# MOVEMENT OF SHORTLEAF PINE SEED ORCHARDS SOUTH MAY GREATLY INCREASE FLOWERING

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Abstract.--Male and female strobilus production by shortleaf clones of Tennessee-North Carolina origin was evaluated in a North Carolina seed orchard and in a south Mississippi clone bank. Performance of shortleaf clones of Arkansas-Oklahoma origin in an Arkansas seed orchard and in the same south Mississippi clone bank was likewise compared. In both cases the southern location produced five times as many male and female strobili as did the seed orchards located near the origin of the clones even though the clone bank was not managed for seed production. Establishing shortleaf seed orchards south of their origin may be a practical method for increasing seed yields.

Additional keywords: Pinus echinata, strobilus, growth, geographic effects.

## INTRODUCTION

Many southern pine seed orchards are located in places too hilly for efficient operation of motorized equipment, on seriously deficient sites, or in areas that have unsuitable climates. Deciding where to establish seed orchards in the future is important, and among the elements to consider is geographic location.

Although copious published results of actual experiments are lacking, there seems to be a consensus that moving trees to a warmer climate will probably be desirable (Werner 1975). Recently it has been found that moving seedling slash pine (Pinus elliottii Engelm.) south of their natural range can enhance precocious flowering (Gansel 1973). In northern Europe, establishing seed orchards south of their original source is a recommended practice (Sarvas 1970).

This paper reports results of an experiment that tested the effects that southward movement had on the flowering of grafted shortleaf pines (Pinus echinata Mill.).

## MATERIALS AND METHODS

In 1967 and 1968 the National Forest, Southern Region Tree Improvement Program provided surplus shortleaf grafts from the Ouachita (central Arkansas), Beech Creek (western North Carolina), and the Erambert (south Mississippi) Seed Orchards for establishment in a clone bank on the Harrison Experimental Forest in south Mississippi (fig. 1). In 1976, those clones in the

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bank having three or more ramets were paired for measurements with a similar number of ramets of the same clones of equivalent age in the orchards of their origin. Since the clone bank was established using surplus orchard grafts, ramets in the clone bank are identical to ramets in the orchards of their origin with respect to clone, rootstock, grafting technique, scion condition, and early handling.

The clone bank differs from the orchards in two ways. Spacing is 15 x 25 feet in the clone bank, compared with 15 x 30 feet in all the orchards. Since the original purpose of the clone bank was preserving a germ plasm it has not been managed for seed production as the orchards have. Thus, the orchards have been fertilized and had pesticides applied to control insects, but the clone bank has not.

In the spring of 1976, male and female strobili were counted on all ramets. At this time height and d.b.h. were measured on three or four ramets of each clone except those from the Mississippi source which were measured in the fall of 1976. A bulk sample of cones was collected from the clone bank to measure seed yield. In the Arkansas versus Mississippi comparison there were three seed sources with a total of 31 clones; in the North Carolina versus Mississippi comparison, two seed sources with 18 clones; and in the Mississippi versus Mississippi comparison, three seed sources with eight clones (Erambert Seed Orchard versus the clone bank). The last comparison is for inferring site effects only, since 27 miles separated the two plantings (fig. 1). Table 1 summarizes location and establishment details. Although a total of four planting locations are reported here, direct comparison among the three seed orchards is not possible since different seed sources and different clones are used in each case. Each of the orchards can only be compared directly to the clone bank location, though indirect comparisons are possible.

Table 1.--Establishment data for each orchard/clone bank comparison

| Orchard location | Age of ramets | Clones | Total ramets | North-South distance to clone bank |
|---|---|---|---|---|
| | Yrs. | no. | no. | km. | °lat. |
| N. Carolina | 8 | 18 | 136 | 480 | 4.5 |
| Arkansas | 9 | 31 | 226 | 380 | 4.0 |
| Mississippi | 9 | 8 | 68 | 44 | 0.4 |

For all pairs of comparisons, the statistical model is:

$$Yijkm = Li + Sj + Cjk + Rjkm + LSij + LCijk$$

where Y is the measured response, L is the location effect, S is the source (provenance) effect, C is clone within source, and R is ramet within clone. Clone and ramet are considered random effects; all others, fixed.

All count data were transformed using $\sqrt{count + 1}$ . Least squares analysis of variance was used for estimating mean squares of treatment effects.

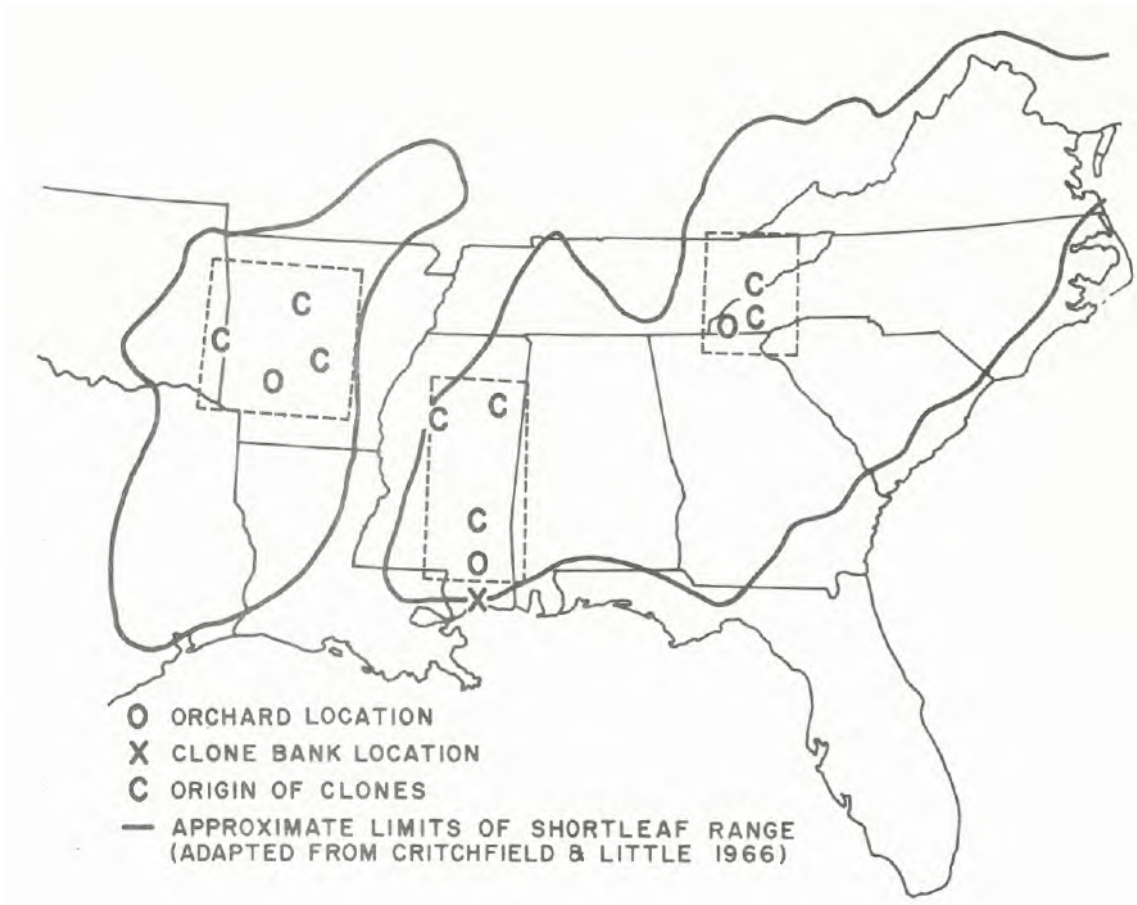


Figure 1.--Location of clone bank, seed orchards, and origin of shortleaf clones.

## RESULTS AND DISCUSSION

In both the North Carolina versus Mississippi and the Arkansas versus Mississippi comparisons, female strobili were much more numerous at the clone bank location than at the orchards (fig. 2). In both cases, approximately a fivefold increase was induced by moving the grafts south. The abundance of male strobili is similarly affected (fig. 3); they were about five times more abundant in the clone bank than at the orchards near their origins.

In the statistical analysis, the pattern of significance is similar for male and female flowering for both geographic comparisons. Location and clone effects and their interaction are always significant; geographic source of the clones and its interactions with other effects are not. The interaction was primarily one of ranking, that is, most clones flowered better at the southern location, but the response varied by clone. In some cases, there were fewer strobili in the southern location. Four of the total of 49 clones had fewer female flowers and two had fewer male flowers in the clone bank. The differences were very small, however, and statistically significant in only one instance.

In both comparisons the trees in the clone bank were slightly larger

though probably not enough to explain the differences in flowering. Ramets in the Arkansas orchard trees averaged about 12 feet versus 13 feet tall for the same clones in the clone bank; the North Carolina ramets averaged 11.6 feet versus 12.2 feet for their southern counterparts. Differences in d.b.h. were less striking, and the trees from the central Arkansas source averaged slightly less in d.b.h. at the clone bank than at the orchard.

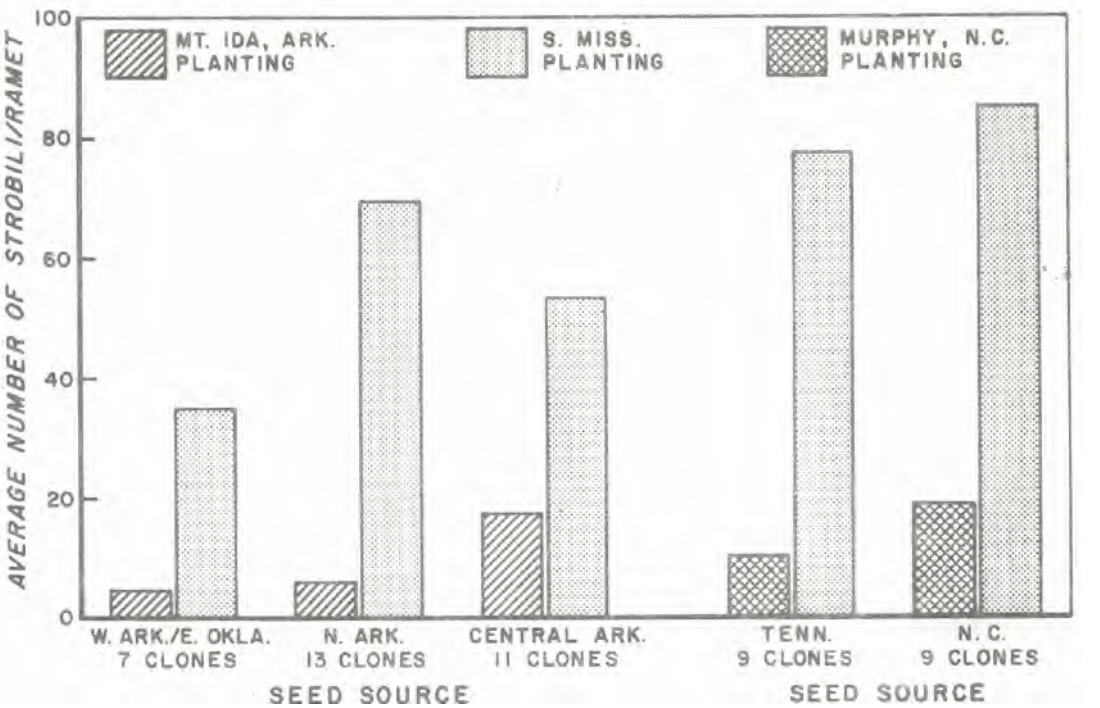


Figure 2.--Female strobili on shortleaf grafts planted near their origin compared with grafts of the same clone planted in a southern location.

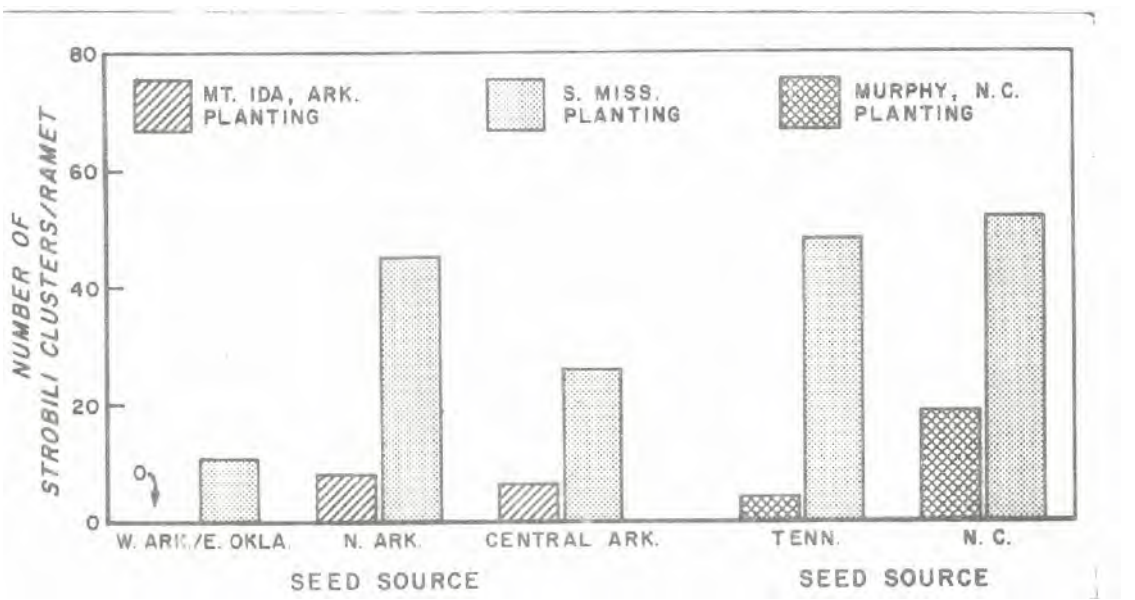


Figure 3.--Male strobili on shortleaf grafts planted near their origin compared with grafts of the same clones planted in a southern location.

Since there are only two locations in each comparison, geographic effects are confounded with site and management differences. There is one comparison, not previously discussed, which illustrates the importance of these differences. Flowering was much better in the clone bank planting than at the northern locations, but the shortleaf pines at the Erambert Seed Orchard, located just 27 miles north, outperformed those in the clone bank. The clones from Mississippi had about six times as many female flowers and about five times as many male flowers at the seed orchard as in the clone bank (fig. 4). Since the sites are otherwise very similar, this difference undoubtedly reflects the difference in management, specifically the fertilization and insect control regimen applied in the orchard. The ramets at the Erambert Seed Orchard are not significantly taller (20.3 feet versus 19.6 feet) but are considerably larger in d.b.h. (4.7 inches versus 3.5 inches) than those in the clone bank.

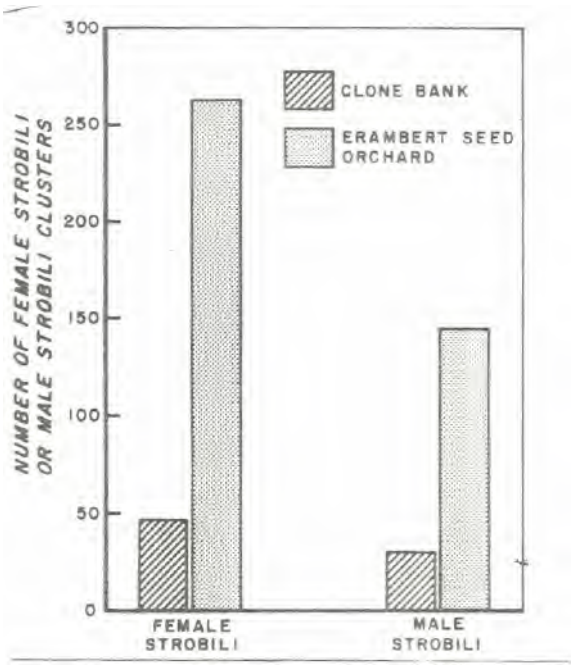


Figure 4.--Flowering in the clone bank compared with the Erambert Seed Orchard.

It is tempting to extrapolate a southern versus northern orchard comparison from our orchard versus clone bank comparisons. The Mississippi and the Arkansas clones are the same age and had approximately equivalent numbers of female flowers in the clone bank (the planting design permits this comparison). The Arkansas clones had five times as many female strobili in the clone bank as in the Arkansas orchard, and the Mississippi clones had six times as many female strobili in the Mississippi orchard as in the clone bank. Thus, one might expect 5 x 6 = 30 times as many female strobili if Arkansas clones were planted in the south Mississippi orchard. While this extrapolation has obvious flaws, site effects would bias the results in the opposite direction from that observed.

The cones collected in the clone bank yielded only an average of 11.6 seeds per cone, of which only 2.5 were filled. A sample taken at the orchard in North Carolina showed approximately 40 sound seeds per cone where insecticide was used, but only three or four per cone where no insecticide was used.2

The later figures are comparable to those from the clone bank, as are the probable conditions that precipitated the low yield--the lack of protection from seed and cone insects. In a shortleaf provenance test located about a mile from the clone bank, seed yields were good in controlled crosses involving a wider sampling of the shortleaf range than reported here

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[2] Ed Manchester, Manager, Beech Creek Seed orchard, Murphy, N.C. personal communication.

(unpublished data). In another study conducted in this planting, differences in reproductive phenology were so small that none of the sources were reproductively isolated from each other or the local source (Schmidtling 1971).

## CONCLUSION

This study appears to lend support to earlier suggestions that southward movement will increase seed orchard productivity. The results reported here are clearcut, but are based on only one year's flowering data and inconclusive seed yield information. Site effects, primarily those related to management, appear to be important. The clone bank will be fertilized to correct this for future work. More importantly, because flower crops vary greatly in a given year from location to location because of variation in local weather conditions, several years' data will be necessary to draw firm conclusions. Nevertheless, I do not anticipate problems involving seed yield arising as a result of movement of shortleaf to the southern edge of its range. A comprehensive survey of southern seed orchard yields is being conducted now by a subcommittee of the Southern Forest Tree Improvement Committee. The survey's results can be used in planning the location of definitive experimental plantings to determine where future orchards should be located.

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