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Bedding Effects in Maturing Slash Pine Stands

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*ABSTRACT. Growth of randomly selected dominant slash pine (*Pinus elliottii *Engelm. var.* elliottii*) trees from a 35-year-old plantation on beds and an adjacent 45-year-old unbedded plantation was examined through stem analysis. Height-over-age curves constructed from these analyses indicated that trees on the beds were consistently taller at comparable ages through 35 years. The difference was greatest, 10.8 feet, at age 17 and decreased to 5.7 feet at age 35. These observations, while not conclusive, indicate that the growth advantage provided by bedding may decline as slash pines mature.*

Planted pines usually grow slowly on poorly drained sites, and early growth is often improved by constructing raised planting beds with a ridging harrow (Derr and Mann 1977, Haines and Pritchett 1964, Lennartz and McMinn 1973). Thousands of acres of poorly drained sites are being bedded and planted each year, on the assumption that the demonstrated growth advantages of the early years will be maintained or increased throughout a rotation of 25 or more years. Actual height advantages on bedded sites at such ages are not known, however, because few sites were bedded prior to 1960.

In northwest Florida is a slash pine stand that was planted on a bedded area in 1940. Immediately adjacent to it is an unbedded area that was planted to slash pine in 1930. Through stem analyses of sample dominant pines, we compared the height growth of these adjacent stands through 35 years after planting. The comparisons cannot be statistically analyzed, and the effect of bedding upon height growth might be confounded by differences in site, year of planting, and planting stock. Considering the dearth of information on the effect of bedding throughout a rotation, however, this report on the history and growth of these stands is justified.

SITE PREPARATION AND PLANTING

The stands were planted by the Florida Forest Service (which has been renamed the Florida Division of Forestry) in Liberty County, Florida, on a property known as the Coline Plantation. That property is now a part of the Apalachicola National Forest.

In January 1930, slash pines were planted at 8- by 8-foot spacing in two 3-acre plots separated by 500 feet in a north-south direction. The west side of both plots has been bounded by a 2-foot-deep road ditch since before planting. A few months after planting, several interconnecting, 1½-foot deep ditches were dug: one bisected both plots; the others were in or near the south plot (Figure 1).

In 1936, a 38-acre area adjacent to the two 1930 plantings was burned and then bedded on 10-foot centers with a road grader. The original height of

these raised planting beds is unknown, but by 1975 their centers had settled or eroded to heights of 8 to 12 inches above the furrow bottoms between beds. This area (Figure 1) was planted to slash pine at 4- by 10-foot spacing in December 1936. Survival was unacceptable, and the area was replanted in January 1940. All of our sample trees were from the 1940 replanting.

We considered the south 1930 planting to be an unbedded-drained plot and the north 1930 planting to be an unbedded-undrained plot. We chose an area immediately to the east of the latter plot for our bedded plot (Figure 1).

SITE

The study area is on a nearly flat Coastal Plain site. In 1975, the three plots supported similar sparse understories of scattered shrubs and herbs beneath their pine overstories. The soil is Plummer sand, a poorly drained member of the siliceous, thermic Grossarenic Palaquults. Soil borings made in April 1975 near the pines selected for stem analyses all revealed about 8 inches of dark gray sandy topsoil grading into a gray sandy layer. A sandy clay loam horizon began 4½ to 5½ feet below the surface. The water table was at, or within a few inches of, the soil surface at all boring positions. Thus, we observed no differences among the three plots that might influence pine growth. Such differences, however, may exist.

YEAR OF PLANTING

Trees planted in 1930 may have grown at different rates than trees planted in 1940, because of differences in weather conditions or in other environmental factors which fluctuate with time. Precipitation records of weather stations near the study area show that both plantings were subjected to periods of both above and below normal precipitation during their first several years after planting. It seems fruitless, however, to speculate upon the effects that various interactions of stand age, rainfall amounts, bedding, drainage, *etc.* might have had upon 35 years of pine height growth. The assumption is that height differences due to fluctuating environmental factors tend to even out over the length of a rotation.

PLANTING STOCK

Old planting records of the Florida Forest Service indicated that the one-year-old nursery seedlings planted on the study area were all raised in northeastern Florida from seed collected in that area. The stock planted in 1930 was raised on a

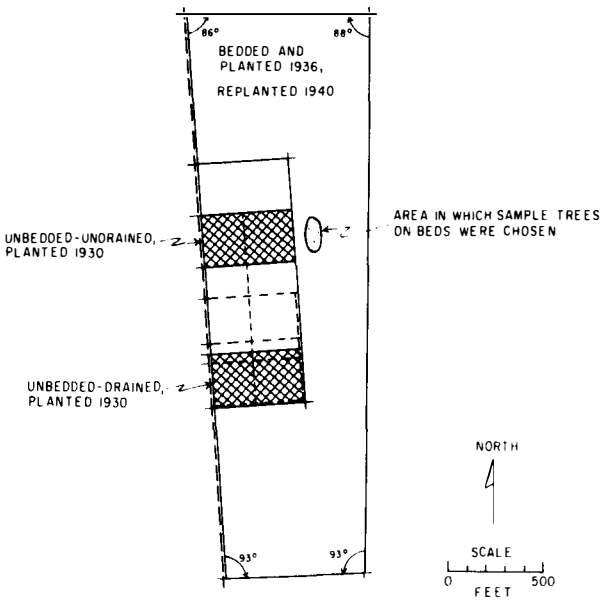

Figure 1. Location of the bedded plot and the two unbedded plots.

state farm in Union County from seed collected in or near Bradford or Columbia Counties. The 1940 stock was raised in a Florida Forest Service nursery in Baker County from seed collected in or near Columbia County.

Since seed source can strongly influence growth, oleoresin analysis was used to verify that the sources were not widely separated.[1] Such analysis is meaningful because of two peculiarities of the oleoresin of slash pine:

(1) The proportions of various monoterpenes in slash pine oleoresin show distinctive patterns over the natural range of the species (Gansel and Squillace 1976).

(2) Slash pines planted far distant from their seed sources have almost the same proportions of various monoterpenes in the oleoresin of their vegetative buds as do their parents (Squillace 1971).

In April 1975, oleoresin samples were drawn from the vegetative buds of 30 trees in each of our three study plots. Some of the buds were collected from the trees felled for stem analyses; the remainder were collected by shooting limbs from standing trees with a rifle. Analyses of the oleoresin from these 90 trees confirmed that the seed sources for all three plots were somewhere within a several-county area of northeastern Florida.

[1] We thank Anthony E. Squillace for analysis and interpretation of the oleoresin data. Squillace, now retired, was chief plant geneticist with the Southeastern Forest Experiment Station when this study was conducted.

STEM ANALYSIS

In April 1975, 45 years after planting of the unbedded plots and 35 years after replanting of the bedded plots, tree growth was compared by stem analysis. Since stocking varied among plots, only height growth was examined.

Five dominant trees from the drained plot, eight dominants from the undrained plot, and five dominants from the bedded plot were felled for stem analyses. Disks about 1-inch thick were sawn from the 18 felled trees at 5-foot intervals on the lower part of the stems and at 2-foot intervals on the upper part of the stems. The disks were identified as to tree and stem position and then carried to the laboratory where they were oven dried at 70°C for two days. The upper surface of each disk was then sanded to facilitate counting of the annual rings. The number of rings on each disk was subtracted from total age to give the age of the tree when its top was at or near the height from which the disk was cut. These heights were plotted over corresponding ages to represent the height growth pattern for each tree. This procedure provided estimates of total tree height through age 35 years for the bedded plot, and 45 years for the unbedded area.

To compute the average height growth pattern on each plot, the data were fitted to a regression model developed by Richards (1959):

$$\text{Height} = A\,[1 - e^{-k(\text{age})}]\,\frac{1}{1 - m}$$

where e is the base of natural logarithms and A, k, and m are coefficients calculated for each plot (Figure 2). These equations accounted for 99, 97, and 91 percent of the height variation for bedded, drained, and undrained treatments, respectively.

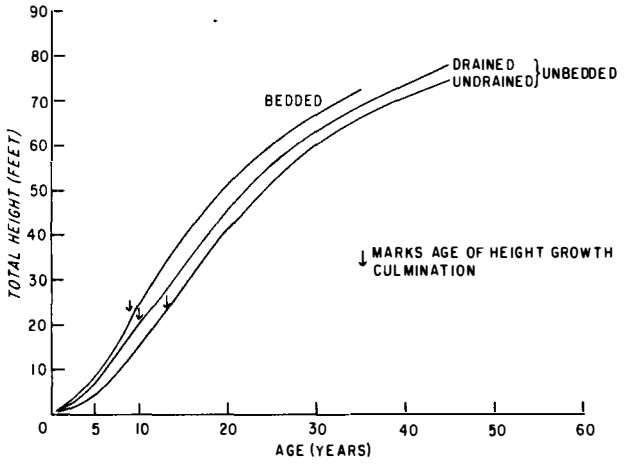

Figure 2. Average heights of dominant slash pines on plots.

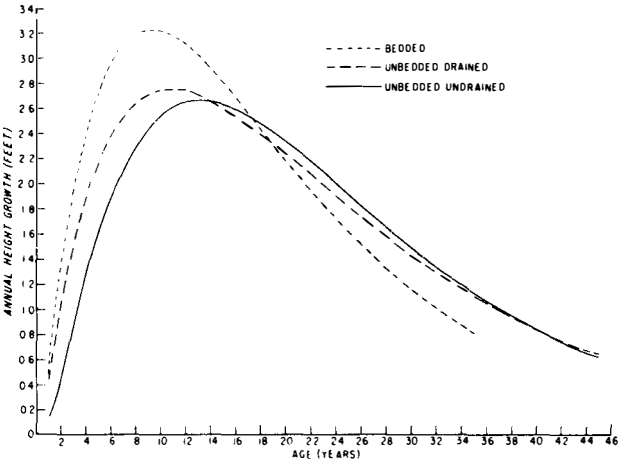

Figure 3. Current annual height increment, by age, calculated from the height equation for each site treatment.

Current annual height increment was then calculated for each plot as the difference between the computed average heights for successive years (Figure 3).

BEDDING EFFECTS

Trees on the bedded plot had greater average heights than those on unbedded plots over the 35 years for which data can be compared, but the advantage of bedding diminished after age 17 (Figure 2). In comparison with unbedded-undrained trees, bedded trees averaged 10.8 feet taller at age 17, but only 5.7 feet taller at age 35. If the height growth trends continue on these two plots, the bedded trees will average less than 2 feet taller than the unbedded by age 50.

Perhaps it is easiest to see what is happening by examining current annual height growth shown in Figure 3. From age 2 through age 15, growth on the bedded plot was well above that on the unbedded. Such increases in early growth have been reported elsewhere (Derr and Mann 1977, Haines and Prichett 1964). By age 18, however, annual growth on the bedded plot fell below that on the unbedded plot, and it continued to decline until it was 0.34 foot less than that on the unbedded plot at age 35.

This decrease in height advantage from bedding is disquieting. The large advantages of bedding which have been reported early in rotations may not translate into taller trees at the end of a long rotation. Lennartz and McMinn (1973) found that on some of their south Florida study sites, height advantages of slash pines on beds began disappearing between the fifth and tenth years after planting.

Fertilizer was not applied when the Coline Plantation was planted, and soil nutrients were not measured as a part of this study. However, research in younger slash pine stands suggests that phosphorus fertilization may be substituted for bedding on wet sites. Mann and McGilvray (1974) found that slash pine height growth through age 8 on plots fertilized with phosphorus was about equal to height growth on plots prepared by bedding, and that bedding and phosphorus fertilization together increased height growth even more. It remains to be seen what phosphorus fertilization benefits will be up to age 35. Meanwhile, forest managers should be aware that phosphorus fertilization may be a substitute for bedding on wet sites.

IMPROVED DRAINAGE

Ditches were dug in the south plot in 1930 to determine whether better drainage would enhance pine growth. The ditches were not maintained, and the drainage system was damaged by several thinning operations. Thus, in April 1975 the ditched plot had standing surface water and appeared to be more poorly drained than the unditched plot a few hundred feet to the north. Some useful observations can be made about the effects of improved drainage early in the stand's life, when the drainage system was probably operating as designed.

Total height on the ditched plot averaged consistently higher than on the undrained plot through age 45 (Figure 2). The maximum advantage, 4.7 feet in height, was at age 14. Thereafter, height growth was as fast or faster on the undrained as on the drained plot (Figure 3). It may well be, however, that the drainage system began to break down at about that time. A more thorough study in a nearby natural slash pine stand revealed significant improvements in height growth for at least three years after drainage improvement at age 19 (Klawitter 1966).

CONCLUSIONS

Results of our study are by no means conclusive for the reasons already mentioned. We report these data primarily because they are the best available at this time, and because their implications seem so important. For years, foresters and forest researchers have speculated on whether the marked early advantages of bedding continue throughout a slash pine rotation. Results presented here indicate that the advantage may decline as a stand matures.

It may be many years before these highly speculative results can be confirmed in long-term controlled studies. In the meantime, it may be best to assume that the early differences in growth between bedded and unbedded planting sites do not continue to increase as a slash pine plantation matures.

We should point out that declines in growth starting at about age 20 may not be very significant if earlier heights are increased several feet by bedding and if a short pulpwood rotation—25 years or less—is envisioned. We should also emphasize that our results are applicable to *poorly* drained sites upon which reasonably rapid pine growth can be anticipated without bedding, and not to the *very poorly* drained sites of northwest Florida that, without bedding, support "hat rack" slash pines. Here, extremely slow growing slash pines with closely spaced branch whorls and needles tufted at the ends of branches resemble hat racks. Bedding such sites usually so enhances growth that pulpwood production becomes possible, leaving little doubt that bedding is profitable. Our results are applicable where reasonably rapid pine growth can be anticipated without bedding, and the forest manager must decide whether or not to bed and whether or not to plan for a short pulpwood rotation or for a longer rotation for larger products.

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