A CHALLENGE FOR TREE IMPROVEMENT

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Abstract. --Growth gains have been projected from several levels of genetic testing. Hard evidence that expected gains are being realized on an operational scale is scarce, and its acquisition will be difficult. Evidence from every potential source should be examined for direct or inferential bearing on the question. Yield trial, progeny test, and field verification information are discussed herein as exemplary sources, and a positive case is made for substantial growth gains in a specific circumstance. The tree improvement community in the South has a collective responsibility to demonstrate that its achievements are real and implementable, and it should be appropriate to meet that responsibility through collective action. Our clients are asking the questions. When will we have the answers?

Additional keywords: loblolly pine, family plantations, progeny tests, yield trials, realized gain.

Maybe the Georgians were right, back in 1983 3/, when they suggested that actual realized gain, at least on an operational scale, from our first generation of tree improvement may never be known. No one is eager to plant much woods-run comparison acreage for the sake of estimating that phantom factor, and that fact in itself is a good indication of a strong general preference for improved stock. But that preference, in turn, is sometimes motivated less by confidence and conviction than by indoctrination and fear of the unknown, sort of like the wayward soul who daresn't blaspheme, just in case. At any rate, the frequency with which questions about how we are really doing and how our orchard programs are paying off are being asked is on the rise, and we, as a southern tree improvement community, have a responsibility to respond with the very best answers we can muster.

The short term answers may all be inferential, by necessity, but they must be as strong and convincing as we can make them. In the long term, it would be prudent to develop some genetic standards which are precisely reproducible and which, because they are also good producers, can be deployed on sufficient acreage to provide some bases for direct measurement of improvement progress (e.g., full sib families, clones?). However we

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1/ Southern Forestry Research, Weyerhaeuser Company.

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3/ J Tankersley, L., B. Bongarten, G. Brister, and M. Zoerb. 1983. Operational plantations of improved slash pine: Age 15 results. 17th South. For. Tree Improv. Conf. Proc. Athens, GA. p. 271-280.

approach it, it's important that an effort is made in every program to accumulate inferential evidence now, and direct evidence later, as we develop and use more advanced material. One more modest contribution to the relatively small stockpile of large scale gain evidence follows.

Plantation Verification

In 1986, we established the mean exhibited site indices for 101 single family plantations in North Carolina. These loblolly stands ranged from five to seven years of field age; represented 16 percent of the plantations we established in 1979, 1980, and 1981 in that region; and were stocked with seven of our best half-sib families. These same seven families are growing on 91 percent of our 1979-81 North Carolina plantations. As indicated in Table 1, mean site indices for these families, as exhibited at ages 5-7, ranged from 68 to 74 feet. Particularly gratifying to us was confirmation that we can discriminate among families with respect to growth even when they are arrayed across 6200 acres of operational plantations. This suggests that remeasurement over time and the scale use of genetic standards might be useful strategies in establishing the worth of orchard lines. While relative growth rates among genetic entities in the field proved to be measurable, the usual dearth of wood-run plantations forced us to turn our attention next to other sources of information, e.g. progeny tests and yield trials, to try to get a handle on the phantom factor.

Table 1 -- Site index means by family for 1979, 1980, and 1981 plantations in North Carolina, as exhibited in 1986.

Family	Number of Plots	Mean site index (feet)	Waller-Duncan T-Test (.05)
74	183	74.3	A
68	212	73.6	AB
42	165	72.9	BC
01	165	72.5	BC
103	142	72.1	C
76	149	69.6	D
59	170	67.9	E

Progeny Test

To that end, we remeasured a 22 year old full-sib progeny test of loblolly pine which had four clonal parents in common with the families which were field verified. This early test was limited in the number of crosses representing most clonal parents, however those parents whose progenies performed unusually well in this test have been eliminated from the program by the weight of cumulative testing, i.e., 78, 63, and 46 didn't hold up across other progeny tests (Table 2). This 1964 wet-site test was not bedded, was not intensively managed, and had conventional ten-tree row plots with 8 by 9 foot spacing. Only the three fertilized replications were measured and at age 22, had stocking of 480 tpa. (79 percent survival), basal area of 180 ft2 /a., exhibited site index of 68 ft., and standing volume of 4560 ft /a.

Table 2 -- Family (clonal) means for volume per tree at age 22, from a 1964 full-sib progeny test. This test was not intensively managed.

Family	Cubic Feet Per Tree	Crosses Per Family	Family Still In Program?
78	11.6	1	No
74*#	11.6	1	
76*#	11.1	2	
102 #	11.1	3	
68*	11.0	6	
141	10.4	1	
63	10.1	1	No
46	9.8	2	No
21 #	9.7	2	
103*	9.5	1	
131	9.5	1	
31	9.3	3	
64	9.0	2	No
73	8.9	2	
53	8.9	3	No
Check	8.8	-	No
33	8.4	9	No
65	7.7	1	No
142	7.5	1	No

* Represented in field verification.
# Compared with yield trial results.

The mean tree volume of the collected families exceeded that of the check trees by 8 percent, as did the corresponding survival rate. Assuming an extrapolated stand density of 444 tpa for the check trees, 45.6 cunits per acre (actual) and 39.1 cunits per acre (extrapolated) respectively represent the standing volumes of the family group and the check trees, or a gain over check of 17 percent (Table 3). Considering the risks of expanding intermixed row plots into a homogeneous stand, the 39.1 cunits per acre check volume can be considered a minimum estimate of what a pure stand of check trees might have produced.

To relate the progeny test information more closely to the field verification, we next compared the performance, relative to check in the progeny test, of the four families common to both efforts (Tables 2, 4). Note that while the proportion of all test trees that were from these four families was 34 percent, their contribution to total test volume was 43

Table 3 -- Comparison of all families with hypothetical check block; 1964 full-sib progeny test, age 22.

	All Families	Check Trees	Gain
Mean volume/tree (ft^3)	9.5	8.8	8%
Survival rate (tpa)	480 actual	444 extrap.	8%
Total volume (ft^3/acre)	4560 actual	3910 extrap. (lower bound)	17%

percent. Mean volume per tree as measured in the four families beat that of the check trees by 23 percent. A 100 tpa or 23 percent advantage in extrapolated survival for the four families produced extrapolated volumes of 58.8 and 39.1 cunits per acre for the four families and the checks, respectively, or a gain estimate of 50 percent. Again, recognizing that we have established ideal upper and lower bounds, the real gain probably lies between 23 and 50 percent for the four families which were evaluated in the field verification project.

Table 4 -- Comparison of families 68, 74, 76, and 103 with hypothetical check block; 1964 full-sib progeny test, age 22.

	Four Families	Check Trees	Gain
Mean volume/tree (ft^3)	10.8	8.8	23%
Survival rate (tpa)	544 extrap.	444 extrap.	23%
Total volume (ft^3/acre)	5880 extrap. (upper bound)	3910 extrap. (lower bound)	50%

Proportion of all test trees from families 68, 74, 76, 103 = 34%.
Proportion of total test volume from families 68, 74, 76, 103 = 43%.

Family Yield Trial

In the spring of 1978, we established a yield trial which would permit comparisons with woods-run check of 16 North Carolina half-sib families when grown in pure family blocks and in blocks which contained non-contiguous mixtures of the same 16 families. Pure families, checks, and mixtures were all grown in 100 tree rectangular plots at 7 by 9 foot spacing, with all measurements confined to an internal 64 trees on each plot. This study was intensively managed and tree heights averaged 28 feet at 8 years from planting, an overall exhibited site index of about 79 feet.

The productivity of the collective pure family blocks was significantly higher than the check block, with superiority in height, survival, and volume per tree contributing to a significant 16 percent gain over check in total volume per acre (Table 5). The mixed families did not do as well, producing lower gain values in general, including an 11 percent gain in total volume per acre, which was not statistically significant. The apparently better performance of the families in pure blocks should provide reinforcement to those of us who live by the family and perhaps some incentive to those who do not. We view this evidence as analogous to the superiority of monoclonal over multiclonal eucalyptus management, as it has been so clearly demonstrated by the Brazilians. We'll follow the growth of this study with interest and bated breath, and doubtless will establish others with advanced material.

Table 5 -- Mean superiority over check for 16 half-sib entries in the family yield trial, at age 8.

	Superiority over check for:				
Plot Type	Height	DBH	% Survival	Vol/Tree	Vol/Acre
	%	%	%	%	%
Pure family	5.8****	1.7ns	6.8***	9.0*	15.6**
Mixed family	3.8**	0.7ns	6.8**	5.1ns	11.3ns

** Significant at 0.01 level.

Yield Trial - Progeny Test Comparison

Mean tree volumes for common families in the yield trial compare well in rank order with those in the progeny test (Table 6) particularly if family 78 is ignored.

Table 6 -- Comparisons of mean tree volumes for families common to the full-sib progeny test (age 22) and the half-sib yield trial (age 8).

	Volume Per Tree		
Family	Progeny Test	Yield Trial	Family Still in Program?
	ft^3	ft^3	
78	11.6	1.7	No
74	11.6	2.0	
76	11.1	2.0	
102	11.1	1.8	
21	9.7	1.8	
31	9.3	1.7	
Check	8.8	1.6	No
33	8.4	1.6	No

Mean superiorities over check for all families (pooled), as calculated from pure blocks in the yield trial, were virtually identical with those of the progeny test, when considered for volume per tree, percent survival, and volume per acre (Table 7). Both tests indicate a gain in volume per acre of 16-17 percent.

Table 7 -- Mean superiority over check for all families, as calculated from pure blocks in the family yield trial and from the 1964 progeny test.

Study	Superiority Over Check for: Volume/Tree	% Survival	Volume/Acre
Yield Trial (8 yrs)	9%	7%	16%
Progeny Test (22 yrs)	8%	8%	17%

Families 21, 74, 76, and 102 were common to the yield trial and progeny test, and when pooled within each test, yielded gains over checks of 20 and 24 percent, respectively, in volume per tree (Table 8). In both studies better family survival (better than in check lots) pushed the per acre volume gains higher, to 27 percent in the yield trial and to 41 percent in the progeny test.

Table 8 -- Mean superiority over check for families 21, 74, 76, and 102, as calculated from pure blocks in the family yield trial and from the 1964 progeny test.

Study	Superiority Over Check for: Volume/Tree	% Survival	Volume/Acre
Yield Trial (8 yrs)	20%	5%	27%
Progeny Test (22 yrs)	24%	14%	41%

Yield Trial - Verification Inferences

The eight year old family yield trial also had four families in common with the plantation verification effort, namely 1, 59, 74, and 76. As shown in Table 9, within the yield trial, the pooling of these four families produced gains over check of 19 percent, 5 percent, and 26 percent, respectively, in volume per tree, survival, and volume per acre. Recalling that we established a 23 percent gain in volume per tree for the four family set in the progeny test and that we concluded that the volume per acre gain in that test probably lies between 23 and 50 percent, the best evidence that we can muster at present implies that our 1979-81 plantations are producing and will continue to produce 25 percent more wood than they would have had we not gotten into the tree improvement business. Six of the seven families which stock 91 percent of this period's plantations are represented in one or both of the tests upon which we base this inference.

Table 9 -- Comparison of families 1, 59, 74, and 76 with check blocks, family yield trial, age 8.

	Four Families	Check Blocks	Gain
Mean Volume/Tree (ft^3)	1.9	1.6	19%
Survival Rate (tpa)	639	608	5%
Total Volume (ft^3/acre)	1210	970	26%

Conclusion

Data from a variety of sources can contribute to inferential assessment of growth gains. The ability to track specific genetic entities over time and across substantial plantation acreages can enhance that assessment. Industries, agencies, and universities supporting tree improvement programs have a vested interest in (1) securing and publicizing current yield information; (2) establishing trials, side-by-side comparisons, etc., which will better equip us to answer questions about the oncoming generations of material ; and (3) considering the joint or independent development of some highly productive, reproducible genetic standards. The phantom factor will succumb only to thought, sweat, and dollars, but a great deal of cooperation among the players can minimize these inputs.