39	2914.4	0.0	2914.4	541.2	0.0	541.2	2373.2	0.0	2373.2
44	3182.0	0.0	3182.0	324.8	0.0	324.8	2857.2	0.0	2857.2
49	3687.6	0.0	3687.6	0.0	0.0	0.0	3687.6	0.0	3687.6

Table 21. Continued

Stand age	Before cut Pine	Before cut Hwd	Before cut Total	Cut Pine	Cut Hwd	Cut Total	After cut Pine	After cut Hwd	After cut Total
Years					Cubic feet				
					Plot 11 (Check)				
18	1472.3	289.3	1761.6	0.0	0.0	0.0	1472.3	289.3	1761.6
23	2081.4	392.5	2473.9	0.0	0.0	0.0	2081.4	392.5	2473.9
28	2815.1	495.3	3310.4	0.0	0.0	0.0	2815.1	495.3	3310.4
34	3524.9	639.5	4164.4	0.0	0.0	0.0	3524.9	639.5	4164.4
39	3874.6	700.8	4575.4	0.0	0.0	0.0	3874.6	700.8	4575.4
44	4505.1	812.1	5317.2	0.0	0.0	0.0	4505.1	812.1	5317.2
49	4701.5	826.7	5528.2	0.0	0.0	0.0	4701.5	826.7	5528.2
					Plot 12 (Normal thinning)				
19	1063.4	130.9	1194.3	176.3	48.4	224.7	887.1	82.5	969.6
24	1775.1	108.4	1883.5	0.0	0.0	0.0	1775.1	108.4	1883.5
29	2619.5	148.4	2767.9	639.9	148.4	788.3	1979.6	0.0	1979.6
35	2817.4	0.0	2817.4	0.0	0.0	0.0	2817.4	0.0	2817.4
38	3108.9	0.0	3108.9	523.4	0.0	523.4	2585.5	0.0	2585.5
43	3464.6	0.0	3464.6	668.8	0.0	668.8	2795.8	0.0	2795.8
48	3418.2	0.0	3418.2	0.0	0.0	0.0	3418.2	0.0	3418.2

Table 21. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 13 (Delayed thinning)					
19	1086.1	59.8	1145.9	0.0	0.0	0.0	1086.1	59.8	1145.9
24	1814.9	104.1	1919.0	0.0	0.0	0.0	1814.9	104.1	1919.0
28	2481.1	123.0	2604.1	0.0	0.0	0.0	2481.1	123.0	2604.1
35	3052.7	2165.2	3217.9	1203.0	165.2	1368.2	1849.7	0.0	1849.7
39	2339.5	0.0	2339.5	0.0	0.0	0.0	2339.5	0.0	2339.5
44	2932.0	0.0	2932.0	521.3	0.0	521.3	2410.7	0.0	2410.7
49	3206.2	0.0	3206.2	0.0	0.0	0.0	3206.2	0.0	3206.2
				Plot 14 (Normal thinning)					
19	1463.5	53.8	1517.3	499.2	47.2	564.4	964.3	6.6	970.9
24	1838.6	8.0	1846.6	431.6	8.0	439.6	1407.0	0.0	1407.0
29	2199.8	0.0	2199.8	761.1	0.0	761.1	1438.7	0.0	1438.7
35	1861.9	0.0	1861.9	541.2	0.0	541.2	1410.7	0.0	1410.7
40	1888.0	0.0	1888.0	0.0	0.0	0.0	1888.0	0.0	1888.0
45	2255.9	0.0	2255.9	0.0	0.0	0.0	2255.9	0.0	2255.9
50	2790.6	0.0	2790.6	0.0	0.0	0.0	2790.6	0.0	2790.6

Table 21. Continued

Stand age	Before cut			Cut			After cut		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Cubic feet								
				Plot 15 (Check)					
19	1359.2	95.5	1454.7	0.0	0.0	0.0	1359.2	95.5	1454.7
24	2113.0	125.5	2238.5	0.0	0.0	0.0	2113.0	125.5	2238.5
29	2890.1	178.3	3068.4	0.0	0.0	0.0	2890.1	178.3	3068.4
34	3352.0	239.4	3591.4	0.0	0.0	0.0	3352.0	239.4	3591.4
40	3326.2	288.7	3614.9	0.0	0.0	0.0	3326.2	288.7	3614.9
45	3824.8	290.0	4114.8	0.0	0.0	0.0	3824.8	290.0	4114.8
50	4082.0	180.5	4262.5	0.0	0.0	0.0	4082.0	180.5	4262.5
				Plot 16 (Check)					
19	964.6	151.0	1115.6	0.0	0.0	0.0	964.6	151.0	1115.6
24	1717.4	181.9	1899.3	0.0	0.0	0.0	1717.4	180.9	1899.3
29	2571.9	218.8	2790.7	0.0	0.0	0.0	2571.9	218.8	2790.7
35	3189.1	281.9	3471.0	0.0	0.0	0.0	3189.1	281.9	3471.0
40	3692.6	304.5	3997.1	0.0	0.0	0.0	3692.6	304.5	3997.1
45	4388.3	476.7	4865.0	0.0	0.0	0.0	4388.3	476.7	4865.0
50	4251.8	494.0	4745.8	0.0	0.0	0.0	4251.8	494.1	4745.8

Table 22. Volume in cords and board feet per acre at various stand ages

Age	Before cut						Cut						After cut					
	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords[1/] - -			-Board feet[2/]-			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
									Plot 1 (Normal thinning)									
17	11.26	1.07	12.33	285	0	285	3.47	0.34	3.81	0	0	0	7.79	0.73	8.52	285	0	285
22	13.14	1.26	14.40	1178	0	1178	0.67	0.12	0.79	0	0	0	12.47	1.15	13.62	1178	0	1178
27	12.85	1.50	14.35	7236	0	7236	3.40	0.64	4.04	1236	0	1236	9.45	0.87	10.32	6000	0	6000
32	5.34	1.10	6.44	10599	0	10599	0.43	0.47	0.90	855	0	855	4.91	0.63	5.54	9744	0	9744
37	3.34	0.61	3.95	16071	0	16071	0.00	0.00	0.00	0	0	0	3.34	0.61	3.95	16071	0	16071
39	1.54	0.47	2.01	17795	0	17795	1.54	0.47	2.01	4236	0	4236	0.00	0.00	0.00	13559	0	13559
44	0.00	0.00	0.00	18488	0	18488	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	18488	0	18488
49	0.00	0.00	0.00	23566	0	23566	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	23566	0	23566
									Plot 2 (Delayed thinning)									
17	9.90	2.46	12.36	0	0	0	0.00	0.00	0.00	0	0	0	9.90	2.46	12.36	0	0	0
22	15.61	3.95	19.56	1939	0	1939	0.00	0.00	0.00	0	0	0	15.61	3.95	19.56	1939	0	1939
27	17.69	4.94	22.63	5426	0	5426	0.00	0.00	0.00	0	0	0	17.69	4.94	22.63	5426	0	5426
32	14.43	5.16	19.59	10508	273	10781	0.00	0.00	0.00	0	0	0	14.43	5.16	19.59	10508	273	10781
37	11.83	4.89	16.72	16464	664	17128	0.00	4.37	4.37	0	388	388	11.83	0.52	12.35	16464	276	16740
42	7.73	0.00	7.73	23014	380	23394	0.00	0.00	0.00	0	0	0	7.73	0.00	7.73	23014	380	23394
47	5.35	0.00	5.35	29866	494	30360	0.00	0.00	0.00	0	0	0	5.35	0.00	5.35	29866	494	30360

1/ Volume in standard cords (outside bark) for trees 3.6-9.6 inches d.b.h.

2/ Volume in board feet, International 1/4-inch rule, for trees 9.6 inches d.b.h. and up.

Table 22. Continued

	Before cut						Cut						After cut					
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
							Plot 3 (Normal thinning)											
17	17.39	0.42	17.81	00	0	0	6.42	0.38	6.80	0	0	0	10.97	0.04	11.01	00	0	0
22	18337	0.10	18.47	577	0	577	4.99	0.10	5.09	0	0	0	13.38	0.00	13.38	577	0	577
27	16.89	0.00	16.89	4820	0	4820	3.62	0.00	3.62	452	0	452	13.27	0.00	13.27	4368	0	4368
32	9.39	0.00	9.39	9160	0	9160	0.00	0.00	0.00	0	0	0	9.39	0.00	9.39	9160	0	9160
37	5.63	0.00	5.63	17097	0	17097	0.00	0.00	0.00	0	0	0	5.63	0.00	5.63	17097	0	17097
39	1.47	0.00	1.47	18174	0	18174	1.14	0.00	1.14	4509	0	4509	0.33	0.00	0.33	13665	0	13665
44	0.38	0.00	0.38	19812	0	19812	0.00	0.00	0.00	2655	0	2655	0.38	0.00	0.38	17157	0	17157
49	0.49	0.00	0.49	20462	0	20462	0.00	0.00	0.00	0	0	0	0.49	0.00	0.49	20462	0	20462
							Plot 4 (Delayed thinning)											
17	12.36	1.00	13.36	0	0	0	0.00	0.00	0.00	0	0	0	12.36	1.00	13.36	0	0	0
22	21.25	1.48	22.73	188	0	188	0.00	0.00	0.00	0	0	0	21.25	1.48	22.73	188	0	188
27	29.67	1.91	31.58	1674	0	1674	0.00	0.00	0.00	0	0	0	29.67	1.91	31.58	1674	0	1674
32	29.55	2.24	31.79	4669	0	4669	0.00	0.00	0.00	0	0	0	29.55	2.24	31.79	4669	0	4669
37	24.49	2.53	27.02	10343	508	10851	0.00	0.00	0.00	0	0	0	24.49	2.53	27.02	10343	508	10851
38	18.17	1.68	19.85	11276	521	11797	15.34	1.68	17.02	1387	521	1908	2.83	0.00	2.83	9889	0	9889
44	2.80	0.00	2.80	17826	0	17826	1.80	0.00	1.80	2788	0	2788	1.00	0.00	1.00	15038	0	15038
49	0.00	0.00	0.00	19457	0	19457	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	19457	0	19457

Table 22. Continued

	Before cut						Cut						After cut					
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
							Plot 5 (Normal thinning)											
18	18.58	0.75	19.33	212	0	212	5.63	0.35	5.98	0	0	0	12.95	0.40	13.35	212	0	212
23	20.27	0.68	20.95	1302	0	1302	7.07	0.22	7.29	0	0	0	13.20	0.47	13.67	1302	0	1302
28	15.40	0.48	15.88	5201	262	5463	4.49	0.10	4.59	0	0	0	10.91	0.38	11.29	5201	262	5463
33	8.15	0.00	8.15	10057	416	10473	0.00	0.00	0.00	0	0	0	8.15	0.00	8.15	10057	416	10473
38	5.59	1.93	7.52	16639	677	17316	2.97	1.93	4.90	2714	0	2714	2.62	0.00	2.62	13924	677	14601
43	0.64	0.00	0.64	19217	964	20181	0.00	0.00	0.00	1702	964	2666	0.64	0.00	0.64	17515	0	17515
48	0.64	0.00	0.64	23532	0	23532	0.00	0.00	0.00	0	0	0	0.64	0.00	0.64	23532	0	23532
							Plot 6 (Delayed thinning)											
18	19.93	1.55	21.48	0	0	0	0.00	0.00	0.00	0	0	0	19.93	1.55	21.48	0	0	0
23	29.43	2.50	31.93	0	0	0	0.00	0.00	0.00	00	0	00	29.43	2.50	31.93	0	0	0
28	34.99	2.89	37.88	1226	0	1226	0.00	0.00	0.00	0	0	0	34.99	2.89	37.88	1226	0	1226
33	36.18	3.38	39.56	4773	313	5086	0.00	0.00	0.00	0	0	0	36.18	3.38	39.56	4773	313	5086
38	32.01	3.31	35.32	9290	339	9629	15.14	2.90	18.04	991	0	991	16.87	0.41	17.28	8299	339	8638
43	15.32	0.45	15.77	12797	456	13253	7.43	0.45	7.88	1263	456	1719	7.89	0.00	7.89	11534	0	11534
48	7.03	0.00	7.03	19698	0	19698	0.00	0.00	0.00	0	0	0	7.03	0.00	7.03	19698	0	19698

Table 22. Continued

Age	Before cut						Cut						After cut					
	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
							Plot 7 (Normal thinning)											
18	14.97	1.41	16.38	0	0	0	4.76	0.56	5.32	0	0	0	10.21	0.85	11.06	0	0	0
23	15.82	1.28	17.10	218	0	218	3.29	1.04	4.33	0	0	0	12.53	0.24	12.77	218	0	218
28	19.10	0.04	19.14	2443	0	2443	6.44	0.00	6.44	0	0	0	12.66	0.04	17.70	2443	0	2443
33	10.83	0.00	10.83	8674	0	8674	0.00	0.00	0.00	0	0	0	10.83	0.00	10.83	8674	0	8674
38	3.32	0.00	3.32	13994	0	13994	2.94	0.00	2.94	1839	0	1839	0.38	0.00	0.38	12155	0	12155
43	0.00	0.00	0.00	17558	0	17558	0.00	0.00	0.00	2694	0	2694	0.00	0.00	0.00	14864	0	14864
48	0.00	0.00	0.00	20476	0	20476	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	20476	0	20476
							Plot 8 (Delayed thinning)											
18	11.43	1.47	12.90	0	0	0	0.00	0.00	0.00	0	0	0	11.43	1.47	12.90	0	0	0
23	18.97	2.18	21.15	0	0	0	0.00	0.00	0.00	0	0	0	18.97	2.18	21.15	0	0	0
28	28.58	2.76	31.34	1034	0	1034	0.00	0.00	0.00	0	0	0	28.58	2.76	31.34	1034	0	1034
35	29.45	3.65	33.10	4247	305	4552	16.28	3.18	19.46	0	305	305	13.17	0.47	13.64	4247	0	4247
40	10.21	0.47	10.68	10915	0	10915	0.00	0.00	0.00	0	0	0	10.21	0.47	10.68	10915	0	10915
45	4.03	0.50	4.53	16820	0	16820	0.00	0.00	0.00	0	0	0	4.03	0.50	4.53	16820	0	16820
50	1.79	0.50	2.29	21767	304	22071	0.00	0.00	0.00	0	0	0	1.79	0.50	2.29	21767	304	22071

Table 22. Continued

	Before cut						Cut						After cut					
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
Plot 9 (Normal thinning)																		
18	12.23	2.59	14.82	157	188	345	4.18	1.01	5.19	0	0	0	8.05	1.58	9.63	157	188	345
23	13.25	2.32	15.57	2733	508	3241	1.39	0.00	1.39	0	0	0	11.86	2.32	14.18	2733	508	3241
28	10.51	2.51	13.02	9059	706	9765	4.30	2.51	6.81	1465	706	2171	6.21	0.00	6.21	7594	0	7594
34	2.21	0.00	2.21	14740	0	14740	0.00	0.00	0.00	0	0	0	2.21	0.00	2.21	14740	0	14740
39	0.00	0.00	0.00	20510	0	20510	0.00	0.00	0.00	3850	0	3850	0.00	0.00	0.00	16660	0	16660
44	0.00	0.00	0.00	19793	0	19793	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	19793	0	19793
49	0.00	0.76	0.76	24542	0	24542	0.00	0.00	0.00	0	0	0	0.00	0.76	0.76	24542	0	24542
Plot 10 (Normal thinning)																		
18	16.24	0.93	17.17	0	0	0	4.64	0.33	4.97	0	0	0	11.60	0.60	12.20	0	0	0
23	18.19	0.88	19.07	692	0	692	4.61	0.36	4.97	0	0	0	13.58	0.52	14.10	692	0	692
28	15.96	0.88	16.84	7076	0	7076	4.93	0.88	5.81	1510	0	1510	11.03	0.00	11.03	5566	0	5566
34	4.83	0.00	4.83	12063	0	12063	0.00	0.00	0.00	0	0	0	4.83	0.00	4.83	12063	0	12063
39	1.96	0.00	1.96	16134	0	16134	1.47	0.00	1.47	2449	0	2449	0.49	0.00	0.49	13685	0	13685
44	0.00	0.00	0.00	19650	0	19650	0.00	0.00	0.00	1864	0	1864	0.00	0.00	0.00	17786	0	17786
49	0.00	0.00	0.00	24283	0	24283	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	24283	0	24283

Table 22. Continued

Age	Before cut						Cut						After cut					
	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
									Plot 11 (Check)									
18	16.98	1.82	18.80	0	412	412	0.00	0.00	0.00	0	0	0	16.98	1.82	18.80	0	412	412
23	23.55	2.59	26.14	642	912	1554	0.00	0.00	0.00	0	0	0	23.55	2.59	26.14	642	912	1554
28	30.52	3.27	33.79	1263	1220	2483	0.00	0.00	0.00	0	0	0	30.52	3.27	33.79	1263	1220	2483
34	33.43	4.01	37.44	5816	1972	7792	0.00	0.00	0.00	0	0	0	33.43	4.01	37.44	5816	1976	7792
39	27.84	3.56	31.40	9774	2562	12336	0.00	0.00	0.00	0	0	0	27.84	3.56	31.40	9774	2562	12336
44	25.48	3.81	29.29	14595	2847	17442	0.00	0.00	0.00	0	0	0	25.48	3.81	29.29	14595	2847	17442
44	19.48	3.39	22.87	18434	3419	21853	0.00	0.00	0.00	0	0	0	19.48	3.39	22.87	18434	3419	21853
									Plot 12 (Normal thinning)									
19	8.82	1.45	10.27	589	0	589	1.83	0.52	2.35	0	0	0	6.99	0.93	7.92	589	0	589
24	11.74	1.25	12.99	2732	0	2732	0.00	0.00	0.00	0	0	0	11.74	1.25	12.99	2732	0	2732
29	13.54	1.54	15.08	8773	241	9014	6.25	1.54	7.79	524	241	765	7.29	0.00	7.29	8249	0	8249
35	5.49	0.00	5.49	13755	0	13755	0.00	0.00	0.00	0	0	0	5.49	0.00	5.49	13755	0	13755
38	2.28	0.00	2.28	15927	0	15927	1.35	0.00	1.35	2564	0	2564	0.93	0.00	0.93	13363	0	13363
43	0.96	0.00	0.96	21264	0	21264	0.49	0.00	0.49	3786	0	3786	0.47	0.00	0.47	17478	0	17478
48	0.00	0.00	0.00	22082	0	22082	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	22082	0	22082

Table 22. Continued

Age	Before cut						Cut						After cut					
	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			Board feet - -		
									Plot 13 (Delayed thinning)									
19	11.72	0.89	12.61	0	0	0	0.00	0.00	0.00	0	0	0	11.72	0.89	12.61	0	0	0
24	18.71	1.50	20.21	894	0	894	0.00	0.00	0.00	0	0	0	18.71	1.50	20.21	894	0	894
28	23.42	1.91	25.33	2380	0	2380	0.00	0.00	0.00	0	0	0	23.42	1.91	25.33	2380	0	2380
35	23.42	2.04	25.46	6814	353	7167	12.37	1.54	13.91	825	353	1178	11.05	0.50	11.55	5989	0	5989
39	8.81	0.00	8.81	9995	0	9995	0.00	0.00	0.00	0	0	0	8.81	0.00	8.81	9995	0	9995
44	5.20	0.00	5.20	14864	0	14864	2.68	0.00	2.68	1796	0	1796	2.52	0.00	2.52	13068	0	13068
49	0.57	0.00	0.57	19330	0	19330	0.00	0.00	0.00	0	0	0	0.57	0.00	0.57	19330	0	19330
									Plot 14 (Normal thinning)									
19	16.59	0.57	17.16	0	0	0	5.32	0.50	5.82	0	0	0	11.27	0.07	11.34	0	0	0
24	20.25	0.10	20.35	858	0	858	4.45	0.10	4.55	394	0	394	15.80	0.00	15.80	464	0	464
29	23.06	0.00	23.06	1494	0	1494	8.89	0.00	8.89	0	0	0	14.17	0.00	14.17	1494	0	1494
35	14.32	0.00	14.32	5189	0	5189	5.06	0.00	5.06	262	0	262	9.26	0.00	9.26	4927	0	4927
40	4.99	0.00	4.99	9312	0	9312	0.00	0.00	0.00	0	0	0	4.99	0.00	4.99	9312	0	9312
45	1.49	0.00	1.49	12262	0	12262	0.00	0.00	0.00	0	0	0	1.49	0.00	1.49	12262	0	12262
50	0.00	0.00	0.00	16156	0	16156	0.00	0.00	0.00	0	0	0	0.00	0.00	0.00	16156	0	16156

Table 22. Continued

	Before cut						Cut						After cut					
Age	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot	Pine	Hwd	Tot
Yrs	- - Cords - -			- Board feet -			- - Cords - -			- Board feet -			- - Cords - -			- Board feet -		
									Plot 15 (Check)									
19	15.99	1.12	17.11	0	0	0	0.00	0.00	0.00	0	0	0	15.99	1.12	17.11	0	0	0
24	24.86	1.49	26.35	0	0	0	0.00	0.00	0.00	0	0	0	24.86	1.49	26.35	0	0	0
29	33.47	2.12	35.59	272	0	272	0.00	0.00	0.00	0	0	0	33.47	2.12	35.59	272	0	27272
34	37.45	2.55	40.00	1311	318	1629	0.00	0.00	0.00	0	0	0	37.45	2.55	40.11	1311	318	1629
40	33.10	2.09	35.19	4434	624	5058	0.00	0.00	0.00	0	0	0	33.10	2.09	35.19	4434	624	5058
45	29.33	2.32	31.65	9163	466	9629	0.00	0.00	0.00	0	0	0	29.33	2.32	31.65	9163	466	9629
50	22.35	2.21	24.56	12646	0	12646	0.00	0.00	0.00	0	0	0	22.35	2.21	24.56	12646	0	12646
									Plot 16 (Check)									
19	9.13	1.74	10.87	529	0	529	0.00	0.00	0.00	0	0	0	9.13	1.74	10.87	529	0	529
24	15.76	2.14	17.90	1600	0	1600	0.00	0.00	0.00	0	0	0	15.76	2.14	17.90	1600	0	1600
29	18.50	2.60	21.10	5807	0	5807	0.00	0.00	0.00	0	0	0	18.50	2.60	21.10	5807	0	5807
35	15.78	3.32	19.10	10822	0	10822	0.00	0.00	0.00	0	0	0	15.78	3.32	19.10	10822	0	10822
40	14.21	3.40	17.61	14978	277	15255	0.00	0.00	0.00	0	0	0	14.21	3.40	17.61	14978	277	15255
45	12.80	4.21	17.01	20637	832	21469	0.00	0.00	0.00	0	0	0	12.80	4.21	17.01	20637	832	21469
50	8.15	3.66	11.81	22346	980	23326	0.00	0.00	0.00	0	0	0	8.15	3.66	11.81	22346	980	23326

Table 23. Crown ratio of pine by plots before and after thinning

Age	Before cut	Cut	After cut
Years	- - - - - - - - -	Percent	- - - - - - - - - -
	Plot 1 (Normal thinning)		
27	48	54	47
32		No record	47
37	41		41
39	38	35	39
44	38		38
49	38		38
	Plot 2 (Delayed thinning)		
27	40		40
32	36		36
37	31		31
42	36		36
47	37		37
	Plot 3 (Normal thinning)		
22		No record	46
27		No record	44
32	46		46
37	36		36
39	34	34	35
44	38	35	38
49	37		37
	Plot 4 (Delayed thinning)		
27	30		30
32	28		28
37	36		36
38		No record	36
44	36	33	38
49	38		38

Table 23. Continued

Age	Before cut	Cut	After cut
Years		Percent	
	Plot 5 (Normal thinning)		
23	42	39	43
28		No record	41
33	39		39
38	34	27	36
43	39	41	38
48	40		40
	Plot 6 (Delayed thinning)		
23	31		31
28	35		35
33	22		22
38		No record	30
43	23	22	24
48	30		30
	Plot 7 (Normal thinning)		
23	31	29	31
28		No record	39
33	41		41
38	33	31	36
43	39	37	39
48	42		42
	Plot 8 (Delayed thinning)		
23	33		33
28	32		32
35	23	19	28
40	34		34
45	33		33
50	33		33

Table 23. Continued

Age	Before	Cut	After cut
Years		Percent	
		Plot 9 (Normal thinning)	
23		No record	48
28		No record	44
34	41		41
39		No record	No record
44	41		41
49	38		38
		Plot 10 (Normal thinning)	
18		No record	53
23		No record	47
28		No record	46
34	41		41
39	37	35	38
44	43	37	44
49	37		37
		Plot 11 (Check)	
23	31		31
28	36		36
34	28		28
39	No record		No record
44	25		25
49	26		26
		Plot 12 (Normal thinning)	
24	47		47
29	43	40	44
35	40		40
38	37	33	38
43	43	42	44
48	44		44

Table 23. Continued

Age	Before cut	Cut	After cut
Years		Percent	
	Plot 13 (Delayed thinning)		
24	43		43
28	41		41
35	32	26	35
39		No record	
44	34	30	36
49	35		35
	Plot 14 (Normal thinning)		
24	37	37	37
29	34	31	35
35	33	32	33
40	37		37
45	36		36
50	38		38
	Plot 15 (Check)		
24	31		31
29	22		22
34	25		[1] 25
40	25		[1] 25
45	31		[1] 31
50	34		[1] 34
	Plot 16 (Check)		
24	47		47
29	37		37
35	32		32
40	38		[1] 38
45	35		[1] 35
50	35		[1] 35

[1] Dominant trees only

Table 24. Mortality per acre at measurement ages in number of trees, basal area, and volume for all species 3.6 inches d.b.h. and up

Stand age	Trees			Basal area			Volume		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	- - - Number - - - -			- - - Square feet - - -			- - - Cubic feet - - -		
				Plot 1 (Normal thinning)					
37	8	12	20	3.51	1.82	5.33	92.3	26.5	118.8
				Plot 2 (Delayed thinning)					
22	4	0	4	1.72	0.00	1.72	35.2	0.0	35.2
27	12	4	16	1.03	1.00	2.03	15.4	12.6	28.0
32	24	16	40	2.32	1.25	3.57	36.6	13.2	49.8
37	16	8	24	4.94	1.76	6.70	82.6	35.7	118.3
42	44	0	44	9.58	0.00	9.58	184.3	0.0	184.3
47	24	0	24	6.20	0.00	6.20	89.7	0.0	89.7
				Plot 3 (Normal thinning)					
22	16	0	16	3.30	0.00	3.30	44.6	0.0	44.6
27	4	0	4	0.29	0.00	0.29	4.8	0.0	4.8
32	20	0	20	2.63	0.00	2.63	43.8	0.0	43.8

Table 24. Continued

Stand age	Trees			Basal area			Volume		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	--- Number ----			--- Square feet ---			--- Cubic feet ---		
				Plot 4 (Delayed thinning)					
22	4	4	8	0.42	0.34	0.76	5.1	3.6	8.7
27	20	0	20	1.69	0.00	1.69	21.8	0.0	21.8
32	60	0	60	6.78	0.00	6.78	103.6	0.0	103.6
37	108	0	108	16.98	0.00	16.98	272.6	0.0	272.6
38	8	0	8	2.52	0.00	2.52	43.8	0.0	43.8
44	8	0	8	3.65	0.00	3.65	87.8	0.0	87.8
				Plot 5 (Normal thinning)					
23	8	0	8	0.96	0.00	0.96	11.6	0.0	11.6
28	4	0	4	0.71	0.00	0.71	10.4	0.0	10.4
43	4	0	4	2.01	0.00	2.01	54.6	0.0	54.6
				Plot 6 (Delayed thinning)					
23	12	4	16	0.88	4.03	4.91	11.9	26.0	37.9
28	64	12	76	6.79	1.08	7.87	107.3	16.6	123.9
33	72	0	72	10.55	0.00	10.55	181.5	0.0	181.5
38	120	0	120	15.28	0.00	15.28	291.2	0.0	291.2
43	4	0	4	0.73	0.00	0.73	15.8	0.0	15.8

Table 24. Continued

Stand age	Trees			Basal area			Volume		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	Number			Square feet			Cubic feet		
Plot 7 (Normal thinning)									
28	32	8	40	3.48	1.13	4.61	49.4	17.8	67.2
33	12	4	16	1.04	0.28	1.32	26.7	3.6	30.3
38	8	0	8	1.94	0.00	1.94	40.6	0.0	40.6
Plot 8 (Delayed thinning)									
23	12	0	12	1.92	0.00	1.92	28.9	0.0	28.9
28	24	0	24	2.18	0.00	2.18	34.0	0.0	34.0
35	68	4	72	12.54	0.36	12.90	201.2	5.0	206.2
40	8	0	8	1.22	0.00	1.22	24.9	0.0	24.9
Plot 9 (Normal thinning)									
39	4	0	4	0.50	0.00	0.50	7.5	0.0	7.5
44	8	0	8	4.71	0.00	4.71	163.0	0.0	163.0
Plot 10 (Normal thinning)									
23	12	0	12	2.36	0.00	2.36	36.6	0.0	36.6
34	4	0	4	0.38	0.00	0.38	4.0	0.0	4.0

Table 24. Continued

Stand age	Trees			Basal area			Volume		
	Pine	Hwd	Total	Pine	Hwd	Total	Pine	Hwd	Total
Years	---- Number ----			--- Square feet ---			--- Cubic feet ---		
Plot 11 (Check)									
23	8	0	8	0.92	0.00	0.92	12.0	0.0	12.0
28	44	0	44	5.92	0.00	5.92	122.7	0.0	122.7
34	96	4	100	12.46	0.33	12.79	195.8	4.2	200.0
39	72	12	84	11.61	2.60	14.21	222.4	35.1	257.5
44	44	0	44	9.17	0.00	9.17	185.4	0.0	185.4
49	40	12	52	13.19	2.17	15.36	375.2	44.1	419.3
Plot 12 (Normal thinning)									
no mortality									
Plot 13 (Delayed thinning)									
28	4	0	4	0.31	0.00	0.31	3.8	0.0	3.8
35	40	4	44	6.77	0.42	7.19	103.5	4.2	107.7
Plot 14 (Normal thinning)									
29	4	0	4	0.44	0.00	0.44	4.6	0.0	4.6
35	16	0	16	2.83	0.00	2.83	56.0	0.0	56.0
40	4	0	4	0.36	0.00	0.36	4.3	0.0	4.3

Table 24. Continued

Stand age	Trees Pine	Trees Hwd	Trees Total	Basal area Pine	Basal area Hwd	Basal area Total	Volume Pine	Volume Hwd	Volume Total
Years	- - - - Number - - - -			- - - Square feet - - -			- - - Cubic feet - - -		
				Plot 15 (Check)					
29	20	0	20	1.97	0.00	1.97	31.0	0.0	31.0
34	100	0	100	11.07	0.00	11.07	183.6	0.0	183.6
40	84	16	100	26.16	1.03	27.19	494.4	22.8	517.2
45	52	0	52	9.02	0.00	9.02	167.8	0.0	167.8
50	76	12	88	12.95	5.09	18.04	286.2	114.2	400.4
				Plot 16 (Check)					
24	0	8	8	0.00	0.61	0.61	0.0	7.9	7.9
29	36	4	40	3.74	0.71	4.45	50.7	8.4	59.1
35	24	0	24	6.51	0.00	6.51	139.2	0.0	139.2
40	32	20	52	4.82	2.55	7.37	84.7	38.6	123.3
45	16	4	20	3.17	0.52	3.69	58.5	8.1	66.6
50	40	16	56	23.19	1.65	24.84	682.1	23.7	705.8

APPENDIX C

TABLES OF NET BASAL AREA AND VOLUME PRODUCTION PER ACRE,

FROM REGRESSION ANALYSES

Table 25. Average basal area production per acre, all species 3.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Square feet	
15	93	82	77
20	120	100	105
25	143	123	127
30	163	146	145
35	181	167	157
40	196	183	164
45	207	190	166
50	216	185	163

Normal thinning basal area = $-2.657 + 7.264x - 0.05x^2$

Delayed thinning basal area = $82.59 - 3.995x + 0.331x^2 - 0.004x^3$

Check basal area = $-35.519 + 9.039x - 0.101x^2$

Table 26. Average basal area production of pine per acre, trees 3.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Square feet	
15	85	69	67
20	110	89	92
25	133	110	113
30	153	130	129
35	170	149	139
40	184	163	145
45	196	170	145
50	205	169	141

Normal thinning basal area = $7.449 + 6.988x_o - 0.055x^2$

Delayed thinning basal area = $42.587 - 0.593x + 0.199x^2 - 0.0027x^3$

Check basal area = $-40.424 + 8.655x - 0.101x^2$

Table 27. Average cubic volume production per acre, all species 3.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Cubic feet	
15	1,255	743	929
20	1,904	1.671	1,680
25	2.652	2.523	2,433
30	3,439	3,298	3,148
35	4,208	3,997	3,785
40	4,901	4,618	4,304
45	5,460	5,163	4,664
50	5,826	5,632	4,825

Normal thinning cubic feet = $476.90 - 29.81x + 6.608x^2 - 0.077x^3$

Delayed thinning cubic feet = $-2503.39 + 239.439x - 1.535x^2$

Check cubic feet = $-910.23 + 85.909x + 3.251x^2 - 0.053x^3$

Table 28. Average cubic volume production of pine per acre, trees 3.6 inches d.b.h. and up, from regression analysis

Stand age (x)	Normal thinning	Delayed thinning	Check
Years		Cubic feet	
15	1,159	689	707
20	1,764	1,509	1,483
25	2,482	2,273	2,198
30	3,251	2,982	2,836
35	4,009	3,635	3,385
40	4,696	4,232	3,829
45	5,251	4,774	4,155
50	5,614	5,259	4,349

Normal thinning cubic feet = $616.76 - 52.004x + 7.091x^2 - 0.081x^2$

Delayed thinning cubic feet = $-2105.7 + 203.046x - 1.115x^2$

Check cubic feet = $-1855.5 + 176.937x - 0.127x^2 - 0.019x^3$

APPENDIX D

FIGURES SHOWING NET BASAL AREA AND VOLUME PRODUCTION PER ACRE,

FROM REGRESSION ANALYSES

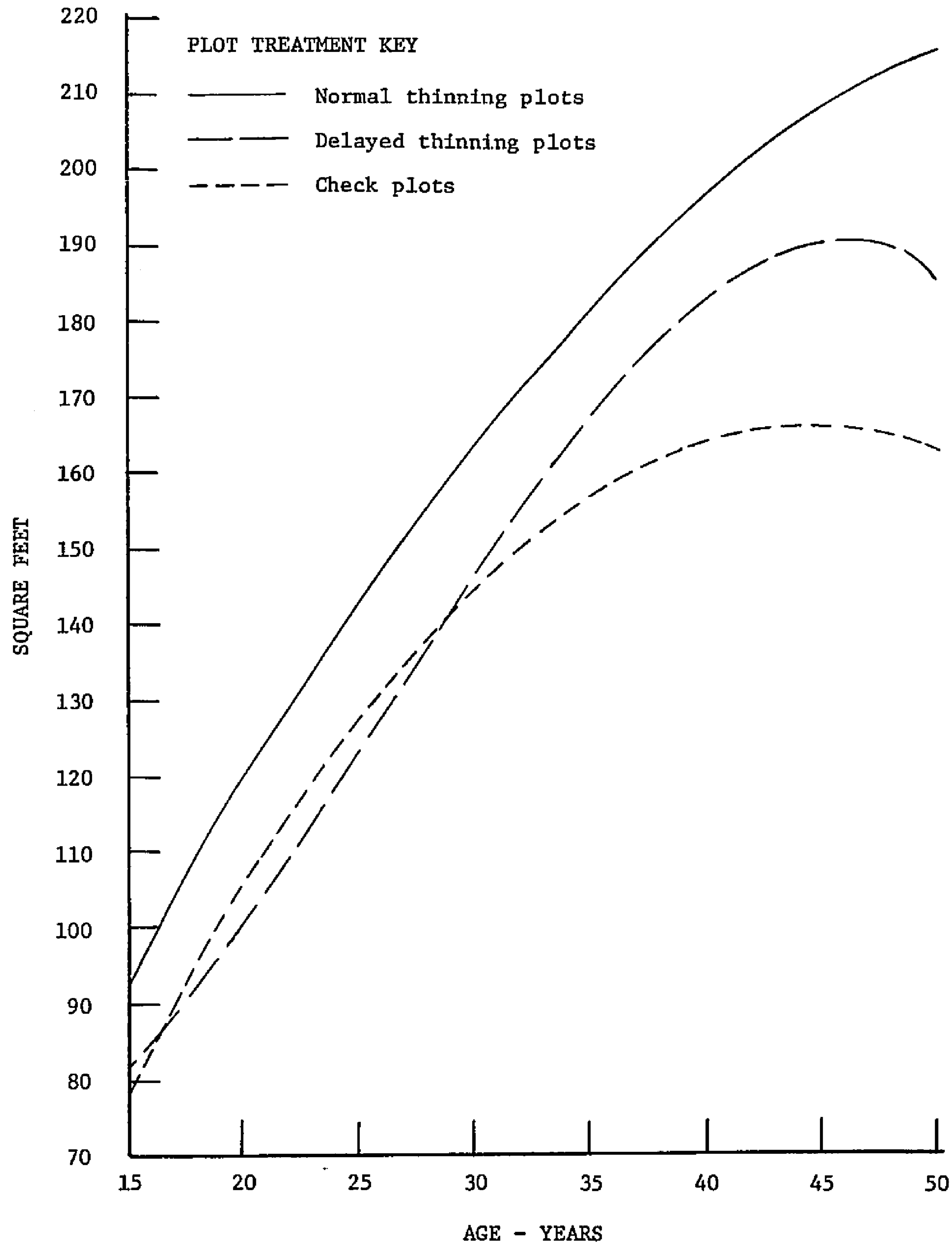

Figure 8. Average basal area production per acre for all species, including thinnings (from Table 25).

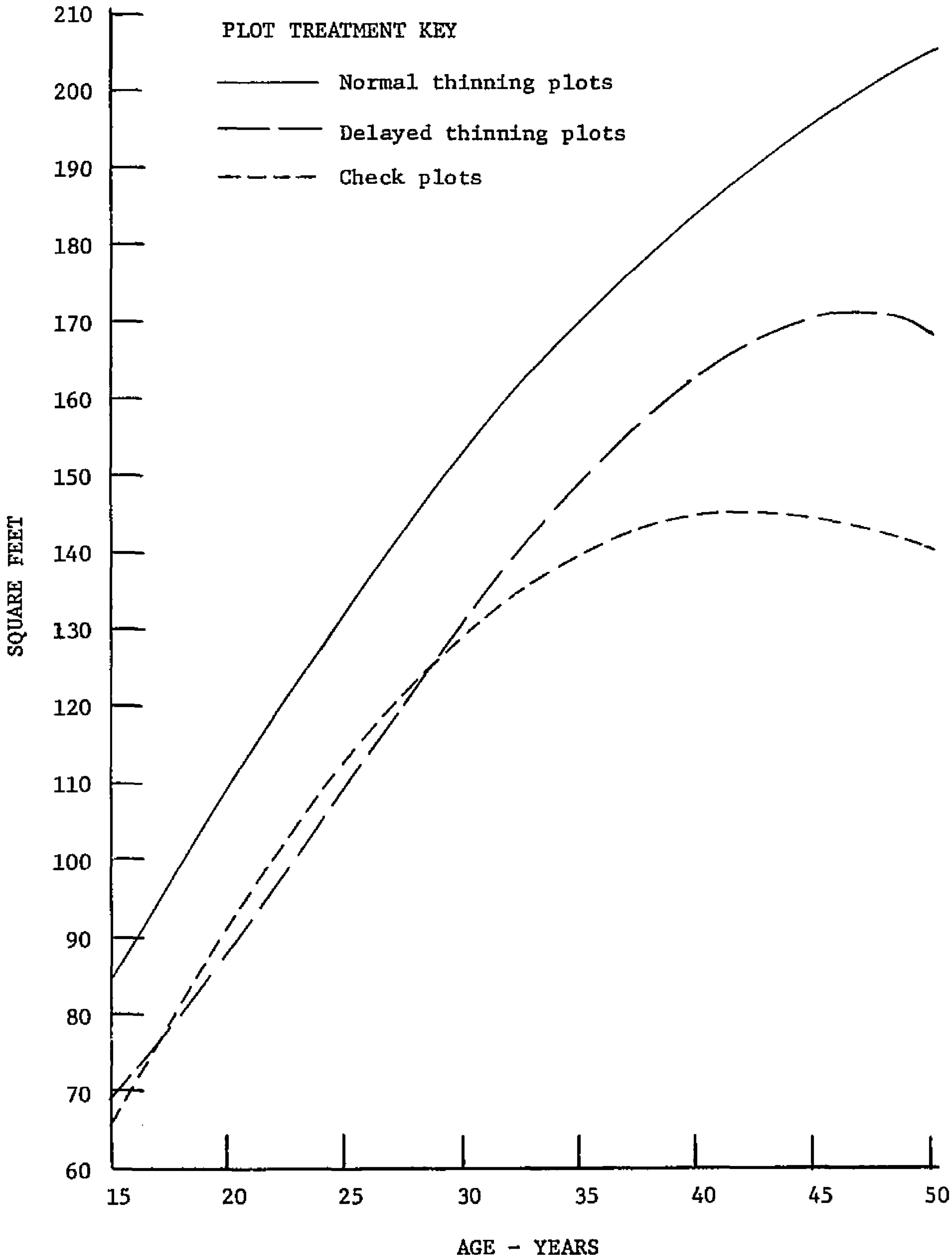

Figure 9. Average basal area production per acre for pine, including thinnings (from Table 26).

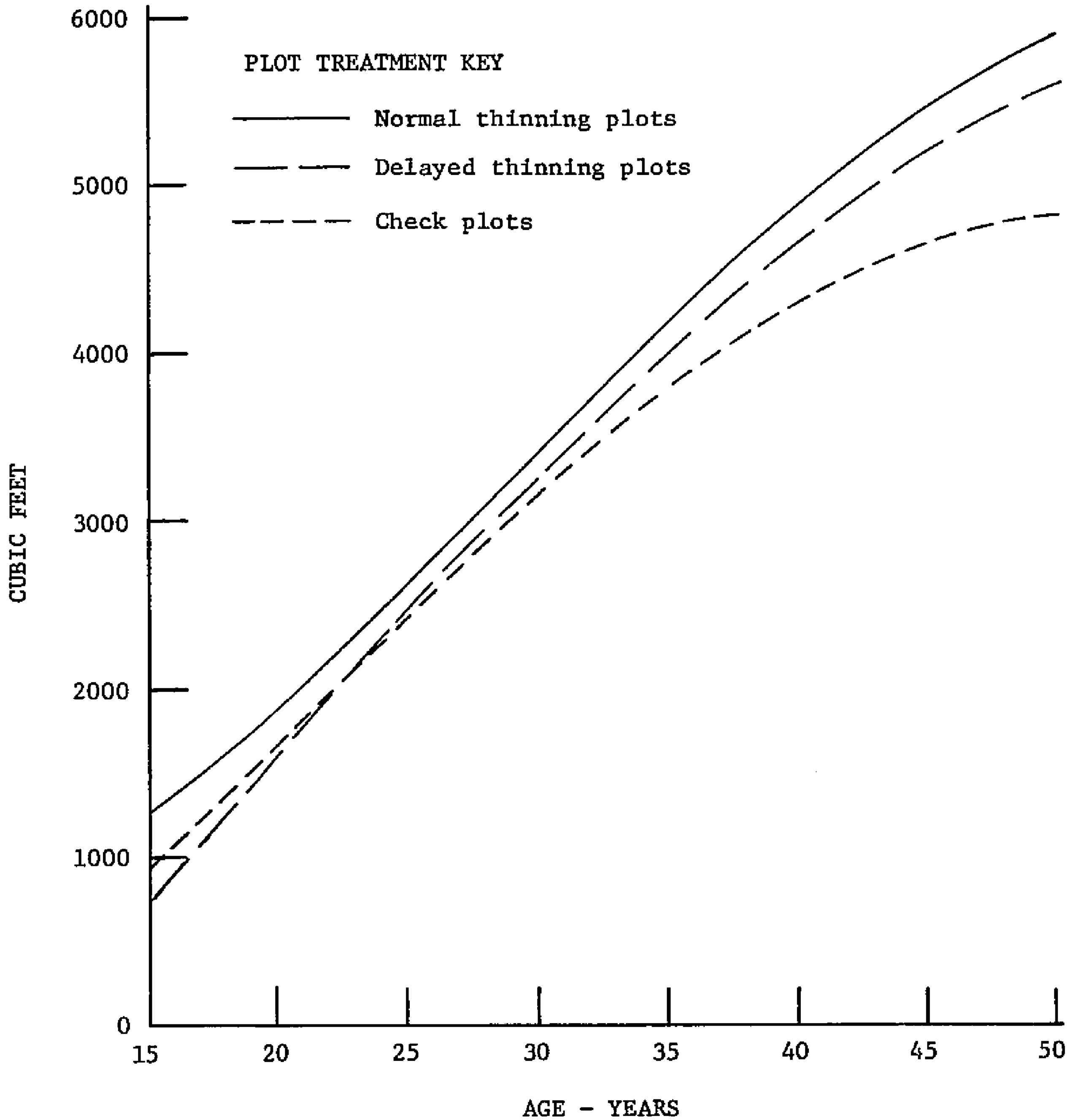

Figure 10. Average cubic volume production per acre, including thinnings, all species (from Table 27).

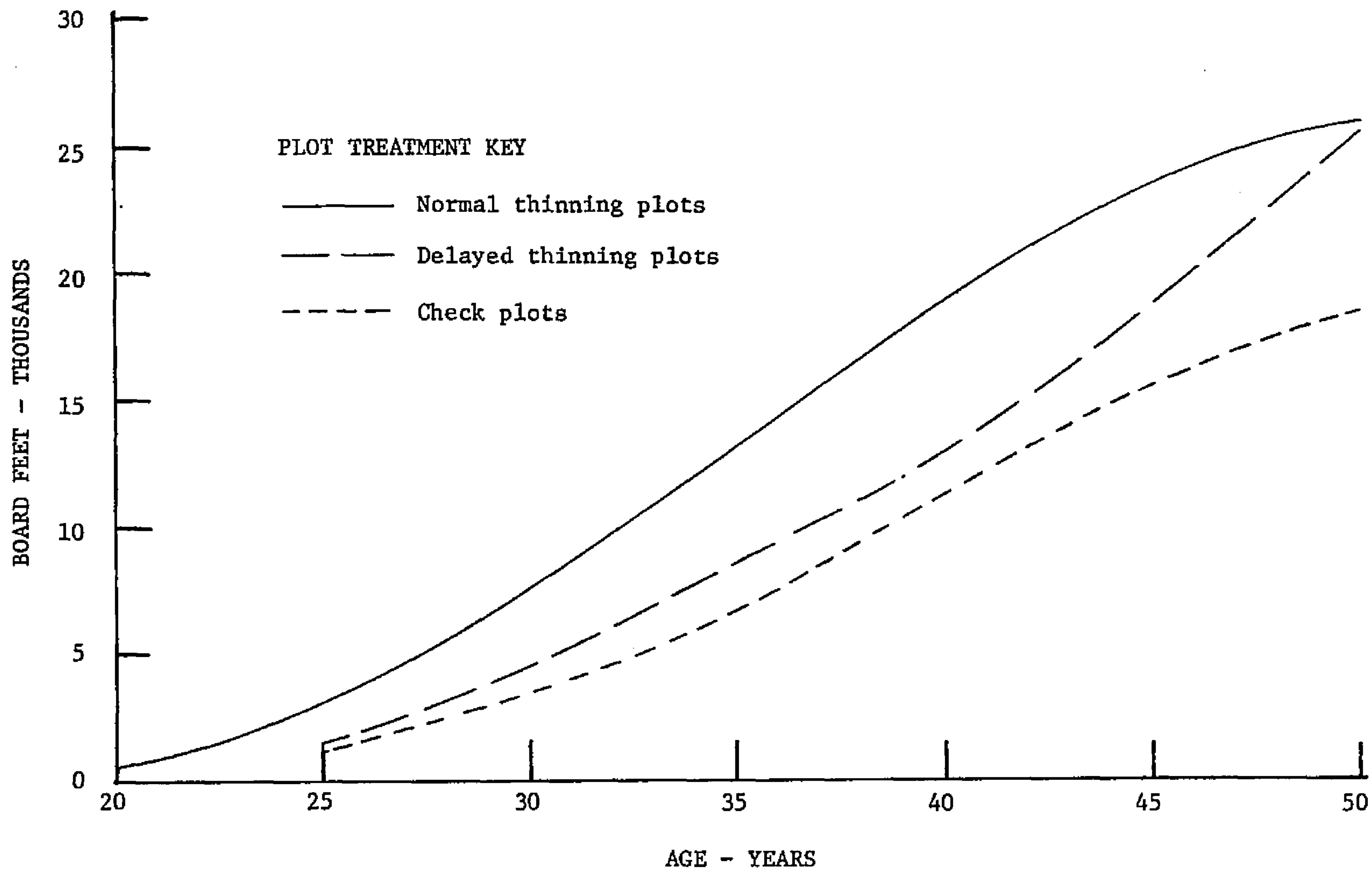

Figure 11. Average sawtimber production per acre, including thinnings, all species (from Table 16).

VITA

Edward Robert Andrulot was born on January 31, 1914, at Manchester, Connecticut. He was the second of four children born to George and Ida Andrulot.

He attended and completed the program at the New York State Ranger School in February 1933.

In 1936 he entered the University of Michigan and received a Bachelor of Science in Forestry degree in 1939. While a member of the staff at Louisiana Polytechnic Institute, he completed the requirements for a Master of Science degree with a major in botany in August 1960. He is presently seeking a Doctor of Philosophy degree from Louisiana State University.

He was employed by the U.S.C.C.C. from May 1933 to September 1936, first as enrollee and later as foreman in charge of surveying and engineering. From September 1939 to February 1941, he was employed as Junior Forester by the U. S. Forest Service and assigned to various C.C.C. camps in Connecticut. In March and April of 1941 he was a highway engineer with the Connecticut Highway Department. He was employed by the Crossett Lumber Company in May 1941 and served as a district forester until July 1956.

Since September 1956, he has been employed by the School of Agriculture and Forestry, Louisiana Polytechnic Institute. His present rank is Associate Professor.

He is married and is the father of two sons, ages 24 and 19.

EXAMINATION AND THESIS REPORT

Candidate: Edward Robert Andrulot

Major Field: Forestry

Title of Thesis: EFFECTS OF THINNING ON YIELD OF LOBLOLLY PINE (PINUS TAEDA L.) IN CENTRAL LOUISIANA

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Date of Examination:

January 12, 1970