United States
Department of
Agriculture

Forest Service

**Southern Forest
Experiment Station**

New Orleans,
Louisiana

Research Paper
SO-283
June 1994

Seasonal and Cumulative Loblolly Pine Development Under Two Stand Density and Fertility Levels Through Four Growing Seasons

James D. Haywood

SUMMARY

A loblolly pine (*Pinus taeda* L.) plantation was subjected to two cultural treatments to examine seasonal and cumulative pine development in the 9th through 12th growing seasons: (1) pine stocking was either reduced by thinning to 303 trees per acre at a 12- by 12-ft spacing or the plots were left uncut with an original density of 1,210 trees per acre at a 6- by 6-ft spacing, and (2) either no fertilizer was applied or diammonium phosphate was broadcast at 134 lb of phosphorus and 120 lb of nitrogen per acre. Competing vegetation was controlled on all plots. Thinning resulted in less spring height growth in the 9th and 10th growing seasons than not cutting, but thinning increased diameter growth each year. Beginning in the 10th growing season, fertilization increased height, diameter, and basal area per acre growth, with the effect of fertilization on diameter growth being most pronounced on the thinned plots (a thinning by fertilization interaction). Therefore, fertilization of thinned plots was more beneficial than thinning alone, and thinning alone resulted in less height and basal area per acre growth than the other treatment combinations for the 4-year period.

Seasonal and Cumulative Loblolly Pine Development Under Two Stand Density and Fertility Levels Through Four Growing Seasons

James D. Haywood

INTRODUCTION

The likelihood that fertilization will increase volume increment in pole- to sawlog-sized loblolly pine (*Pinus taeda* L.) stands is greatly dependent on the initial stand basal area per acre (Moehring 1966, Wells and others 1976, Windsor and Reines 1973). Therefore, the fertilization of stands that had been thinned is often much more beneficial for increasing diameter and height increment than either fertilization or thinning alone (Jones and Broerman 1977). The cumulative effect is to increase net volume (and value) per tree left in thinned stands as fertilization acts to speed up site reoccupancy (Ballard 1981, Ballard and others 1981).

Both thinning and fertilization influence stand development, but it is not clear when the effect of cultural treatments occurs during the growing season. In this study, loblolly pine height and diameter measurements were made periodically over 4 years to determine: (1) when growth responses to thinning and fertilization occur and (2) what the cumulative growth responses to these two cultural practices were.

STUDY AREA

The 2.8-acre site, located in Rapides Parish, Louisiana, is a gently sloping Beauregard silt loam (Plinthaquic Paleudults, fine-silty, siliceous, thermic) soil. Soil drainage is adequate, and slope is sufficient that water does not pond. The site was planted with loblolly pine seedlings at a 6- by 6-ft spacing in May 1981. The planting stock was container seedlings that had been grown in styrofoam blocks for 14 weeks. More than 97 percent of the planted trees survived through 1987, when this study was initiated. The 3 percent that did not survive did not create any openings in the stand canopy. Loblolly pine was the dominant vegetation as measured by basal area per acre, frequency of occurrence, and occupancy of the canopy. Diameters at breast height (d.b.h.'s) of all pine trees were measured in September 1987. These data indicated that pines of similar size were evenly distributed across the site.

METHODS

Experimental Design and Treatment

In April 1988, the understory hardwood trees, shrubs, brush (including *Rubus* spp. and *Smilax* spp.), and herbaceous plants were cut with a tractor drawn, rotary mower. Twelve research plots were established with each plot containing 13 rows of 13 trees each (0.14 acre).

Treatments were randomly assigned to the 12 plots in a 2 by 2 factorial arrangement with 3 replications as follows:

1. *Thinning*. Plot stocking was either reduced to 303 trees per acre in November 1988, at the end of the eighth growing season, or the plots were left uncut with an original density of 1,210 trees per acre.
2. *Fertilization*. Either no fertilizer was applied or diammonium phosphate was broadcast at 667 lb per acre (134 lb/acre of phosphorus and 120 lb/acre of nitrogen) in April 1989 at the beginning of the ninth growing season. This choice and rate of fertilizer was based on prior knowledge of loblolly pine response to fertilization on a Beauregard silt loam soil (Tiarks 1982).

On the thinned plots, the trees were removed to leave a 12- by 12-ft spacing by cutting every other row of trees and every other tree in the uncut rows. This left 12 pines on the interior measurement area of each cut plot. The plots were not selectively thinned to avoid biasing the comparison of the thinned and uncut plots. The purpose of thinning was not to improve the population of trees, but rather to compare growth between like populations of trees growing under different management practices. On the uncut plots, 12 trees were systematically selected for collecting height data, rather than measuring the height of every tree. The same selection scheme was used to choose these 12 trees as was used to choose the residual trees on the thinned plots. The 12 selected trees on each plot were banded with red paint at about 5.5 ft to ensure relocation. All trees on the interior measurement areas were marked with a blue painted line at d.b.h. for consistent resampling.

James D. Haywood is a silviculturist at the Alexandria Forestry Center, U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, Pineville, LA 71360.

Competition from other plant species was not a factor in this research. Therefore, all remaining large woody vegetation and vines were cut, and the herbaceous and small woody competitors were sprayed with glyphosate in April 1989. The plots were rotary mowed 3 weeks later and retreated with glyphosate later in the growing season to maintain weed control. In 1990, the plots were again sprayed with herbicide and mowed. In 1991 and 1992, the vines were cut and the plots sprayed with glyphosate and a mixture of 2,4-D, dicamba, and dichloroprop and rotary mowed 3 weeks after spraying.

Measurements and Experimental Design

The interior measurement area was that portion of each plot originally occupied by the central seven rows of seven trees each (0.04 acre). On March 27, 1989, pine tree diameters (of all trees on the interior measurement area) were measured to the nearest 0.1 inch with a diameter tape, and total heights (of the 12 selected trees only) were measured with a clinometer to the nearest 0.5 ft. This measurement provided a baseline covariate for future analyses. The plots were again measured on July 5 and October 2, 1989; March 19, June 13, October 29, and December 14, 1990; March 8, June 24, September 24, and December 4, 1991; and March 23, June 17, September 17, and December 3, 1992.

Data were analyzed by analyses of covariance with the covariate being the original height, diameter, or basal area per acre data (α = 0.05). These analyses determined that seasonal differences among treatments in 1989 and 1990 were important, but seasonal effects did not occur in 1991 and 1992. Therefore, the reported dependent variables were the periodic growth differences in the spring, summer, and fall of 1989 and 1990, as well as the cumulative (yearend) growth differences throughout the 4-year period.

The spring-growth periods were from March 27 through July 5, 1989 (100 days), and from March 19 through June 13, 1990 (86 days). The summer-growth periods were from July 5 through October 2, 1989 (89 days), and from June 13 through October 29, 1990 (138 days). The fall-growth periods were from October 2, 1989 through March 19, 1990 (168 days), and from October 29 through December 14, 1990 (46 days).

RESULTS AND DISCUSSION

Thinning to 303 pine trees per acre at age 8 resulted in less total height growth through age 12 compared to no thinning (fig. 1). The dampening effect of thinning on height growth was most pronounced in the spring of the 9th and 10th growing seasons (table 1). Thinning did not affect height growth in the 11th and 12th growing seasons (fig. 1). Ginn and others (1989) also reported an early suppression in loblolly pine height growth from reduction in stand stocking.

Fertilization increased total height growth for the 4-year period, but the effect of fertilization on height growth was not evident until the 10th growing season, when height growth was increased on the uncut plots in spring 1990 (see the thinning by fertilization interaction effect in table 1). Height growth on both the thinned-fertilized and uncut-fertilized plots increased in summer 1990 (fig. 1, table 1). Thus, the effect of fertilization on height growth was delayed, whereas the effect of thinning on height growth was immediate.

The cumulative influence of thinning and fertilization on pine height growth was additive for the 4-year period (fig. 2). Periodic height growth averaged 11.6, 14.4, 9.5, and 12.7 ft from the 9th through 12th growing seasons on the uncut-unfertilized, uncut-fertilized, thinned-unfertilized, and thinned-fertilized treatments, respectively.

Thinning significantly increased diameter growth of the residual trees for the 4-year period (fig. 1). The seasonal effect of thinning on diameter growth was immediate, and this positive growth response was significant every season from spring 1989 through summer 1990 (table 1).

Fertilization significantly increased seasonal diameter growth in summer 1989 and 1990 (fig. 1, table 1). Other studies have shown that initial stand basal area greatly influences pine tree responses to fertilization (Moehring 1966, Wells and others 1976, Windsor and Reines 1973), and fertilization of thinned stands is often more beneficial than either fertilization or stand density reduction alone (Jones and Broerman 1977). This was demonstrated by a significant thinning by fertilizer interaction effect on diameter growth at the end of 1990, 1991, and 1992 (table 1), with fertilization having little cumulative benefit on pine diameter growth on the uncut plots (figs. 1, 2). Periodic diameter growth for the 4-year period averaged 0.7, 0.8, 1.8, and 2.6 inches on the uncut-unfertilized, uncut-fertilized, thinned-unfertilized, and thinned-fertilized treatments, respectively.

Thinning resulted in less cumulative basal area growth per acre than no thinning at a probability > F-value = 0.1372 (table 1), and the uncut and thinned treatments averaged a 44.8- and 38.8-ft^2 gain in basal area per acre for the 4-year period, respectively (fig. 1). Fertilization increased cumulative basal area growth, especially on the thinned plots (fig. 2), but there was no significant thinning by fertilization interaction effect in the cumulative basal area per acre analysis (probability > F-value = 0.4135; table 1). The 4-year gain in basal area was 41, 49, 32, and 46 ft^2 per acre on the uncut-unfertilized, uncut-fertilized, thinned-unfertilized, and thinned-fertilized treatments, respectively.

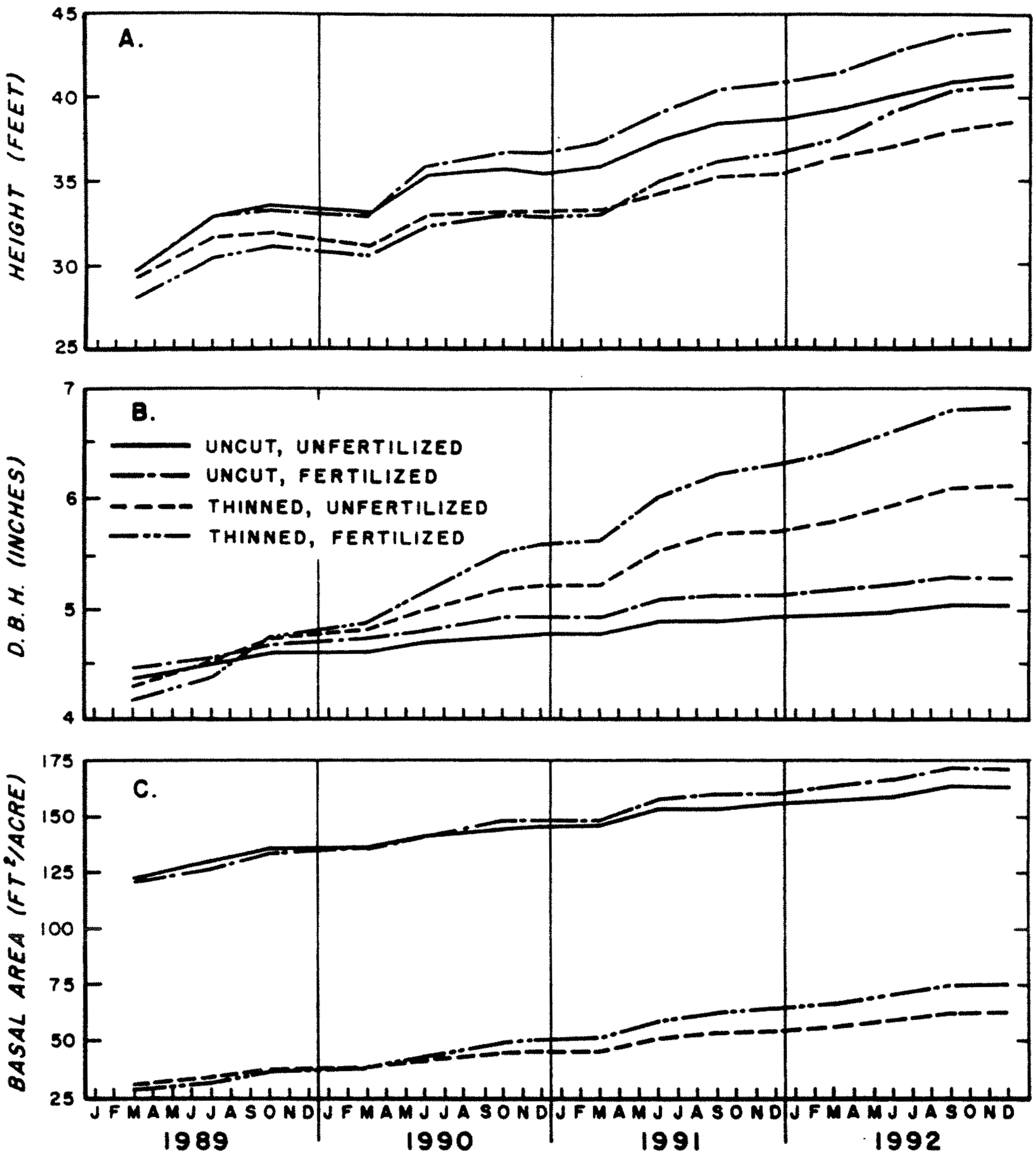

Figure 1.—*Cumulative loblolly pine height, diameter, and basal area per acre in the 9th through 12th growing seasons for thinning and fertilization treatments.*

Table 1.—*Probability of a greater F-value for the main effect treatments and interaction term when comparing seasonal and cumulative height, diameter, and basal area per acre growth of loblolly pine in the 9th through 12th growing seasons (1989 through 1992)**

Variable response	9th Spring	9th Summer	9th Fall	9th Yearend	10th Spring	10th Summer	10th Fall	10th Yearend	11th Yearend	12th Yearend
	(Probability > F-value)									
Height growth										
Thinning	0.0042	0.6832	....†	0.0024	0.0013	0.2905	0.4172	0.0004	0.0002	0.0038
Fertilizer	0.6114	0.5813	....	0.4796	0.1421	0.0055	0.8574	0.0431	0.0007	0.0007
Thin × fert.‡	0.8882	0.1506	....	0.2391	0.0343	0.9839	0.9265	0.3925	0.8758	0.7084
Diameter growth										
Thinning	0.0075	0.0001	0.0202	0.0004	0.0012	0.0001	0.0708	0.0001	0.0001	0.0001
Fertilizer	0.3643	0.0046	0.0627	0.1476	0.1653	0.0002	0.3964	0.0056	0.0051	0.0026
Thin × fert.‡	0.7190	0.0507	0.9345	0.1762	0.0382	0.0692	0.0785	0.0307	0.0312	0.0309
Basal area/acre growth										
Thinning	0.0376	0.0908	0.8027	0.0143	0.3736	0.8376	0.5710	0.0383	0.0682	0.1372
Fertilizer	0.0985	0.0080	0.0008	0.5008	0.9515	0.0003	0.7297	0.0078	0.0067	0.0092
Thin × fert.‡	0.2558	0.8308	0.0660	0.2981	0.1554	0.3328	0.1691	0.2080	0.1745	0.4135

*Probabilities are from analysis of covariance with the initial height, diameter, and basal area per acre data, taken in March 1989, as the covariate. The accepted level of significance was $\alpha = 0.05$.

† Inaccurate data; no analysis was made.

‡ The thinning by fertilization interaction.

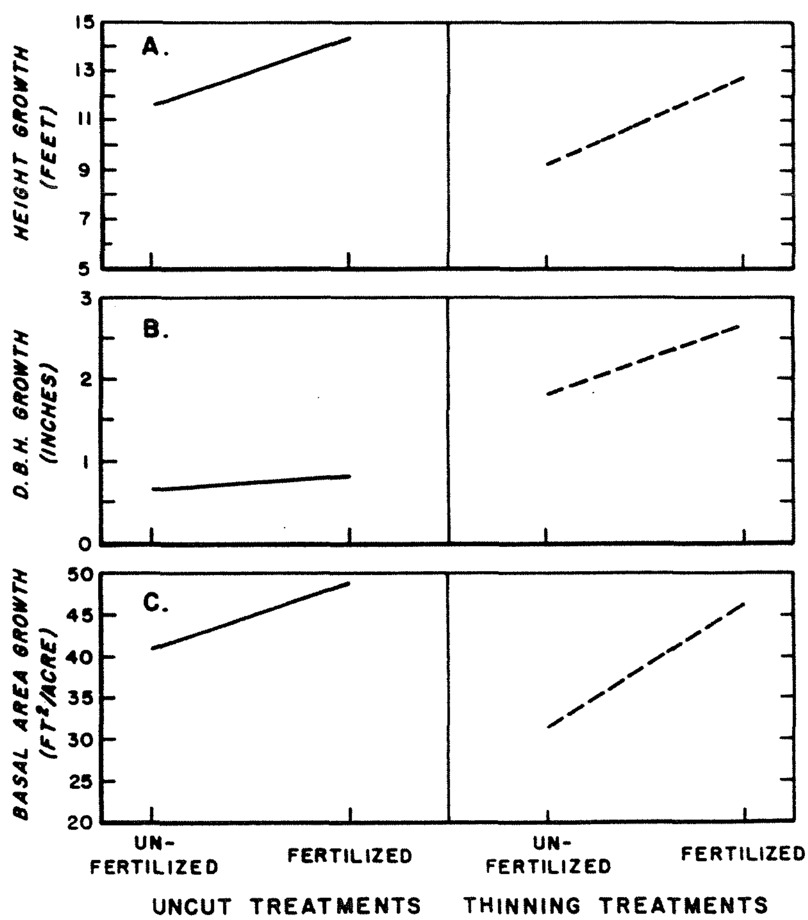

Figure 2.—*Periodic increment for loblolly pine height, diameter, and basal area per acre in the 9th through 12th growing seasons as a response to thinning and fertilization treatments.*

To conclude, managers wanting to accelerate diameter growth in dense young stands of loblolly pine should do more than just apply fertilizer. Rather, overstocked stands will most likely have to be commercially or precommercially thinned before fertilization will benefit diameter and basal area increment. Thinning alone increases diameter growth, but thinning will have a negative effect on loblolly pine height increment for the first 2 years after cutting. This effect may still be evident in later years because height growth returns to its prethinning pattern rather than accelerating its growth pattern. Thinning alone resulted in less basal area growth per acre than the other three treatment combinations for the 4-year period.

LITERATURE CITED

Ballard, R. 1981. Nitrogen fertilization of established loblolly pine stands: a flexible silvicultural technique. In: Barnett, James P., ed. Proceedings of the 1st biennial southern silvicultural research conference; 1980 November 6–7; Atlanta, GA. Gen. Tech. Rep. SO-34. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 223–229.

Ballard, R.; Duzan, H.W.; Kane, M.B. 1981. Thinning and fertilization of loblolly pine plantations. In: Barnett, James P., ed. Proceedings of the 1st biennial southern silvicultural research conference; 1980 November 6–7, Atlanta, GA. Gen. Tech. Rep. SO-34. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 100–104.

Ginn, S.E.; Seiler, J.R.; Cazell, B.H.; Kreh, R.F. 1989. Physiological responses to thinning in eight-year old loblolly pine on the Virginia Piedmont. In: Miller, James H., comp., Proceedings of the 5th biennial southern silvicultural research conference; 1988 November 1–3; Memphis, TN. Gen. Tech. Rep. SO-74. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 67–73.

Jones, S.B.; Broerman, F.S. 1977. Thinning and fertilization of sixteen year old loblolly pine. Woodlands Res. Notes 34. Savannah, GA: Union Camp Corporation, Woodlands Research Department. 2 p.

Moehring, D.M. 1966. Diameter growth and foliar nitrogen in fertilized loblolly pines. Res. Note SO-43. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 3 p.

Tiarks, Allan E. 1982. Phosphorus sorption curves for evaluating phosphorus requirements of loblolly pine (*Pinus taeda*). Communications in Soil Science and Plant Analysis. 13(8): 619–631.

Wells, Carol G.; Crutchfield, D.M.; Trew, I.F. 1976. Five-year volume increment from nitrogen fertilization in thinned plantations of pole-size loblolly pine. Forest Science. 22(1): 85–90.

Windsor, Carlton L., Jr.; Reines, M. 1973. Diameter growth in loblolly pine after fertilization. Journal of Forestry. 71(10): 659–661.

*U.S.GPO:1994-565-016/00008

Haywood, James D. 1994. Seasonal and cumulative loblolly pine development under two stand density and fertility levels through four growing seasons. Res. Pap. SO-283. New Orleans, LA: U.S. Department of Agriculture. Forest Service, Southern Forest Experiment Station. 5 p.

A loblolly pine stand was subjected to two cultural treatments to determine treatment effects in the 9th through 12th growing seasons. Thinning resulted in less spring height growth in the 9th and 10th growing seasons than no thinning, but thinning resulted in more diameter growth each year. Fertilization increased height and diameter growth beginning in the 10th growing season, with the effect of fertilization on diameter growth being most pronounced on the thinned plots.

Keywords: Intermediate harvesting, nitrogen and phosphorus fertilization, *Pinus taeda* L., thinning.

United States
Department of Agriculture

Forest Service

Southern Forest
Experiment Station
701 Loyola Ave., Rm.T-10210
New Orleans, LA 70113-1931