CROWN EXPANSION FOLLOWING THINNING IN NATURALLY REGENERATED AND PLANTED LONGLEAF PINE

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The recent focus on restoration of longleaf pine (*Pinus palustris* Mill.) forests has frequently led to planting longleaf pine on old-field and cutover sites. While many perceptions regarding response of longleaf pine to management are based upon measurements in naturally regenerated stands, it is generally observed that crown development in planted longleaf stands is dissimilar to that observed in natural stands; that is, planted longleaf pine trees tend to have more branches and wider, more "full" crowns at young ages in comparison to naturally regenerated trees. Many planted longleaf stands are reaching the size and age for thinning and with these observed differences in crown characteristics, it is important to explore further whether the response of tree crowns in plantations differs from that of naturally regenerated trees. Few (if any) published studies other than Minor (1951), however, have examined crown dimensions of individual longleaf pine trees as influenced by stand characteristics.

We examined post-thinning crown expansion of planted and natural longleaf pine by comparing trees in thinned and unthinned stands for each establishment type. This study was located at Ichauway, an 11 750-ha preserve located near Newton in southwest Georgia. Planted longleaf were measured in a 25-year-old plantation that was thinned at 17 years (with a portion not thinned). Trees from natural stands were selected from intermediate and small codominant crown classes in plots thinned using individual tree selection and unthinned control plots that are part of a long-term research project. These natural stands are multi-aged, but average age of the canopy dominants is 80 to 90 years. In the plantation, six fixed-area plots were randomly located in both thinned and unthinned areas. In the natural stands, previously mapped trees were randomly selected for sampling, with trees selected from a similar diameter range as those in planted stands. Two crown diameters were measured at right angles for all target trees using a densitometer to identify crown "edges." Diameter at breast height (d. b.h.) was then recorded, and local stocking and competition were characterized using overstory abundance index (OAI, Battaglia and others 2002) in a 7-m radius around each tree. Mean values for stand characteristics were compared for all treatment and stand combinations using ANOVA (PROC MIXED; SAS Institute 2002-2010). Linear regression was used to examine for differences in crown response for different tree sizes and stand conditions by comparing regression parameters between treatment/stand-type combinations. Statistical comparisons of the regression parameters were carried out in SAS using PROC GENMOD (SAS Institute 2002-2010).

Results for average stand characteristics are shown in table 1. Thinned stands of either type had larger average size (d.b.h or crown diameter) and lower OAI than the unthinned stands. Generally, there were no significant differences by stand type, and the interaction between stand type and treatment was only significant for d.b.h. due to the large diameter differences between treatments in the natural stands. These results are not surprising given the well-understood responses of tree size to thinning, and lower OAI is to be expected following removal of trees in the thinning operation. There was, however, a wider range of values around the mean characteristics in the unthinned stands in comparison to the thinned stands (data not shown).

Regression analyses showed mixed results for crown diameter as a function of d.b.h. and OAI (fig. 1), with no significant differences in slope and only occasional differences in intercept parameters between treatment and stand type

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Table 1--Mean values, and standard errors (SE), for overstory abundance index (OAI), diameter at breast height (d.b.h.), and crown diameter (CD) by stand type and treatment. Statistical significance was tested at the 0.05 level

	Mean values (SE)				Pr > F		
	Natural thinned	Natural unthinned	Plantation thinned	Plantation unthinned	Treatment	Stand type	Trtmt * Std type
OAI	506 (51.0)	865 (67.6)	749 (43.6)	1,248 (48.6)	<0.0001	<0.0001	0.21
D.b.h. (*cm*)	29.2 (0.92)	20.7 (1.18)	26.3 (0.90)	23.7 (0.54)	<0.0001	0.95	0.0009
CD (*m*)	5.03 (0.19)	3.37 (0.24)	4.55 (0.25)	3.19 (0.13)	<0.0001	0.092	0.46

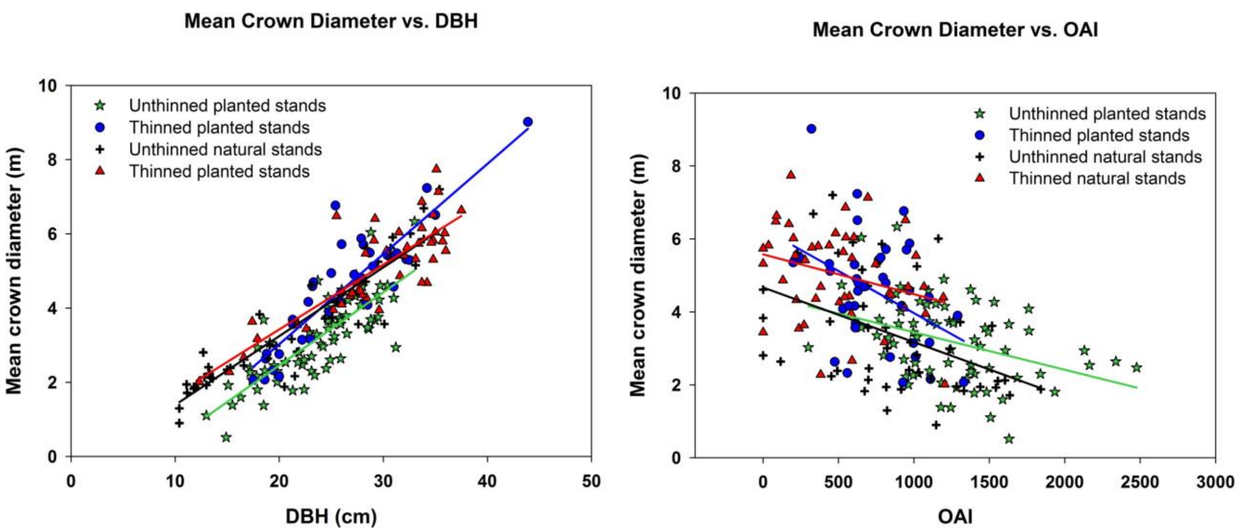

Figure 1--Average crown diameter as a function of diameter at breast height (d.b.h., left) and overstory abundance index (OAI, right). Points represent measured data by treatment and stand type, and lines represent linear regression results by treatment and stand type. In general, slopes were not significantly different across stand type and treatment for either relationship, but some intercept parameters were significantly different between treatment/stand combinations.

combinations. Given the observed differences in crown morphology between planted and natural stands, our hypothesis was that slopes for the different treatment/stand-type combinations would be statistically significant, indicating a varying response to thinning by stand type.

The lack of statistically significant differences in slope was somewhat unexpected given the plotted regression lines shown in figure 1 but is likely due to the variability in the data and, to a lesser degree, the limited range of tree sizes sampled (especially in the plantation stands). The significant differences in intercept terms could indicate a difference in crown width for a given tree size or level of competition, but statistical significance was indicated for only a few comparisons (data not shown) and did not show any definite trends with treatment or stand type. One interesting factor to think about is the influence of height on individual crown characteristics as shown by Murphy and Shelton (1995) for uneven-aged loblolly pine. We did not examine any height influence, but it is perhaps an important factor to consider given the large differences in age and height for the plantation and natural stands used in this study.

Although our working hypothesis was that individual tree crowns in the plantation and natural stands would respond differently to canopy manipulation through thinning (as indicated by differences in regression parameters), the lack of significant results is actually useful, especially in terms of modeling responses for the two stand types: i.e., separate models are likely not needed for plantation and natural stands. The results of this study are preliminary, however, with several confounding factors such as age differences, time since thinning, type of thinning operation and variable spacing. Additional study of these relationships will be required during the development of predictive models.

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