Four-year Growth Results from 16 Year Old Intensively Managed Low Density Loblolly Pine Plantations

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FOUR-YEAR GROWTH RESULTS FROM 16-YEAR-OLD INTENSIVELY MANAGED LOW DENSITY LOBLOLLY PINE PLANTATIONS[1]

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Abstract-In 1994 eighty four permanent research plots were established in two twelve year-old loblolly pine (*Pinus taeda*) plantations in East Texas. Plots differed in relation to: soil-site type, density of trees per acre, fertilization treatments, and competing vegetation control. Three levels of thinning treatments reduced the basal areas to 36, 60, and 84 square feet of basal area (approximately 100,200, and 300 stems, respectively) per acre. All residual trees were pruned to a height of 25 feet. Plots were re-measured in 1995, 1996, and 1998. Significant differences in diameter and height growth rates were detected in 1996 and 1998. Average diameter growth rates from 1995 to 1998 ranged from 0.64 to 0.31 inches per year depending on density class and treatment type.

INTRODUCTION

In 1994, Stephen F. Austin State University in cooperation with Temple-Inland Forest Products Corp., established 84 monumented experimental plots in two typical loblolly (*Pinus taeda*) pine plantations in East Texas. This study was designed to evaluate the effects of heavy thinning, pruning, fertilization, and competition control, the goal being to produce large clear sawtimber on short rotations. This project was based on studies reported by Burton (1982) and Wiley and Zeida (1992). The style of management on these studies are sometimes referred to as "Sudden Sawlog". Both studies used very intensive management practices such as multiple thinnings, bush-hoggings, and prunings, the later study also included three prescribed burnings. While these studies utilized silvicultural practices to maximize sawtimber production, there was no consideration given to the costs associated with this management. The main goal of our study is to grow the largest amount of high quality, knot free, wood while being able to recapture the management costs and still be a profitable investment. The objectives of this study were to report on the growth results four years after thinning treatments were applied.

STUDY SITES

The two study sites differ in relation to soil drainage type. Site one is located in the southern comer of Angelina County and is considered a moderately drained site with a Moswell complex (Dolezel 1988). Site two is located in south-eastern Anderson County and is considered a well drained site with a Fuquay series (Coffee 1975). Both study areas were on non-old-field sites that were previously forested with loblolly pine. Both stands were planted in 1982 with a local variety seed source. Site one was more densely planted with approximately 800 stems per acre while site two was planted with approximately 800 trees per acre. The understory in site one was almost non-existent, while site two contained a heavy mix of woody shrubs and hardwood saplings.

METHODS

The study was implemented during the summer of 1994, while the stands were in their twelfth growing season. Three treatments were installed in a completely randomized without replacement factorial design with three replications for each treatment. Treatments included in the study were three levels of residual densities (35, 60 and 84 square feet of basal area per acre), two levels of fertilization (fertilized and non-fertilized), and two levels of competition control (herbicide and non-herbicide). For each level of thinning, one plot would receive no fertilization and no competition control; one plot would receive fertilization only; one plot would receive competition control only and one plot would receive both fertilization and competition control. Six control plots per site were also established which would receive a standard row thin and no other silvicultural treatment. Plots were positioned within the two stands in a strip-wise pattern as closely together as possible while maintaining uniformity and avoidance of windrows, skid roads, drainages, trails and other anomalies. Each plot consisted of a square one-quarter-acre inner plot surrounded by a 33 foot wide buffer. Plot buffers would receive the same treatment as the plot they surrounded, but would not be used in data collection.

Each tree in a plot was measured for diameter in inches at 4.5 feet above ground level (dbh), total height in feet, height to first live branch, and crown width. Presence of fusiform rust (*Cronatium quercuum* f. sp. *fusiforme*), crooks, forks or other defects were also tallied.

After plot boundaries were established and tree data were recorded, each plot was revisited for residual crop trees selection. Residual trees were selected in the following five criteria, in order of decreasing importance: (1) Larger dbh, (2) stem form, (3) taller trees, (4) spatial distribution, and (5) crown quality. Residual densities were achieved using a modified form of Reineke's stand density index (SDI) (Zeide 1985). Selected densities can then be calculated using the following equation:

$$SDI = N\left(\frac{D}{10}\right)^{1.7} \quad (1)$$

Where:
N = Number of stems per acre
D = Quadratic mean diameter

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[1] Paper presented at the Tenth Biennial Southern Silvicultural Research Conference, Shreveport, LA, February 16-18, 1999.

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Table 1 shows residual density relationships. Thinning treatments were conducted in the fall of 1994 and all harvested trees were hauled to area mills. All residual trees in treatment plots were subsequently pruned during the winter of 1994-l 995 to a height of 25 feet. The following summer (1995) each tree was numbered and remeasured. That fall, plots to receive competition control were treated by hand spraying of herbicides. Herbicide application consisted of approximately 16 ounces of Arsenol AC, 24 ounces of Garlon 4, and 32 ounces of Red River 90 per acre. Mixture totaled approximately 30 gallons per acre for application. Hardwood trees and shrubs greater than two inches in diameter were also "hacked and squirted". In the spring of 1996, fertilization plots were treated with a combination of Urea and Diamonium Phosphate (DAP) giving a blended analysis of 29.21-16.79-O. Fertilizer was applied with shoulder mount hand crank spreaders at a rate of 563 pounds per acre. Plots were remeasured again during the summers of 1996 and 1996.

RESULTS

Stand attributes before thinning are given in Table 2. Dominant heights at site one were in the mid to upper sixties and in the mid to upper **fifties** on site two. For both sites this is out of the range of most site quality curves. Maximum diameters for both sites were in the 11 inch class. Stand attributes after thinning are shown in Table 3. For both sites the average diameter increased with decreasing density.

Table l-Density attributes after thinning for the two study sites

Site	Density class	Density level	Stand density index	Basa area/acre	Stems per acre
				Ft²	
1	Low	1	70	35.6	103.7
1	Med	2	120	60.1	196.3
1	High	3	170	63.7	300.0
2	Low	1	70	35.6	105.3
2	Med	2	120	60.6	190.3
2	High	3	170	64.2	290.0

This is due to the selection method in which the biggest and best trees were selected for the lowest density plots. While the higher density plots contained the same kind of trees as their lower density counterparts they also contained "less than the best" trees as well. The same relationship holds true for the average total tree heights.

Diameter Growth

Tree tagging accomplished in 1995 allowed tracking of individual tree growth through 1996. If treatments besides thinning are disregarded, significant differences in diameter growth (alpha = 0.05) were detected between each of the thinning levels. At both sites, diameter growth was greatest for the lowest density level and decreased with increasing density. Growth rates ranged from 0.27 inches per year for density class three on site one to 0.64 inches per year for density class one on site two (table 4).

When all treatments were added back into the model, no interactions were detected between the three factors. For each density level with the exception of density class one on site two, diameter growth was significantly greater with fertilization treatments. Even at the exception, plots with the fertilization treatment had a greater, although not statistically significant growth rate. There were no significant differences detected due to the competition control treatments (table 5).

Height Growth

When looking only at thinning treatments no significant differences in height growth where detected for site one. Site two however showed density one had significantly slower height growth than the group of density class two and three. As shown in Table 6, height growth ranged from one foot per year for site one density two to 2.3 feet per year for density level three on site two. Additionally, although the trees where taller on site one, site two had significantly greater height growth. Site two had an overall average yearly height growth of 2.0 feet, while site one's growth was 1 **.1** feet per year.

No interactions were found between fertilization and competition control treatments. Significant differences between fertilization treatments were found on density levels one and two for site one. For those two treatment levels fertilization increased height growth. For the competition control treatment, density level one and two on site one showed significantly different height growth. No competition control for density level one on site one yielded greater height growth, while on density level two on site one growth was higher for the competition control treatment. For the remaining density and site levels no recognizable trends were present (table 7).

Table P-Initial stand attributes (before thinning) for the two study areas

Site	Stems per acre	Basal area per acre	Average diameter	Average total height	Average volume per acre
		Ft²	*Inches*	*Feet*	*Ft³*
1					
2	710.5550.9	166.6 132.4	6.3 6.4	46.143.6	3,899.5 2,767.0

Table 3-After thinning stand attributes for the two study areas

Site	Density level	Average diameter	Average total height	Average volume per acre
		Inches	*Ft*	Ft^3
1	1	7.81	52.8	889.2
1	2	7.33	51.9	1,436.4
1	3	8.98	51.3	1,988.0
2	1	7.83	45.1	885.1
2	2	7.54	44.8	1,468.1
2	3	7.20	44.5	1,951.7

Table 4-Average diameters and diameter growth by site and density level between 1995 and 1998

Site	Density level	Average diameter 1995	1998	Growth per year
		- - - - - - - - - Inches[a] - - - - - - - - -		
1	1	8.07	9.75	0.56 A
1	2	7.55	8.77	.40 B
1	3	7.28	8.03	.27 C
2	1	8.12	10.04	.64 A
2	2	7.78	9.08	.43 B
2	3	7.40	8.33	.31 c

[a] Like letters within the same site show no significant difference using Duncan's multiple range test at the alpha = 0.05 level.

Table 5—Average yearly diameter growth between 1995 and 1998 by site, density level, fertilization, and competltlon control treatments

Site	Density level	Treatments: Fertilization	No fertilization	Competition	No competition
1	1	0.60 A	0.53 B	0.57 A	0.56 A
1	2	.45 A	.36 B	.42 A	.38 A
1	3	.29 A	.25 B	.28 A	.26 A
2					
2	11	.68 .49	.39 AB	.45 A	.42 A
2	3	.33 A	.29 B	.32 A	.30 A

Like letters within the same site, density, and treatment type show no significant difference using Duncan's multiple range test at the alpha = .05 level.

DISCUSSION

Diameter Growth

When thinning treatments are looked at independent of the other treatments, heavier thinning or less residual densities resulted in greater diameter growth. This could be attributable to two causes. First, the objective of thinning is to re-distribute growth to the fewer residual trees. Therefore, the lower the residual density the more growth can be allocated to each remaining tree. Second, increased growth could be due to the residual selection method, where on the lowest density plots the absolute best trees were selected as the crop trees. The medium density class would then contain the best trees as well as the next to the best trees. Finally, the highest density plots would contain the best of the best, the next to the best, and then other less desirable stems to maintain spacing and density requirements.

When looking at diameter growth in relation to density and the fertilization treatment, higher growth rates resulted from trees being fertilized. Although one exception was noted, probably due to some unknown variation, the trend was the same.

Competition control treatments made no significant difference in relation to diameter growth. There was, however, a trend favoring competition control. Although

Table 6—Average heights and height growth between 1995 and 1998

Site	Density level	Average height 1995	Average height 1998	Growth per year
		---------- Feet[a] --------		
1	1	56.6	59.5	1.0 A
1	2	55.7	59.2	1.2 A
1	3	55.1	58.5	1.1 A
2	1	48.8	53.6	1.6 B
2	2	48.2	54.5	2.1 A
2	3	47.9	54.8	2.3 A

[a] Like letters within the same site show no significant difference using Duncan's multiple range test at the alpha = 0.05 level.

Table 7-Average yearly height growth between 1995 and 1998 by site, density level, fertilization, and competition control treatments

Site	Density level	Treatments: Fertilization[a]	No fertilization	Competition	No competition
1	1	1.7 A	0.7 B	0.5 A	1.4 B
1	2	1.5 A	.a B	1.5 A	.a B
1	3	1.3 A	1.0 A	1.1 A	1.1 A
2	1	1.4 A	1.8 A	1.6 A	1.6 A
2	2	2.1 A	2.1 A	2.0 A	2.2 A
2	3	2.4 A	2.2 A	2.3 A	2.3 A

[a] Like letters within the same site, density, and treatment type show no significant difference using Duncan's multiple range test at the alpha = 0.05 level.

the average difference only amounted to 0.026 inches per year, the trend was consistent.

Height Growth

No significant differences in height growth were detected in site one and only density class one was significantly lower than either class two and three on site two. The trend in lower height growth on lower densities that occurred in site two would seem logical in that on lower density conditions there would be less competition for light. However, site one did not display the same relationship.

When looking at the effects of fertilization and competition control combined with density levels, a small percentage of statistically significant differences were detected. However, it would seem there was no logical pattern that arose and therefore it was concluded there was no practical significance and differences may be attributed to happenstance and/or measurement anomalies.

In summary, a surprising preliminary result was that site two started out with virtually the same average diameter as site one: Site one had trees averaging over seven feet taller:

and site two has out performed site one both in diameter and height growth. Although site one was considered to be much better than site two at the beginning of the study, growth rates could be better at site two for three reasons. First, site two initially had much more competing vegetation than site one. Therefore, by reducing the non-planted vegetation as well as the competing pines, by means of thinning, the residual crop trees could be responding at a greater rate. Second, it is possible that site two could have received more rain during the two severe droughts that East Texas had experienced since the study plots were established. The third possibility may also be that lands of lower site quality respond more favorably to intensive low density management.

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