Loblolly Pine Productivity After Five Years Growing in Four Planting Configurations

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Abstract

A study was installed at three locations in the spring of 2012 to compare the growth and productivity of loblolly pine planted at varying densities in four planting configurations. A planting density of 436 trees per acre (tpa) on a 10 ft x 10 ft spacing was compared to three other configurations where alternating rows were planted at within-row densities intended to produce shorter-rotation (biofuel or pulpwood) vs longer-rotation (chip-n-saw or sawtimber) products. After five years, there are significant differences in fiber production among the four planting concepts. Compared to the 436 tpa planting, the three alternatives increased total inside-bark volume per acre by as much as 84 percent. If this pattern of growth continues, these planting options would enable landowners to consider removing the higher-density rows for biomass or pulpwood products in an early (age 10-16) thinning while leaving the lower-density rows for a subsequent harvest of solid-wood products.

Methods

Conditions involving supply and demand for wood fiber between 2005 and 2010 led many analysts to forecast shortages of wood for the biofuel market. There was concern that loblolly pine removals could exceed production in some areas of Virginia. One approach to address this scenario was examined in this study: by designing planting configurations to provide multiple products from the same acre of land, it could be possible to generate more total pine volume per acre and increase the availability of small-diameter trees for chip or pellet markets while still maintaining a portion of the stand for a more traditional pulpwood and/or sawtimber product mix.

To examine the potential growth responses of several alternative planting designs, a study was planted in the spring of 2012 on three state forests: Appomattox-Buckingham, Cumberland and Dragon Run. At each location, four plots were installed to compare four planting configurations (Figure 1):

1. 436 trees per acre (tpa) planted on a square 10-foot by 10-foot spacing ("traditional" configuration);
2. 720 tpa planted in rows spaced 10 feet apart and alternating between rows with 10-foot ("sawtimber") and four-foot ("biomass") within-row spacings ("biomass*1" configuration);

3. 1,300 tpa planted with one "sawtimber" row alternating with two "biomass" rows ("biomass*2" configuration), and
4. 1,240 tpa planted with three alternating rows spaced nine-feet apart – one at a nine-foot "sawtimber" spacing, one at a three-foot "biomass" spacing and one at a six-foot within row "pulpwood" spacing ("3-product" configuration).

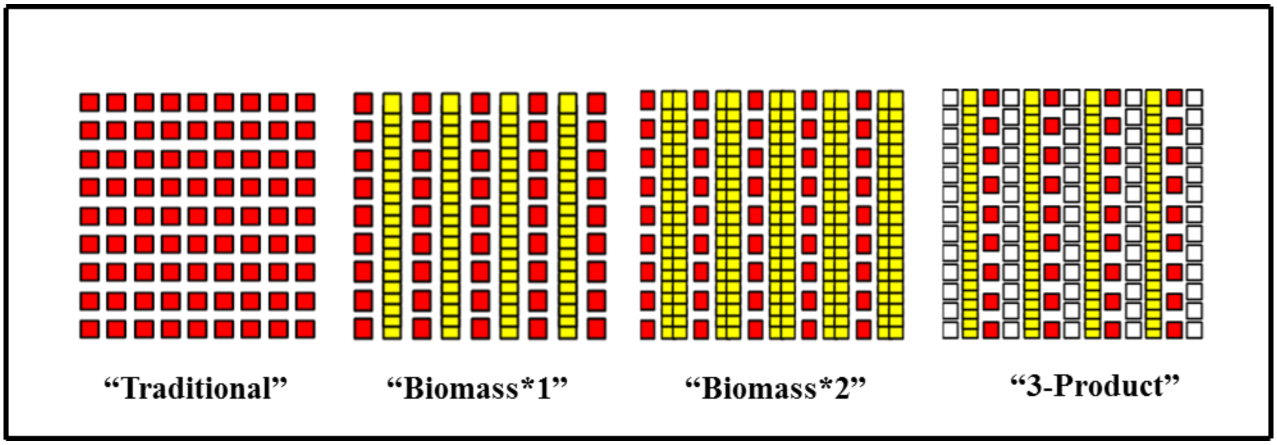

Figure 1: Planting configurations tested in the 2012 study. Red = "sawtimber" rows, yellow="biomass" rows and white = "pulpwood" rows.

To address concerns about increasing seedling costs when planting densities nearly triple (as under some of these designs), the "sawtimber," "pulpwood" and "biomass" seedlings were planted with the VDOF Nursery's Virginia's Best, Premium and Orchard Mix genetic offerings from the 2012 catalog, respectively. By planting so that seedling density is inversely related to price (i.e. using the cheapest seedlings for the highest density rows), seedling cost can be reduced.

Hardwood competition was controlled on all plots at all locations with both operational aerial herbicide applications and follow-up backpack applications. Pine survival, height and diameter breast height (dbh) have been measured annually since planting. From those data, basal area and total tree volume (inside bark from stump to tip, using equations developed by the Forest Modeling Cooperative for unthinned stands) were calculated – also annually. Means were compared using two-way analysis of variance for a randomized complete block experimental design with three replications (locations) and four treatments (planting configurations).

The plots will be re-measured annually to monitor trends in productivity and growth. When the data indicate that growth rates have diminished in the biomass and pulpwood trees, those rows will be removed. We estimate that those thinning activities will occur around age 10-12 and 14-16 in the biomass and pulpwood rows, respectively.

Results

After five growing seasons, average tree DBH varies significantly among planting configurations (probability of greater F statistic of 0.062 – meaning there is only a 6.2 percent chance the differences occurred by random chance). There are no statistically-significant differences in average survival or individual tree height. The trends in the data follow logical patterns (Table 1). Trees of the better genetics and at the wider row spacing ("sawtimber") are larger individually than the lower rated and more densely planted trees ("pulpwood" or "biomass"). Averaged across planting configurations, the DBHs of sawtimber, pulpwood and biomass seedlings are 3.3, 2.7 and 2.5 inches; heights are 16.5, 15.7 and 15.4 feet, and the individual tree volume indices are 1.3, 0.9 and 0.7 cubic feet, respectively, after five growing seasons.

Figures 1-3 show the trends in tree volume over the first five years of the trial averaged for each of the three alternative configurations (the "traditional" plot means are plotted on each graph for reference). Individually, tree sizes consistently rank "sawtimber" > "pulpwood" > "biomass." On the 3-product plots, the "sawtimber" trees are slightly smaller, probably because the within- and between-row spacing on those plots is nine feet instead of the 10 (as on the other three plots).

The differences in total pine volume production among the different planting designs (Figure 4) *are* statistically significant (probability of greater F statistic of 0.021). This is not surprising since numerous studies in the past have documented that total stand production increases with increasing planting density, although growth rate diminishes earlier at higher densities due to intraspecific competition. Each of the biomass plots contains the same amount of "sawtimber" volume – so through five years, at least, the added biomass*2 configuration has doubled the production of small-diameter trees without sacrificing the larger-diameter production.

Table 1. Individual tree and stand level metrics for loblolly pine five growing seasons after establishment under four alternative planting configurations.

Planting Configuration	Product Objective	Survival	Height (ft)	DBH (in)	Basal Area (ft^2/ac)	Percent BA Gain	Volume (ft^3/ac)	Percent Volume Gain
Traditional	Sawtimber Only	94%	16.5	3.3	26.3		158	
Biomass*1	Combined Average	92%	15.6	2.9	31.3	19%	177	12%
	Sawtimber	94%	16.4	3.3	14.3		85	
	Biomass	91%	15.1	2.6	17.1		92	
Biomass *2	Combined Average	91%	16.1	2.7	50.2	91%	291	84%
	Sawtimber	93%	16.9	3.4	13.9		86	
	Biomass	90%	15.9	2.6	36.2		205	
3-Product	Combined Average	94%	15.5	2.6	39.9	52%	253	61%
	Sawtimber	98%	16.3	3.1	9.6		68	
	Pulpwood	91%	15.7	2.7	15.2		84	
	Biomass	94%	15.1	2.4	15.1		101	

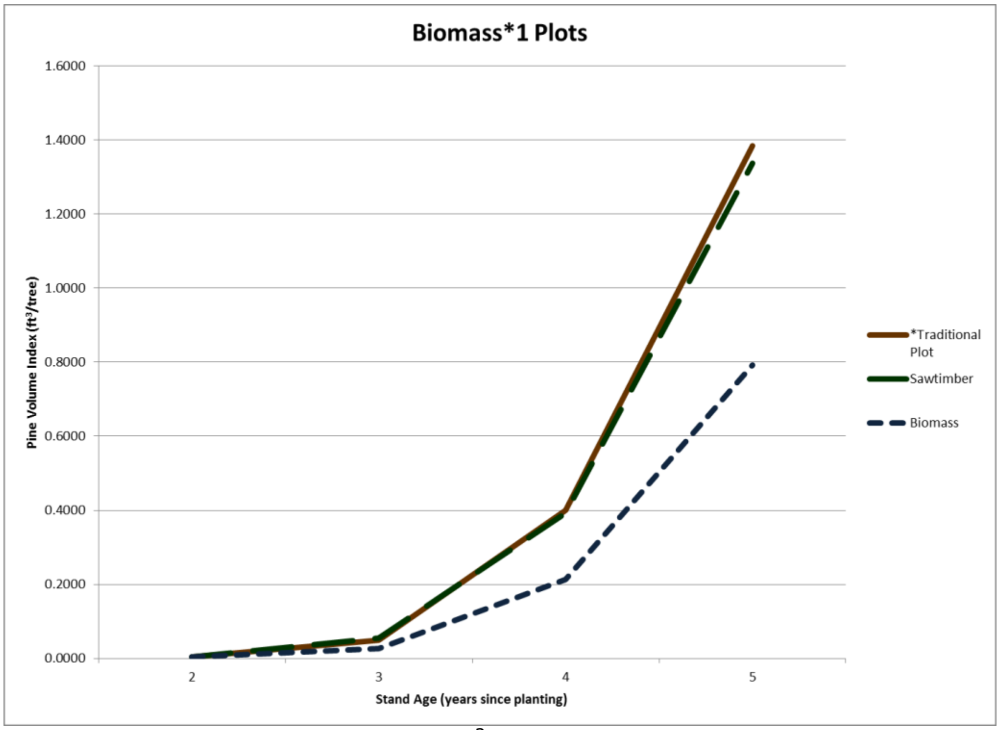

Figure 1: Average total volume inside bark (ft^3/tree) through five growing seasons in plots with 720 tpa planted with alternating of "sawtimber" and "biomass" rows. Growth of trees in a plot with only "sawtimber" trees planted at 436 tpa is shown for reference.

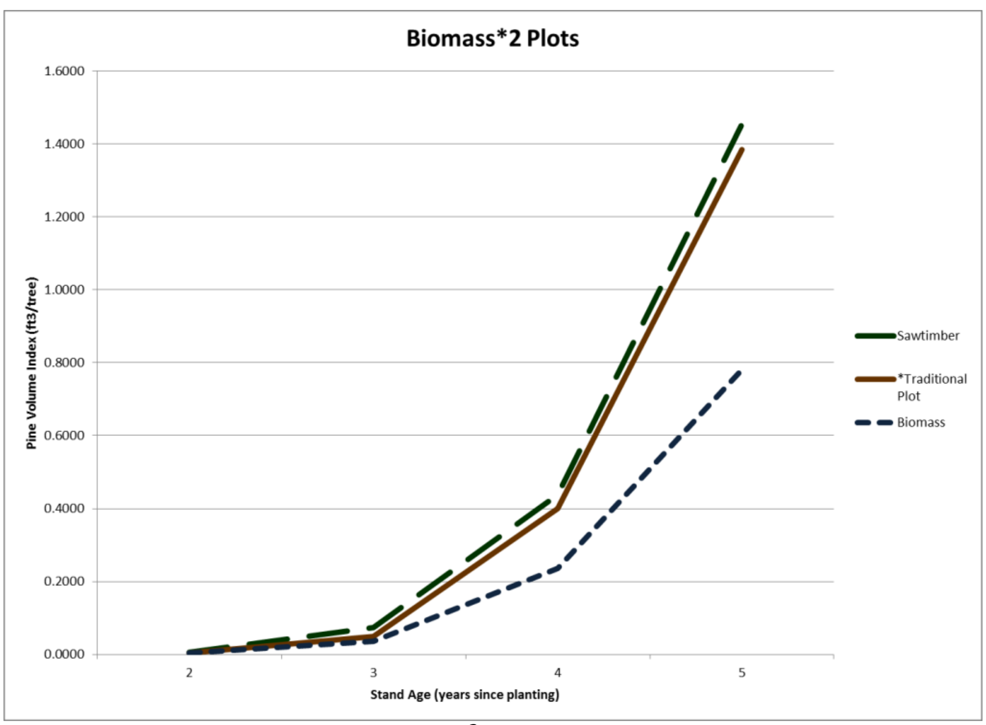

Figure 2: Average total volume inside bark (ft^3/tree) through five growing seasons in plots with 1,300 tpa planted with one "sawtimber" row alternating with two "biomass" rows. Growth of trees in a plot with only "sawtimber" trees planted at 436 tpa is shown for reference.

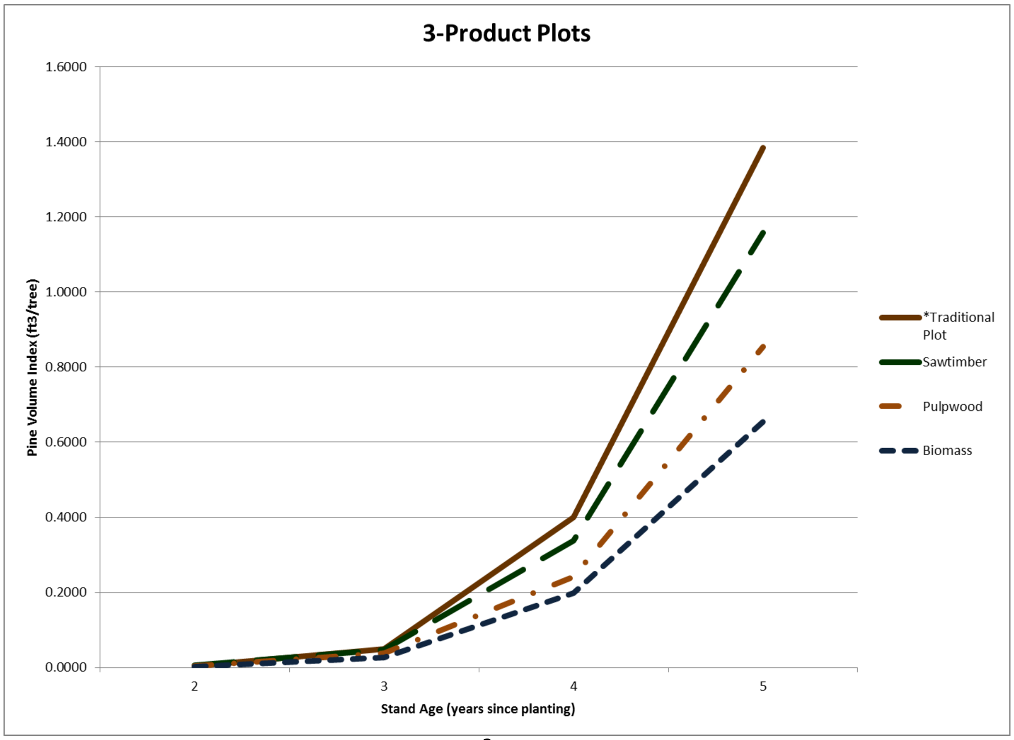

Figure 3: Average total volume inside bark (ft^3/tree) through five growing seasons in plots with 1,240 tpa planted with three alternating rows – one "sawtimber," one "biomass" and one "pulpwood." Growth of trees in a plot with only "sawtimber" trees planted at 436 tpa is shown for reference.

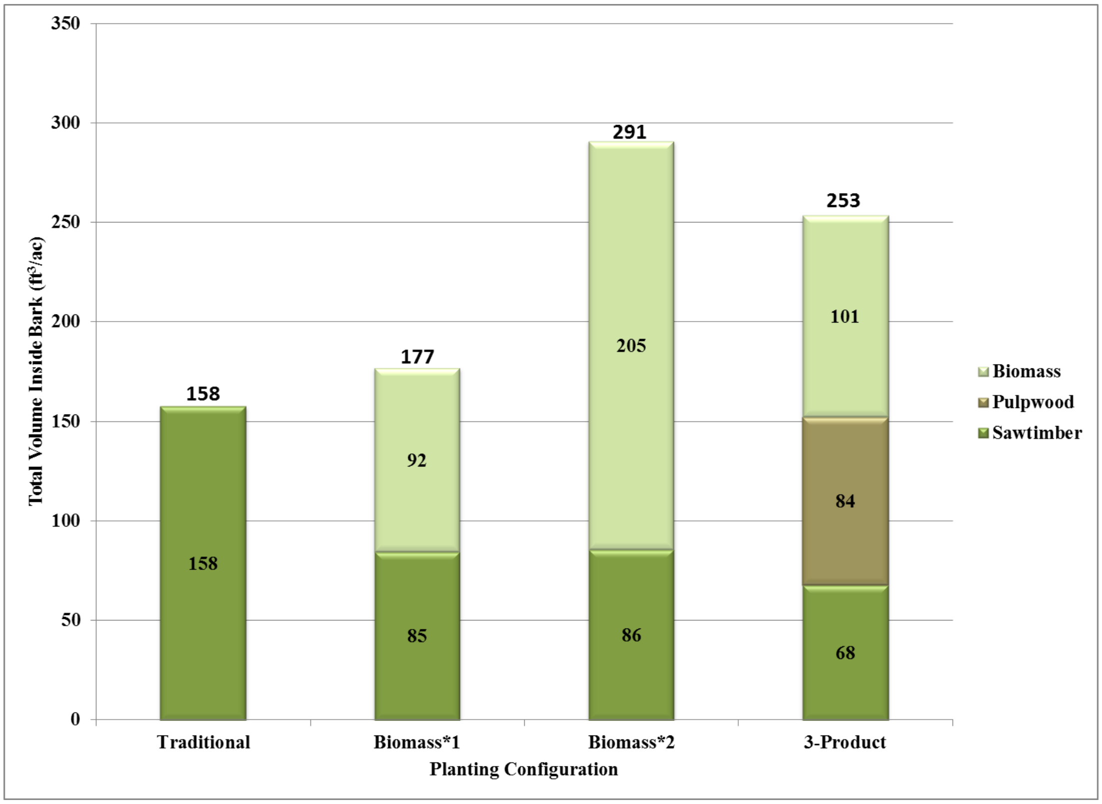

Figure 4: Total volume inside bark (ft^3/ac, stump to tip) after five growing seasons in plots planted with four planting configurations.

Discussion

The early productivity gains documented in these plots are encouraging; adding biomass or pulpwood rows to the stands has increased volume production by 12 percent to 84 percent. In particular, the "biomass*1" and "biomass*2" plots suggest that we can double the amount of "biomass" production without sacrificing the growth of the "sawtimber" trees. These early data suggest that we can grow specific seedlings for different product classes and target rotation lengths in a mixed stand at significantly higher stand density than currently used.

The value of changing planting designs to increase per-acre volume production and provide multiple products from pre-determined rows depends on market conditions and growth:drain ratios. If the demand for pine fiber (particularly small-diameter biofuel material) is relatively low and the current stands are growing adequate volume to exceed harvest, there is less motivation to make these changes. While it is feasible to plant seedlings in rows with varying configurations, doing so would entail added costs of seedlings and planting and require added attention to thinning logistics and timing.