Interplanting is futile in slash pine plantations

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In old fields where slash pines were originally planted at a 15-by 15 foot spacing and interplanted between each row after 1 year, merchantable volume of the original planting at age 25 was 28.9 cords while interplants contained only 2.6 cords. Ninety-nine percent of the original plants were of merchantable size compared to 59 percent for interplants. Alternatives to interplanting are to eradicate the existing stand and replant, or accept the reduced stocking.

Although interplanting is not common, it has been tried by some landowners to increase the stocking in slash pine *(Pinus elliottii* Engelm. var. *elliottii)* plantations. Poor survival in the original planting or a change in objectives may lead to the conclusion that a plantation is understocked. Interplanting was accepted under the USDA's Agricultural Conservation Program. and the current Rural Environmental Assistance Program allows cost-sharing for adding trees to bring stocking up to 500 trees per acre (7).

Growth in several old-field plantations on the Holt Walton Experimental Forest' shows conclusively the futility of interplanting slash pines. Interplanting, in this article, means adding rows of trees in a well distributed, though perhaps sparse, stand planted earlier; it does not include the filling of large voids caused by mortality.

Study Plantations

In 1945, nine abandoned agricultural fields in Dooly County, Ga. were planted with slash pine seedlings at spacings of 15 by 15 and 12 by 12 feet. Seedlings were handplanted and distance between rows varied from 9 feet to more than 17 feet. The management objective at the time was to produce naval stores. This objective was subsequently changed to include pulpwood production, and in 1946 an additional row of trees was interplanted in one direction between each of the original rows. Resulting spacings were approximately 6 by 12 feet and 7% by 15 feet (605 and 387 trees per acre). In addition to interplanting rows, (lead or missing trees from the original planting were replaced. In this article, however, comparisons are made only between rows of original and interplanted trees. Replacement of dead seedlings in the original planting made it impossible to determine first-year survival of the original planting. Some wild trees were present. They were tallied as a component of the plantations but they had little, if any., effect on the growth of the planted trees.

In 1954, when interplanted trees were 8 years old, they were smaller than the original plants by 2.0 to 2.5 inches in diameter and 8.5 feet in height. These and later growth differences were reported by Bennett (l, 2) and Schultz (6).

Of the nine interplanted areas, two of the 15- by 15-foot plantations (C and H), containing a total of 21 acres, were remeasured in 1970 when the trees were 25 and 26 years old. Both plantations have similar soils-combinations of Lakeland loamy sand and Cuthbert sandy loam-with 25-year site index of about 66 feet for slash pine. Both areas had been cultivated for watermelons and cotton before being planted to trees. Original and interplanted seedlings came from the State tree nursery at Albany, Ga. The only thinning has been a very light salvage cut after an ice storm in 1964. when interplants were 18 years old.

Independent measurements were made in each plantation. Breast-high diameters of all trees were measured with tree calipers: originals, interplants, and wilds. Total heights of approximately 1/35th of the trees in each diameter class were measured with a Blume-Leiss altimeter. Heights

1The Holt Walton Experimental Forest. near Cordele. Ga.. is a facility of the Southeastern Forest Experiment Station in cooperation with the Holt E. Walton Estate and St. Regis Paper Company.

were sampled separately for originals and interplants, but covariance analysis indicated that the heightover-diameter curves were not significantly different in either level or slope so the curves were combined within each plantation. These curves permitted estimation of merchantable cubic-foot volume by diameter class for each plantation.

Results

Volumes and tree sizes in the two plantations were very similar at age 25 (mean d.b.h. is given in inches; volume per acre is in cubic feet):

	Plantation C		*Plantation H*	
	Orig.	Inter-plant	Orig.	Inter-plant
Mean d.b.h.	8.8	5.2	9.0	5.1
Vol. per acre	2,277	229	2,426	191

These and other stand data for the two plantations are averaged together (table 1). Of the 343 trees per acre surviving at age 25, 55 percent were originals and only 24 percent were interplants, although there had been about the same number of each at the start. The remaining 21 percent were wildlings. Basal area totaled 108 square feet per acre, of which 77 percent was in original plants and the remainder was equally divided between interplants and wildlings.

Average diameter was 3.7 inches smaller for interplants than for originals. Diameters ranged from 1 to 9 inches for interplants but most were less than 5 inches. Original trees averaged almost 9 inches d.b.h., and some were larger than 14 inches. Although mortality had disrupted the pattern to some extent at age 25, most interplanted rows were still conspicuous by their submerchantable diameters in contrast with their much larger neighbors in the original rows (fig. 1). Ninety-nine percent of the original plants had merchantable-size d.b.h. (4.6 inches and larger) compared to only 59 percent of the interplants (table 1). Seventeen percent of the original plants and none of the interplants were classified as sawtimber. Cordwood volume in the originals was more than 10 times that in the interplants at age 25.

TABLE 1.—Averages of data taken from two interplanted slash pine plantations

Item	Original plants	Inter-plants	Wild-lings
Years from seedling	26	25	—
Number of trees per acre	189	81	73
Basal area per acre in square feet	83	12	13
Mean d.b.h. in inches	8.9	5.2	5.8
Number of merchantable trees per acre[1]	187	48	39
Number of sawtimber trees per acre[2]	32	0	2
Merchantable volume at age 26 (25):			
Cubic feet	2,351	210	289
Cords	25.56	2.28	3.14
Salvage cut at age 19 (18):			
Cubic feet	623	57	36
Cords	3.38	0.31	0.19
Total yield:			
Cubic feet	2,974	267	324
Cords	28.94	2.59	3.34

[1]Trees 4.6 inches d.b.h. and larger.
[2]Based on 9.6 inches minimum d.b.h. and bole quality.

FIGURE 1.—At age 25, the banded interplanted tree (center) is 3.2 inches d.b.h., and the 1-year-older original plants are 10.7 inches (left) and 6.1 inches (right).

The light salvage cut in 1964 removed less than 4 cords per acre. mostly in originally planted trees. Only 9 of the 61 trees cut per acre were interplants because most of the interplants at age 18 were still less than merchantable size. Consequently, many undersized, ice-damaged interplants were left: some died and others, though still living in 1970, were permanently deformed.

Total merchantable volume production, including that removed in the salvage cut, at the end of the 25-year rotation averaged 34.9 cords per acre for the two sample plantations (table 1). Eighty-three percent of this was in original plants compared to only 7 percent in interplants and 10 percent in wildlings. Interplants were rapidly declining at age 25: in fact. wildlings contributed more to total merchantable volume production than did interplants.

Discussion

Many tree growers who have seen these plantations have hesitated to accept that 1-year-younger interplants in 12- and 15-foot wide rows would perform so poorly. Questions have been asked and answers given to explain the results. Some ask if poor seedlings were planted in the second year, but the fact is that other seedlings from the same nursery and in the same shipment were planted in other fields as first plantings and have grown very well. Some ask if local weather conditions at time of planting in 1946 and during the following summer were detrimental to the interplants, but weather records indicate not. Poor site is yet another suggested cause, but Lakeland and Cuthbert soils are not inherently poor tree sites, as the success of the original planting proves.

It is reasoned that the interplants were victims of competition from the original trees. Sunlight was perhaps the first critical factor. The 1-year older original plants had a height advantage from the start and this could mean a difference of 2.5 to 3.0 feet in total height as early as the second or third growing season. The original plants could easily maintain this advantage over the interplants, and when shading became effective, sunlight became even more critical for the interplants. Soil moisture and nutrients were probably less of a limiting factor, although when root competition did develop, perhaps after age 7, it added to the disadvantage of the interplanted trees. This rationale is based largely on Harms' (5) findings that differences in growth, up to age 7, among various spacings of slash pine could not be attributed to measured differences in soil moisture, but must be due to competition for light.

Wakeley (8) reported that trees 1 year younger replaced in individual fail spots in plantings of slash pine, as well as loblolly *(P. taeda* L.) and longleaf *(P. palustris* Mill.), did not survive or grow well enough to justify the cost of planting them.

Cost of interplanting is likely to be as much as the cost of the original planting. It may even be greater if the site cannot he burned or if special planting measures must be used to avoid damage to the first planting. Doubling the planting cost certainly cannot be justified if as in this article, interplants produce only 7 percent of the merchantable wood volume at age 25.

If plantation survival is appreciably below the intended level, a decision must be made whether to accept the stand as it is or to eradicate it and start over. In making this judgment, a forest manager can compare the yields to be expected from the lower and higher stocking levels. Bennett (3) has generalized that for planted slash pine on medium and better sites, 400 trees per acre will produce about 85 percent as much merchantable volume as 1,000 trees at age 25. Although they don't go to the 1,000tree level, one source of these estimates (4) gives the following yields, for example, at age 20, on site 60 (index age 25), for various stockings:

Trees per acre	Cords
200	19.2
300	22.5
400	24.9
500	26.8
600	28.3
700	29.9

For illustration, if 700 trees per acre were the intended stocking but first year's survival affords only 400, then subtraction shows that replanting for the higher stocking will result in a 5-cord greater yield at age 20. If the first planting is destroyed in order to replant for a higher stocking, then the value of the additional yield must be enough to repay the investment loss of the first planting plus interest. Adjustments should be made to reduce yields or extend the rotation for 1 year to allow for the *year* of growth lost in replanting. Results of this comparison will vary considerably depending on stocking levels, rotation age, site index, and stumpage price.

In summary. interplanting is a poor way to improve slash pine plantation stocking, and the resulting yield increase at age 20 or 25 is not likely to be sufficient to pay the cost of interplanting. Alternatives are to accept the stand as it is, or to eradicate the first planting and start anew. Evaluation of the increase in projected yield compared with the additional cost of replanting can be a guide in making this decision.

Literature Cited

1. Bennett, Frank A.
195-la. Reduction in growth of interplanted slash pine. U.S. Dep. Agric. For. Serv. Southeast. For. Exp. Stn. Res. Note 55, 2 p. Asheville, N.C.

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Pine seeds withstand severe drying before, after germination: seedling drought tolerance may be reduced

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Pine seeds partially freeze-dried to a low moisture content before germination or air-dried after germination recovered and grew when planted. Seedling growth was unaffected by freeze-drying but air-drying resulted in reduced growth at low and moderate soil water stresses and poor survival at high soil-water stress.

Literature Cited

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2. Bennett, Frank A.
19546. Interplanted slash pine fails. South. Lumberman 189(2369):166.

3. Bennett. Frank A.
1963. Growth and yield of slash pine plantations. U.S. Dep. Agric. For. Serv. Res. Pap. SE-1, 23 p. Southeast. For. Exp. Stn.. Asheville, N.C.

4. Bennett, Frank A.
1970. Yields and stand structural patterns for old-field plantations of slash pine. U.S. Dep. Agric. For. Serv. Res. Pap. SE60, 81 p. Southeast. For. Exp. Stn., Asheville, N.C.

5. Harms. William R.
1962. Spacing-environmental relationships in a slash pine plantation. U.S. Dep. Agric. For. Serv. Southeast. For. Exp. Stn. Pap. 150. 16 p. Asheville, N.C.

6. Schultz, A. Jay
1961. A second report on interplanted slash pine. U.S. Dep. Agric. For. Serv. Southeast. For, Exp. Stn. Res. Note 154, 2 p. Asheville. N.C.

7. U.S. Department of Agriculture
1972. State program handbook, Georgia rural environmental assistance program. Agric. Stab. and Conserv. Serv., 95p.

8. Wakeley, Philip C.
1968. Replacement planting of southern pines unsuccessful. U.S. Dep. Agric. For. Serv. Res. Note SO-85, 4 p. South. For. Exp. Stn., New Orleans, La.

Early studies demonstrated that seeds of ponderosa pine *(Pinus ponderosa)* and eastern white pine *(P. strobus L.)* can be air-dried after germination and still resume growth when rewatered (2). These early studies showed that seeds with radicles I to 2 mm before air-drying recovered best (81 percent) while those with radicles 6 to 15 mm recovered poorly (4 percent).

This article reports on studies designed to see if air-drying ponderosa pine seed after germination would increase the drought tolerance of the resultant seedlings. Some seeds were partially freeze-dried before germination as an additional treatment.

The Study

Ponderosa pine seeds of an Arizona source kept frozen during storage were divided into four lots with each lot (divided further into three sublots) receiving one of the following treatments: 600 seeds partially freezedried at 5 μHg before germination; 450 seeds germinated until radicles emerged about 3 mm and then airdried 4 days; 1.050 seeds freeze-dried and air-dried as described above; 150 seeds untreated control. Seed moisture contents were calculated on a dry weight basis from samples ovendried at 100° C for 24 hours.

After treatment, the seeds were kept moist in covered dishes until the radicles were about 10 mm. Twenty. four seeds of each treatment were then transferred to 12, 25-mm diameter glass or clear plastic tubes (2 seeds per tube) previously filled with coarse vermiculite and free-drained.

Controlled water stresses to seedlings were achieved by watering with one of three osmotic solutions: - -1/10 bar, -4 bars, and -8 bars potential. All solutions contained nutrients, the -4 and -8 bar solutions also contained polyethylene glycol 400 to lower the osmotic potential to the desired level (1). Osmotic potentials of solutions were verified by therma couple psychrometry.

Seedlings were harvested at 42 days. Growth data were subjected to least squares analysis of variance.