Morphological Seedling Grades Compared After Thirteen Growing Seasons

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The separation of seedling, into morphological grades at the nursery is designed to characterize the capacity of the seedling to survive and grow well after outplanting. Wakeley's (5) three grades, haled on measurable and observable characteristics, have been widely used to segregate seedlings of different quality and particularly to mull poor (grade 3) seedlings. However, in Iris summary of a series of studies examining the efficacy of morphological grading, Wakeley (6) concludes that, if bed density is . uniformly below 60 seedlings per square foot, grading according to morphological standards is of questionable value except that damaged. insect-infested, and disease infected seedlings should he culled.

Recent studies, however, have shown that the relative performance after outplanting of the three morphological grades has been more predictable. Bunts and Brendemuehl (2) found that grading efficiently ranked the subsequent survival and growth of slash pine (Pines *elliottii* var, *elliottii)* seedlings front three Florida nurseries, In each ease, grade 1 seedlings survived and grew best, followed by grade 2 and then grade 3. In discussing soil management in forest tree nurseries, Switzer and Nelson (4) showed that the superiority of grade 1 over grade 2 and grade 2 over grade 3 was evident after one growing season and continued to increase during the 5-year period the outplantings were measured. Their conclusions were based on the growth of loblolly pine (P. *taedal* seedlings from four nurseries outplanted in two consecutive years. In the oldest test of seedling grades in the southern pines, Wakeley (7) found that, after 30 to 34 years, grade 1 seedlings survived and grew better than did those of grade 3.

In an attempt to examine long-term survival and growth of seedlings of the three morphological grades, a study was initiated in 1959 by International Paper Company at Southlands Experiment Forest near Bainbridge, Ca.

Materials and Methods

In the winter of 1959-60, slash pine seedlings from two Georgia (designated as A and B) and two Florida (C and D) nurseries and loblolly pine from one Alabama (E) nursery were taken from randomly chosen bundles that had been delivered for operational planting. Seedlings were carefully graded according to Wakeley's (5) criteria with special emphasis on root collar diameter. Slash pine sources were planted in an abandoned agricultural field that had been disked prior to planting. The loblolly source was planted in an open meadow. An 8-by 8-foot spacing was used for both species.

A randomized block design was used for each nursery source for both species. Slash pine sources were planted in separate,, though adjacent, plantings. The three seedling grades were randomly assigned within each of 10 replications for sources B and D, nine replications for source A, and six replications for source C. Each grade was represented by a 25-tree row-plot. Five replications were planted for the loblolly source, E, with each plot consisting of a 26-tree row,

Survival was measured after the first and third growing seasons. During the thirteenth growing season, diameter was measured and fusiform rust (caused *by Cronartium fusiforme* Hedge. and Hunt ex Cumm.) and forking were assessed on all trees. The plantings were then thinned by removing the surviving trees at every third planting space in each row. Felled-tree height was measured on each tree cut.

For the slash pine sources, a volume

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equation-total volume = 0.3199 + 0.0029 D'H-was developed from measurements taken on a sample of 92 trees felled as the plantings were thinned. For the loblolly pine source, an equation-total volume = 0.3199 + .0025 D^2H-that had been developed from measurements of 435 trees from nearby stands of similar age was used.

The variables, transformed where necessary and subjected to analysis of variance, were:

Volume growth per acre per year-in cubic feet

Volume of a tree of mean dbh and height-in cubic feet

Percentage of surviving trees (nontransformed)

Percentage with fusiform rust infection (nontransformed) and

Percentage of forked trees (arcsin transformation).

All tests of significance were conducted at the 5 percent level of probability, except where noted. Single degree of freedom comparisons were made between the performance of grades 1 and 2 vs. grade 3 and grade 1 vs. grade 2.

Results and Discussions

Rust Infection and forking

The proportion of trees with rust infection varied from 35 to 45 percent in the slash pine sources to 24 percent in the loblolly source and the proportion forked varied from 9 to 11 percent in the slash and was 5 percent in the loblolly source. Differences among nursery sources and among grades within nurseries were not large nor consistent enough to he detected statistically. Survival

Most mortality occurred during the first growing season (table 1). Analysis of the percentage of trees surviving after 13 years showed that slash pine grades 1 and 2 survived better than grades 3 for nurseries B. C, and D. No statistically significant differences could be detected between grades I and 2 for these same nursery sources. For nursery A, however, grade 2 survived best followed by grade 3 and then grade 1 (table 1). While no difference could he detected in the comparison of grades 1 and 2 vs. grade 3, the survival of grade 2 was significantly better than grade 1.

For loblolly (nursery E), grade 2 survived best at 78 percent, followed by grade 1 at 74 percent and the grade 3 at 70 percent. No statistically significant differences could he detected, however.

Table 1.—*Percentage of surviving trees, 1 and 13 years after outplanting*

Grade	Nursery Source									
	Slash								Loblolly	
	A		B		C		D		E	
	1 yr.	13 yr.	1 yr.	13 yr.	1 yr.	13 yr.	1 yr.	13 yr.	1 yr.	13 yr.
	Percentage									
1	60	52	94	83	81	72	55	49	86	74
2	82	71	84	75	69	63	44	39	87	78
3	75	65	64	60	61	53	14	13	75	70

We have no satisfactory explanation for poor survival of grade 1 seedlings in nurseries A and E. To qualify as a grade 1, a seedling had to he greater than 3/16 of an inch in root collar diameter: there was no upper limit. Consequently, the low survival of grade 1 seedlings for these nursery sources may have been due to the difficulty experienced in transplanting very large seedlings (1, 3).

Volume

For all nursery sources except C, grades 1 and 2 were significantly superior to grade 3 in individual tree volume (table 2). Although the differences among and between grades were not significant in nursery C, a similar trend exists. Note that for nursery A, although grade 1 seedlings survived less well than both grades 2 and 3, the individual tree volume of grade 1 seedlings was superior. Although part of this superior volume could he attributed to reduced competition within the rows occupied by grade 1 seedlings, the fact that grade 1 seedlings in the remaining nursery sources showed superiority in volume and in survival suggest that differential competition was not the determining factor. We believe that grade 1 seedlings will

maintain their relative superiority in volume of individual trees.

The most important variable from an economic standpoint is growth, as measured in volume per acre per year. For all nurseries except A. trees from grades 1 and 2 produced significantly more wood than grade 3 (table 2). Additionally, grade I was superior to grade 2 in nurseries B and D. The important influence of survival in volume production per unit area is exemplified by the relative performance of the grades from nursery A. Although grades 1 and 2 were superior to grade 3 in individual tree volume for this nursery source, no differences could be detected when grades were compared in this manner using volume per acre per year as the variable. Because of their relatively better survival, grade 2 seedlings produced significantly more fiber than grade 1 when expressed as volume per acre.

To examine the overall performance of the three slash pine grades, we used an unweighted combined analysis of the four nurseries for both individual tree volume and volume per acre per year. For bulb variables, there was a large interaction between nursery source and seedling grade. For example, compare (i) the volume per acre performance of grades 1 and 2 for nurseries .A and B and (ii) the individual tree volume for grades 2 and 3 for nurseries C and D (table 2). Although this large interaction prevented the statistical detection (5 percent level) of the differences among nursery grades, the average volume per acre per year of grades 1 and 2 combined was superior to grade 3

TABLE 2.—*Mean volume by individual tree and growth per acre per year expressed in cubic feet and measured after 13 years*

Grade	Nursery Source				
	Slash				Loblolly
	A	B	C	D	E
			Cubic Feet		
1: Individual tree	7.1	6.3	3.4	7.7	6.5
growth/ac/yr.	186	270	211	198	224
2: Individual tree	6.7	5.8	3.1	6.6	6.0
growth/ac./yr.	245	227	170	140	224
3: Individual tree	6.3	5.0	3.1	3.6	5.0
growth/ac./yr.	214	154	135	42	167

for each nursery source in both species. This comparison was significant at 10 percent (exact probability was 9 percent). On this basis, we feel the relationship illustrated (fig. 1) is strung evidence to support careful culling of grade 3 seedlings.

We a examined the relative worth of acceptable (grades 1 and 2) and cull (grade 3) seedlings by discounting the valor of the difference in volume of the 13-v ear-old planting to the 1959 planting date. For the slash pine nursery sources, the acceptable grades produced an average of 905 cu. ft. (9.8 curls) per acre more than the culls at age 13. Using $7.50 per curl as the stumpage value and 8 and 10 percent interest rates, we found that grades 1 and 2 seedlings were worth $39.69 more at 8 percent and $31.26 more at 10 percent than the grade 3 culls per thousand seedlings. The acceptable loblolly grades produced 741 cu. ft. (8.1 curds) inure than the cull seedlings and the discounted value of this difference was $32.80 per thousand at the 8 percent discount rate and $25.84 per thousand at 10 percent.

Conclusions

There are no differences among the three seedling grades with respect to rust infection and tendency to fork.

In general, grades 1 and 2 survive and grow better than grade 3. The important exception in this experiment (nursery A) emphasizes that morphological grades as defined by Wakeley (1954) alone are not universally accurate in ranking the subsequent survival and growth performance of seedlings.

Even though the inferior performance of grade 3 seedlings was detectable only at a higher probability of error (9 percent) when analyzing all nurseries combined, we recommend the runt in tied careful culling of grade 3 seedlings. The value of the additional fiber produced by grades 1 and 2 at age 13, discounted to date of planting. shows that costs incurred in culling are more than offset by the superior growth of seedlings of grades 1 and 2.

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Figure 1.—Volume performance of graded slash pine seedlings after thirteen growing seasons.