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An Evaluation of a Multi-species, Multi-product Planting System: Six Year Results

Bill Pickens – Conifer Silviculturist, NC Forest Service, Raleigh, NC
Sarah Crate – Longleaf Coordinator, NC Forest Service, Raleigh, NC

This study evaluates techniques and identify obstacles of a non-conventional, multi-species multi-product forest management system. The goal is to provide forest landowners early income that increases overall profits while establishing a longleaf pine forest. We examine stand growth and development of loblolly *(Pinus taeda)* and longleaf *(Pinus palustris)* when planted together to provide mixed sawtimber-biomass products. Once marketable, the lobolly will be harvested at first thinning to provide early income as a short rotation biomass component leaving a longleaf stand that can be managed for ecosystem, wildlife or timber values. We established two planting treatments. In Treatment 1 loblolly and longleaf were planted during the same planting season, and in Treatment 2 longleaf was planted in the first year with the loblolly seedlings planted the following growing season. After five growing seasons the loblolly in Treatment 1 surpassed the longleaf in height and diameter growth. In Treatment 2 the loblolly (age 5) outperformed longleaf (age 6) in height (16.9 ft., 15.9 ft.) but not diameter (3.0 in., 3.2 in.). Loblolly Mean Annual Increment (MAI) for treatment 1 was 3.5, and longleaf MAI was 2.4 feet per year - a difference of 1.1 feet. In Treatment 2 the MAI was 3.4 feet and 2.6 feet respectively – a difference of 0.8 feet. Comparison of Periodic Annual Increment (PAI) after height growth initiation in longleaf showed loblolly outgrowing the longleaf in Treatment 1 and Treatment 2, but the difference in the annual growth between the two pines for Treatment 2 versus Treatment 1 (0.5 ft., 0.8 ft.) decreased.

Introduction

Longleaf pine *(Pinus palustris*) is well suited for long-term management goals. Its superior wood qualities are preferred for high quality timber products and high valued utility pole markets. Its long needles are a favored landscape mulch. The species-rich diversity of a longleaf pine ecosystem provides excellent wildlife habitat valued by many landowners. However, longleaf pine's slow early growth, high establishment costs, and long rotation reduce its economic rate of return, deterring some from pursuing it as a forestry investment.

For the landowners who are interested in establishing a longleaf forest, a mixed species multi-use planting system could offer an opportunity to provide early income from a faster growing species while establishing the slower growing longleaf. If successful, a multi-product management design makes establishing longleaf pine a more attractive investment, offers a hedge against uncertain markets, and provides future environmental value.

The purpose of our study is to evaluate techniques and identify obstacles of a non-conventional, mixed sawtimber -biomass forest management system. We will grow two timber products, a short rotation loblolly crop for biomass and a long rotation longleaf crop for saw-timber and other values of a longleaf forest. Loblolly pine is fast growing and is the favored species for intensively managed forest plantations to produce biomass chips, pulpwood or solid wood products on short rotation.

In the study we planted half the loblolly seedlings one year after the longleaf. We hypothesize a one year delay in planting the loblolly component will provide the longleaf an additional growing season to begin height growth and thus reduce the likelihood the loblolly trees will significantly overtop and stagnate longleaf growth. We also hypothesize that although the loblolly is likely to be taller than the longleaf at first thinning, the longleaf will respond to the release. We will continue to follow this project until the loblolly component is harvested.

Figure 1. Alternating rows of longleaf (left) and loblolly (right) 5 years after planting *(October 2017, Treatment 1).*

This report compares the growth performance of the loblolly and longleaf trees after six growing seasons.

Methods

The study is located on a former loblolly cutover site in southeastern North Carolina at Bladen Lakes State Forest. The site includes two soil series Centenary and Ocilla. The

Centenary series is a moderately well drained sandy soil with a $SI^{50}85$ for loblolly and $SI^{50}72$ for longleaf. The Ocilla series is a somewhat poorly drained loamy fine sand with a $SI^{50}85$ for loblolly and $SI^{50}72$ for longleaf.

Following the clearcut harvest, the site was prepared for planting with a mid-July herbicide treatment (tankmix of 1 -gallon Prep-it™ + 1-gallon Accord XRT™) followed by a late September prescribed burn.

Two treatments differ in the growing season the loblolly was planted.

Treatment 1 – Loblolly and longleaf seedlings were planted in the same growing season (2012).
Treatment 2 – Longleaf seedlings were planted in year one (2012) with the loblolly seedlings planted the following growing season (2013-14).

The study is laid out in a randomized block design of six replications. Each treatment plot consists of 16 rows - 8 rows of loblolly and 8 rows of longleaf. Seedlings are planted in alternating rows at a row spacing of 8 feet. In-row tree spacing is every 5 feet for loblolly and every 7 feet for longleaf, resulting in 389 longleaf seedlings per acre and 545 loblolly seedlings per acre.

The seedlings were grown at the North Carolina Forest Service (NCFS) Claridge Nursery. Longleaf seedlings in both treatments were NCFS 1st Generation improved containerized longleaf seedlings. For loblolly, Treatment 1 utilized NCFS 3rd cycle improved containerized loblolly seedlings and Treatment 2 used NCFS Improved 2nd cycle loblolly bareroot seedlings.

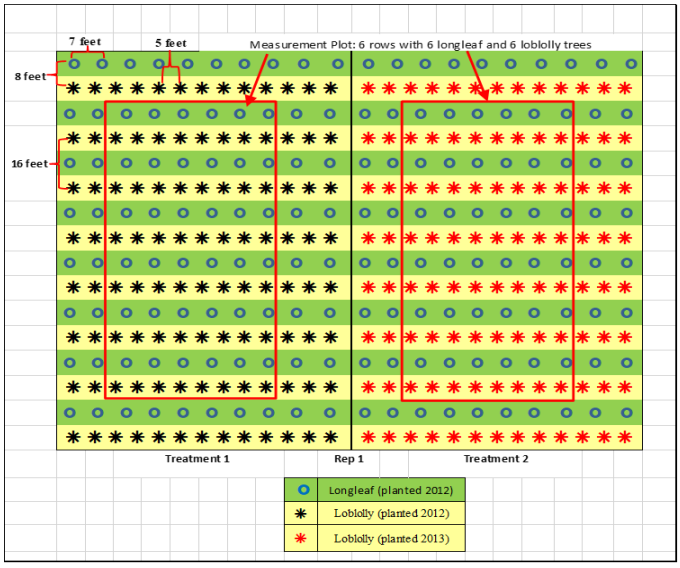

Figure 2. Graphic depiction of a treatment plot layout showing the alternating species rows and the with in row spacing of every 5 feet for loblolly and every 7 feet for longleaf. Planted stand density was 934 seedlings per acre (545 loblolly seedlings and 389 longleaf seedlings). Planting year is in parenthesis.

The longleaf rows in Treatment 1 and Treatment 2 were planted in December 2012. The loblolly rows in Treatment 1 were planted in November of the 2012-13 planting season. The loblolly rows in Treatment 2 were planted the following 2013-14 planting season in January of 2014.

Differences in seedling type and timing of planting were due to stock and planting crew availability.

Survival was determined at age two by counting all trees within the treatment plots. Height data was collected on the loblolly trees at age 1 and age 2. Height data was collected on the longleaf trees beginning in year 2 after height growth had initiated, and the percent number of seedlings out of the grass stage was determined. In the fall of 2017, measurement plots of 30 trees were established and the height and diameter at age 5 were measured in Treatment 1 for both loblolly and longleaf. In the fall of 2018, we measured the height and diameter of the trees in Treatment 2 (age 5 for the loblolly and age 6 for the longleaf).

Results

The overall survival of both species was high, but loblolly seedlings had the highest survival rate across all treatments (95.3 % loblolly versus 90.2% longleaf, Table 1.). The loblolly average survival was 97.7 % in Treatment 1 and 92.8 % in Treatment 2. Survival of the loblolly seedlings was lower in Treatment 2 due to severe winter temperatures in January of 2013 after outplanting. Percent survival of the longleaf averaged 90.3% in Treatment 1 and 90.0% and in Treatment 2.

Percent Survival at Age 2				
	Treatment 1		Treatment 2	
	Lob (2012)	LL (2012)	Lob (2013)	LL (2012)
AVG	97.7	92.8	90.3	90.0

Table 1. Mean percent survival at age 2 for Treatments 1 and Treatment 2. All trees within the study design were tallied to determine survival. Planting year is in parentheses.

Eighty-three percent of the longleaf seedlings initiated height growth by the end of the second growing season. Seedlings were tallied as out of the grass stage if they were greater than 4 inches tall, measured to the tip of the terminal bud.

Throughout the 5-year measurement period loblolly outperformed the longleaf in both mean height (Table 2). By age five the average height of the loblolly in Treatment 1 was 5.55 feet greater than the longleaf (17.47 feet versus 11.92 feet). In Treatment 2 the growth of loblolly at age 5 was only 1.02 feet greater than the longleaf at age 6 (16.90 feet versus 15.88 feet). First year growth of Treatment 1 loblolly was adversely impacted by tip moth infestation, visually estimated at 90% of the seedlings damaged.

Mean Height (feet)				
Year	Treatment 1		Treatment 2	
	Lob height (age)	LL height (age)	Lob height (age)	LL height (age)
2013	1.85 *(1yr)*	—	—	—
2014	4.84 *(2yr)*	1.72 *(2yr)*	1.65 *(1yr)*	1.70 *(2yr)*
2015	—	—	4.66 *(2yr)*	—
2017	17.47 *(5yr)*	11.52 *(5yr)*	—	—
2018	—	—	16.9 *(5yr)*	15.89 *(6yr)*

Table 2. Mean height in feet for Treatment 1 and Treatment 2 longleaf and loblolly. Data was collected at age 1, age 2, and age 5 for loblolly seedlings in both treatments. Height data for the longleaf seedlings was collected at age 2, and age 5 in Treatment 1 and age 2 and age 6 in Treatment 2. Age at measurement is in parentheses.

At age 5 Treatment 1 loblolly's average diameter was 1.27 inches greater than the longleaf (3.38 inch DBH versus 2.11 inch DBH). The average diameter of the longleaf at age 6 in Treatment 2 was 0.27 inches greater than the loblolly at age 5 (2.98 inches versus 3.17 inches).

Mean Diameter (inches)			
Treatment 1		Treatment 2	
Longleaf *(age)*	Loblolly *(age)*	Longleaf (*age)*	Loblolly *(age)*
2.11 *(5yr)*	3.38 *(5 yr)*	3.17 *(6 yr)*	2.98 *(5 yr)*

Table 3. Mean diameter in inches for Treatment 1 and Treatment 2. Treatment 1 trees were measured when both were 5 years old. Trees in Treatment 2 were measured when the loblolly was 5 years and the longleaf was 6 years old. The longleaf diameter is greater than the loblolly but note that it one growing season older. Age at measurement is in parentheses.

The loblolly mean annual increment (MAI) was greater than the longleaf in both treatments . At age 5 the loblolly MAI for treatment 1 was 3.49, and longleaf MAI was 2.38 feet per year - a difference of 1.11 feet. In Treatment 2 (age 5 for the loblolly and age 6 for the longleaf) the MAI was 3.38 feet and 2.64 feet respectively – a difference of 0.74 feet.

We calculated the periodic annual increment (PAI) to compare growth after the longleaf initiated height growth. In Treatment 1 loblolly outperformed the longleaf by 2.43 feet (12.63 feet versus 10.20 feet) in the 3 year period from age 3 to age 5. Annual height growth averaged 4.21 feet per year and 3.40 feet per year for loblolly and longleaf respectively during that period. While the loblolly is still out growing the longleaf, the difference in growth rate from age 1 to age 5 compared to the growth rate from age 3 to age 5 has decreased (1.01 feet versus 0.81 feet).

The height growth of the loblolly seedling in Treatment 2 from age 3 to age 5 was 12.24 feet compared to 14.19 feet from age 3 to age 6 for the longleaf. The annual growth rate for the loblolly in Treatment 2 average 4.08 feet compared to 3.55 feet outperforming the longleaf by 0.53 feet per year.

		Total Height in feet (age)	Mean Annual Increment feet/year (MAI)	Periodic Height (ft) Growth (age)	Periodic Annual Increment feet/year (PAI)
Treatment 1	Loblolly	17.5 (5)	3.5	12.6 (3-5)	4.2
	Longleaf	11.9 (5)	2.4	10.2 (3-5)	3.4
Treatment 2	Loblolly	16.9 (5)	3.4	12.2 (3-5)	4.1
	Longleaf	15.9 (6)	2.7	14.2 (3-6)	3.6

Table 4. Total Height and Mean Annual Increment (MAI) for height at age 5 for loblolly and longleaf in Treatment 1, loblolly in Treatment 2 and at age 6 for longleaf in Treatment 2 shows a clear growth advantage for loblolly. However, if we compare periodic annual increment (PAI) in height growth for the period after longleaf initiates height growth we see the difference in annual growth between the species decreases in both Treatment 1 and Treatment 2. Age for MAI and the specific time period for PAI is shown in parenthesis.

Discussion

The loblolly and longleaf seedlings high survival reflects the high level of vegetative control provided by the site preparation prior to planting and the quality and vigor of the seedlings planted. The number of longleaf seedlings initiating height growth after two growing seasons is a positive indicator of its early and future growth potential on a medium quality site. It is especially important for longleaf to get off to good start to be competitive with loblolly.

The loblolly trees continue to out perform the longleaf trees in total average height, mean annual height, and mean annual diameter through age 5 when the two were planted in the same year. This is expected as loblolly is known for its fast juvenile growth. Longleaf is a slow starter largely due to a 2-3 year delay in height growth initiation after outplanting. However, when the loblolly was planted one year after the longleaf, we found that the longleaf diameter had exceeded the loblolly diameter while the loblolly height was only slightly greater.

When we examined longleaf's height growth rate for the growth period after the longleaf trees initiated height growth, we see a shift. During that period, the difference in annual growth rate between the two pines decreased. The accelerated growth, referred to as the rocket stage, was expected. It remains to be seen if that rate will continue and enable longleaf to keep pace with loblolly and not become significantly overtopped.

The one year delay in planting loblolly as a strategy to al-

low longleaf to keep pace seems to be working. The difference in height between the two pines is significantly less and diameter was better, reducing the likelihood that the longleaf will become overtopped and stagnate.

The next several years are critical for the planting systems success. We will continue our measurement schedule until loblolly component is harvested and we can ascertain if the residual longleaf responds and becomes a viable stand.

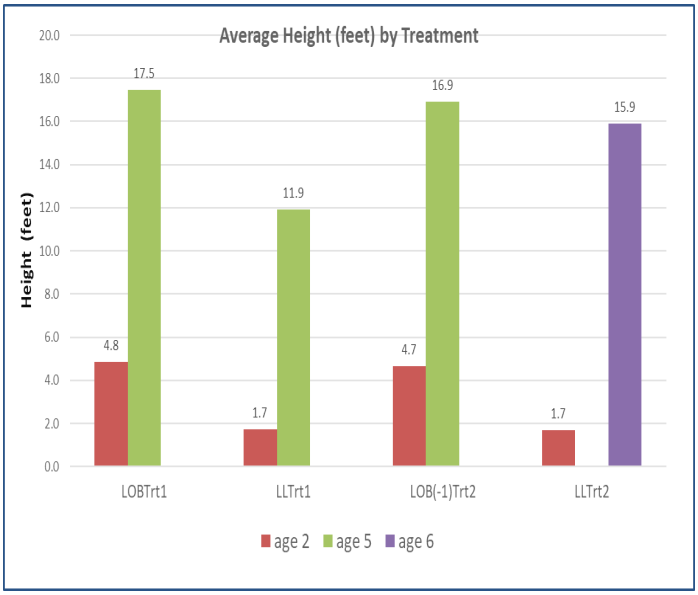

Figure 3. This chart shows the progression of height through age 5 for loblolly and longleaf for Treatment 1 and loblolly in Treatment 2, and through age 6 for longleaf in Treatment 2. It is interesting to note the height of longleaf at age 6 is about one foot less than the loblolly at age 5 suggesting similar growth rates once longleaf initiates height growth. PAI for the period after longleaf height growth begins for treatment 2 shows a similar growth rate for the two species (see Table 4.).