EFFECTS OF CULTURAL INTESITY AND DENSITY REGIME TREATMENT ON POST-THINNING LOBLOLLY PINE INDIVIDUAL TREE DBH INCREMENT IN THE LOWER COASTAL PLAIN OF THE SOUTHEASTERN UNITED STATES

John T. Perren, Michael Kane, Dehai Zhao, and Richard Daniels[1]

Abstract—Thinning is a well understood concept used to manage density dependent factors at the stand level. This study evaluates the effect of planting density, cultural intensity, and thinning treatment on loblolly pine post-thinning individual tree development. The Lower Coastal Plain Culture/Density Study, has four initial densities, in combination with two cultural treatments, that were thinned at age 12 to the current density on the lowest initial density. Analysis of data six years post-thin for the Lower Coastal Plain focuses on the effects of cultural intensity and density regime effects alone or in combination on individual tree development in DBH. We evaluated thinning intensity effects on individual tree development. Results indicate that initial density has the largest effect on the development of diameter growth following the thinning with trees from higher densities having a higher greater response in diameter increment.

INTRODUCTION

The southeastern United States produces a large volume of commercially grown timber that comes from plantations. The most dominant species in the region is loblolly pine (*Pinus taeda*). In an attempt to maximize returns on investment, many intensive management practices have been implemented to increase the production on any given site. One of the first considerations is planting density. Initial planting density has a strong effect on diameter growth. As planting density increases, mean diameter of individual stems declines (Zhao and others 2011). Another consideration for initial planting density is the desired products from the stand, with high densities being more appropriate for lower value product classes (Ameteis and Burkhart 2012). Fertilization and weed control have both been shown to have large impacts on the productive capacity of a stand. Nutrients are limiting in most southern timberland, with nitrogen and phosphorous being of primary concern. Fertilization and the removal of competing vegetation to increase the availability of nutrients to crop trees has been shown to more than justify the price of application in most markets (Fortson and others 1996; Fox and others 2007). Thinning is often used to maintain vigorously growing stands. When stands reach high levels of stocking, there is more competition for a fixed amount of resources. Competition leads to a higher mortality rate in stands with a greater stocking, as compared to those with lower levels (Hennessey and others 2004). Thinning is often used in conjunction with other silvicultural treatments. Many studies have looked at thinning as a component of intensive management. A study in the Western Gulf region showed that with thinning alone, 50 percent of the trees were classified as chip-and -saw by age 17. When fertilization was added to the thinning regime, greater than 70 percent of the trees were classified as chip-and-saw (Sword Sayer and others 2004).

The Plantation Management Resource Cooperative (PMRC) established the Culture Density Study to evaluate the effect of initial density and cultural intensity on stand development. At age 12, a subset of four installations from the original study were thinned to further evaluate the relationship between density management and stand development. A stand level view of these installations was completed by the PMRC, but analysis at the individual tree scale is needed to better explain the relationship between thinning and stem. Understanding individual tree response to treatment will lead to better prescriptions at the stand level.

METHODS

The data used in this analysis is a subset from the PMRC's Lower Coastal Plain Culture Density Study that was established in 1996. There were four installations

[1]Masters Student, University of Georgia; Professor, University of Georgia; Research Associate, University of Georgia; Professor, University of Georgia, Athens, GA, 30602.

Citation for proceedings: Schweitzer, Callie J.; Clatterbuck, Wayne K.; Oswalt, Christopher M., eds. 2016. Proceedings of the 18th biennial southern silvicultural research conference. e–Gen. Tech. Rep. SRS–212. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 614 p.

with thinning across the Lower Coastal Plain. Two installations in South Carolina, one in Georgia, and one in Florida gave a good geographic distribution of site locations. These sites have six year post thinning data, which should be a sufficient amount of time to express the effects of thinning. Each installation has four initial densities of interest: 300, 600, 900, and 1200 trees per acre. Each of these densities has two cultural treatments (operational and intensive). The operational plots received bedding, banded chemical site preparation, and first year banded herbaceous weed control (table 1). These plots also received fertilization at planting, year eight and year twelve. The intensive culture plots included the same treatments as the operational plots with the addition of tip moth control, complete vegetation control, and fertilization in year three and even aged years starting in the fourth year.

Thinning was imposed on the 600, 900, 1200 TPA plots under operational and intensive culture at age 12. Plots were thinned to match age 12 TPA on the corresponding 300 TPA-planting density plots, which provided the non-thinned counterpart. Thinning consisted of third row removal with selection. Thinning to a standard number of trees per acre resulted in different levels of residual basal area and percent of the initial stand removed (table 2). Due to different levels of residual basal area left in each of the initial planting density and management combinations, the initial planting densities were referred to as density regimes after thinning.

Data collection

Data was collected by the PMRC field crew. The PMRC crew re-measured each installation periodically with no longer than two years between measurements through

Table 1—Silvicultural treatments for each cultural regime

Operational Regime	Intensive Regime
Bedding	Bedding
Fall banded chemical site preparation	Fall broadcast chemical site preparation
	Tip moth control
Herbaceous weed control: 1st yr. banded	Repeated herbicide application to achieve complete vegetation control
Fertilization: at planting, 500 lbs./acre of 10-10-10; spring of 8th, 12th, and 16th growing season, 200 lbs./acre of N and 25 lbs./acre of P	Fertilization: at planting, 500 lbs./acre of 10-10-10; spring 3rd growing season, 600 lbs./acre 10-10-10 + micronutrients + 117 lbs./acre NH4NO3; spring 4th growing season 117 lbs./acre NH4NO3; spring 6th growing season 300 lbs./acreNH4NO3; spring 8th, 10th,12th,14th , 16th and 18th growing season 200 lbs./acre of N and 25 lbs./acre of P

Table 2—Mean basal area removal by management and density regime across four location

Management	Density Regime	BA Age 12 Pre-Thin (ft^2/acre)	BA Age 12 Post-Thin (ft^2/acre)	BA % Removal
Intensive	300 (No-thin)	133.3	133.3	No Thin
	600 (Thin)	173.5	86.7	50%
	900 (Thin)	167.6	67.6	60%
	1200 (Thin)	196.8	63.8	68%
Operational	300 (No-thin)	115.8	115.8	No Thin
	600 (Thin)	144.0	79.3	45%
	900 (Thin)	159.8	68.4	57%
	1200 (Thin)	170.1	64.7	62%

age 18. Standard measurements, such as diameter at breast height (DBH), were taken. Measurement plots varied in number of trees per plot by initial density and were surrounded by a treated buffer.

Analysis

This analysis focused on the DBH and DBH growth in relation to the cultural intensity and density regimes. For the analysis, trees that had died prior to age eighteen were omitted from the data set. Analysis of variance was used to determine if there were statistically significance differences across density regimes, cultural intensity, and their combinations. To address and illustrate the effect of thinning on the individual density regimes and management combinations, linear regression was used to compare the growth increment in DBH over the post-thinning period to the initial DBH at the time of thinning. The data was divided by density regime and cultural regime (management). Each combination was an aggregate of the data from all four installations. DBH increment for each tree was calculated using the age 12 measurements and post thin measurements at age 18.

RESULTS

Management intensity, density regime and their interaction showed a significant effect on both age twelve and eighteen DBH (table 3). More intensive management resulted in increased mean DBH. For density regimes, mean DBH decreased with increasing density. Both of these results follow the trends reported by Zhao and others (2011) when evaluating all of the sites from the culture density study in the Lower Coastal Plain. Though the treatment effects on DBH further validated the earlier studies, the main focus of this analysis was the effects of the different treatments on DBH increment. DBH increment showed a different trend than the age twelve and eighteen year DBH results. DBH increment increased with increasing initial density. The effect of management was not significant on DBH increment (table 3). Density regime effects and the interaction of management and density regime on DBH increment were significant. The different density regimes showed the same pattern of growth response in DBH within each management intensity (fig. 1). For both the operational and intensive treatments, larger more dominant trees outgrew smaller trees and the higher initial planting density-thinned regimes had a higher level of growth response in DBH. When comparing the differences in DBH growth for a given density regime by management intensity the results vary. For both the 300 no-thin and 600 thin density regime the operational management treatment produced greater DBH increment than the intensive across the entire pre-thin age twelve DBH range (fig. 2). A different relationship was observed with the 900 and 1200-thin density

Table 3—Effects of management, density, and their interaction on DBH age 12, age 18 and DBH increment across four locations

Source	DBH Age 12	DBH Age 18	DBH Increment
Management	**	**	NS
Density Regime	**	**	**
Man x Den Reg	*	**	*

(NS= not significant,*P< 0.05, **P<0.01)

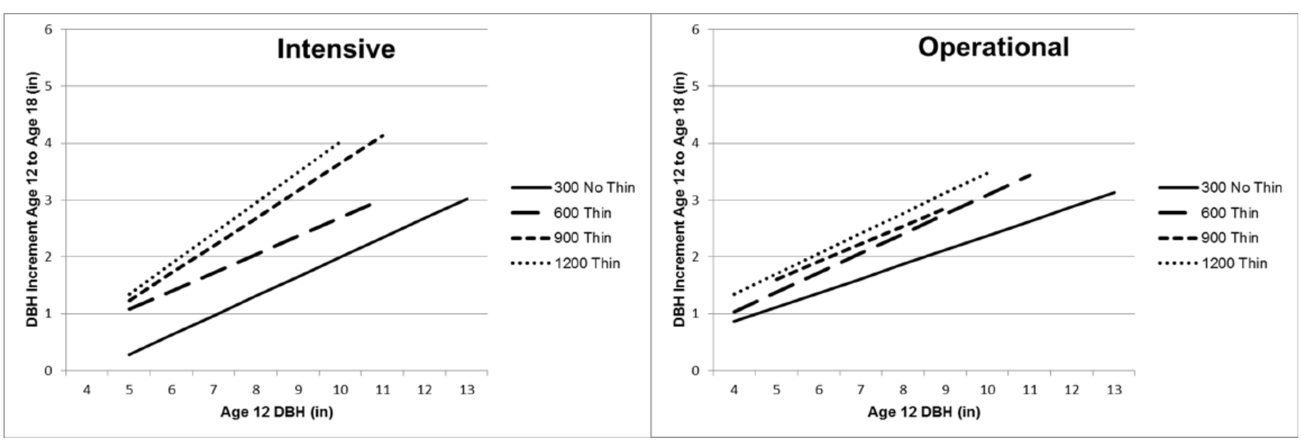

Figure 1—Relationship between post-thin DBH increment (age 12 to 18) and age 12 diameter distribution by density regime for operational and intensive treatments.

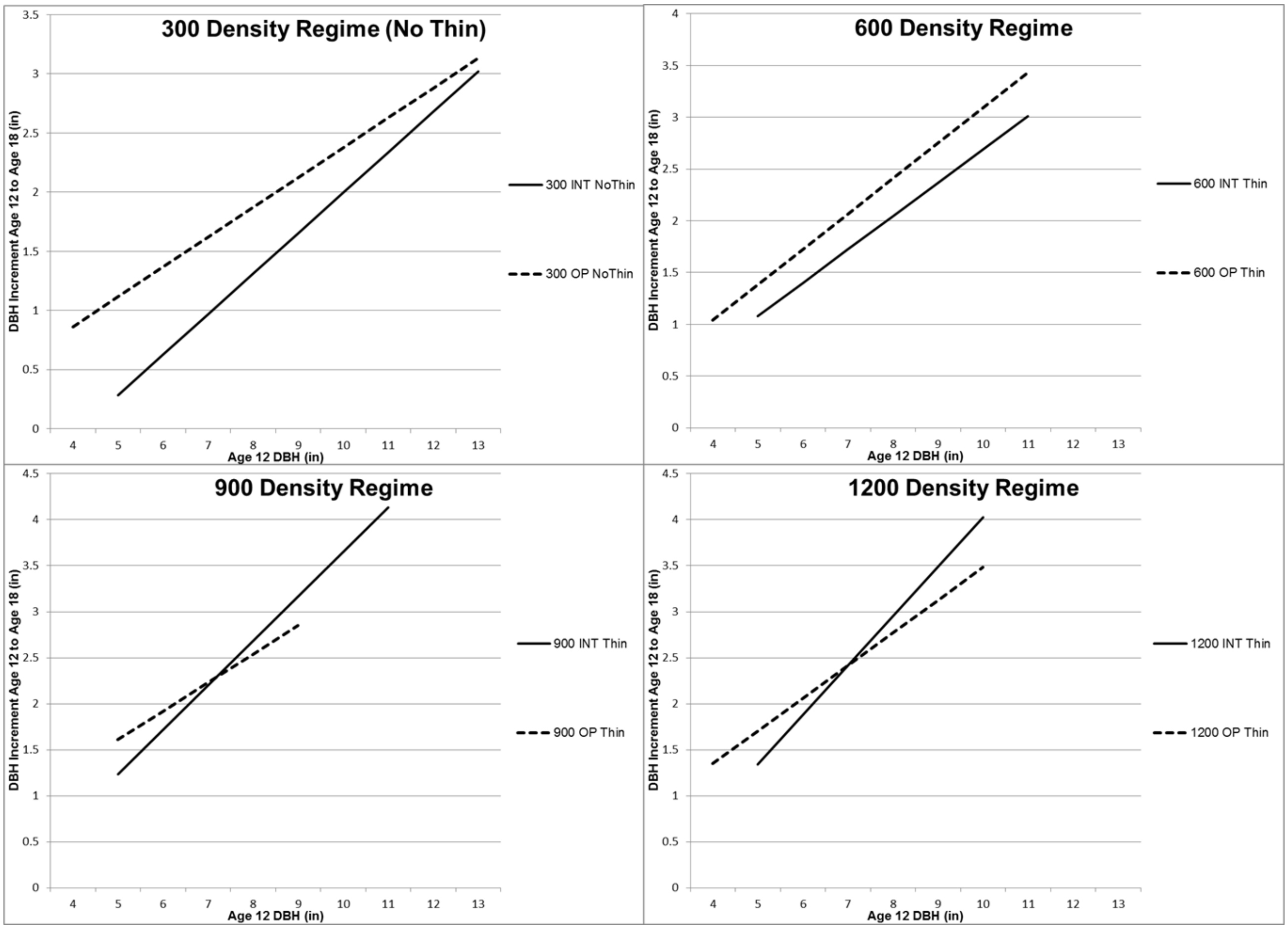

Figure 2—Relationship between post-thin DBH increment (age 12 to 18) and age 12 diameter distribution by individual density regime and management combination.

regimes. With these two density regimes, operational management outperforms the intensive at the lower DBH range, but the intensive management produced larger increments at initial age twelve DBHs that were greater than approximately 7.5 inches.

DISCUSSION

Trees in each density regime and management combination responded differently to thinning due to the different stages of stand development at the time of thinning and the relative thinning intensity imposed (table 2). Though cultural intensity does not seem to effect individual tree DBH response to thinning, it has a large effect on the pre-thin basal area of the 300 and 600 density regimes. When this specific thinning method was imposed to the 600 density regime, there was a large variability in residual basal area between cultural intensities with 87 square feet per acre in the intensive and 79 square feet per acre in the operational due to smaller individual stem DBH. This led to different growing conditions post thinning with the intensive plot having a higher average residual basal area, leading to less available resources per tree. Once trees have similar room to grow, nutrient availability seems to become a more important influence impacting growth. This is seen on the 900 and 1200 density regimes, where cultural intensity has a more noticeable impact. The range in residual basal area was 64 to 68 square feet per acre for the 900 and 1200 density regimes for both management treatments. Due to the small range in average residual basal, trees in the intensive plots had more available resources and more competitive trees responded with greater DBH increment growth. Across all management and density regime combinations, there was a common trend of trees with larger initial DBH having larger DBH increments in response to thinning than trees with smaller initial DBH.

CONCLUSION

Managing intraspecific competition may be the most important factor in this study for maintaining vigorously growing individual trees and consequently stands. Improving the nutrient availability of a stand will also increase the growth of individual trees that have room to grow. Trees with larger initial diameter at the time of thinning have a greater ability to obtain more resources needed to increase growth, and are thus more competitive. The nutrient availability at stand establishment, up to the time of thinning, has a large effect on the initial condition of stand. It also determines when thinning should occur and the level of response that should be expected.

ACKNOWLEDGMENTS

The authors acknowledge the Plantation Management Resource Cooperative (PMRC) in developing the platform for this research.

LITERATURE CITED

Amateis, R.L.; Burkhart, H.E. 2012. Rotation-age results from a loblolly pine spacing trial. Southern Journal of Applied Forestry. 36(1): 11-18.

Fortson, C.F.; Shiver, B.D.; Shackelford, L. 1996. Removal of competing vegetation from established loblolly pine plantations increases growth on Piedmont and Upper Coastal Plain Sites. Southern Journal of Applied Forestry. 20(4): 188-192.

Fox, T.R.; Allen, H.L.; Albaugh, T.J. [and others]. 2007. Tree nutrition and forest fertilization of pine plantations in the southeastern United States. Southern Journal of Applied Forestry. 31(1): 5-11.

Hennessey, T.C.; Dougherty, P.M.; Lynch, T.B. [and others]. 2004. Long-term growth and ecophysiological responses of a southeastern Oklahoma loblolly pine plantation to early rotation thinning. Forest Ecology and Management. 192(1): 97-116.

Sword Sayer, M.A.; Goelz, J.C.G.; Chambers, J.L. [and others]. 2004. Long-term trends in loblolly pine productivity and stand characteristics in response to thinning and fertilization in the West Gulf region. Forest Ecology and Management. 192(1): 71-96.

Zhao, D.; Kane, M.; Borders, B.E. 2011. Growth responses to planting density and management intensity in loblolly pine plantations in the southeastern USA Lower Coastal Plain. Annals of Forest Science. 68: 625-635.