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GENETIC FAMILY AND STOCK TYPE INFLUENCE SIMULATED LOBLOLLY PINE YIELDS FROM WET SITES

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ABSTRACT

Planting adapted families or a bulked seedlot of bare-root and container-grown seedlings of loblolly pine (*Pinus taeda* L.) were contrasted as cost effective alternatives for regenerating Arkansas' wet sites. Survival data from two wet sites were used to simulate 15 years of growth. Containerized seedlings provided 17% greater survival than bare-root seedlings, but yielded a lower present net worth than bare-root seedlings. Planting families adapted to excessive moisture provided 7% greater survival and yielded a greater present net worth than planting a bulked seedlot consisting of adapted and poorly adapted families.

INTRODUCTION

Many loblolly pine sites in the South have soils underlain with a hardpan. During the traditional planting season a perched water table may develop making these sites especially hard to regenerate, as seedlings often die. Periodic flooding may complicate successful regeneration even more (Yeiser and Paschke, 1987). Planting during periods of excessive soil moisture increases the probability of seedling mortality due to anaerobic conditions. Postponing planting until the water table recedes can increase first-year survival, if the use of containerized seedlings can be economically justified (Yeiser and Paschke, 1987).

Survival of seedlings on wet sites may be increased by planting seedlings from families known to be well adapted to excessive soil moisture. The adaptability of families to these sites may be determined by a two-stage testing scheme described by Byram *et al.* (1986).

Planting of seedlings from families which have shown the ability to survive well on wet sites increases first-year survival, and consequently, by providing the desired spacing, increases yield of wood and income from these sites. First-year survival and future yields may also be increased by late planting of containerized rather than bare-root seedlings (Yeiser and Paschke, 1987).

Containerized seedlings are generally more expensive than bare-root seedlings due to limited production and availability. Also transportation costs for containerized seedlings are higher than those for bare-root seedlings (Guldin, 1983). Conventional planting practices include planting bare-root seedlings originating from bulked seedlots. A common industry minimum acceptable stocking is 300 seedlings per acre.

The objectives of this study were as follows:

1. To compare the 15-year simulated mean per acre yield of two families of loblolly pine selected for high adaptability to wet sites against the mean of five families representing a bulked seedlot, and
2. To contrast the cost effectiveness of planting two families of loblolly pine with high adaptability to wet sites with a bulked seedlot comprised of five families both planted as bare-root and containerized seedlings.

MATERIALS AND METHODS

Survival Data

First-year seedling survival from two wet sites in south Arkansas was selected for analysis. Site one is located near Ingalls, Arkansas, on a moderately drained Myatt silt loam (Larance, 1961). The second site is located near Locust Bayou, Arkansas, on a poorly drained Amy silt loam soil (Gill *et al.*, 1980). For a more detailed account of planting sites see Yeiser and Paschke (1987).

Seven families of loblolly pine, all part of a tree breeding program, were tested by Yeiser and Paschke (1987) for their ability to survive on wet sites. Progeny test data were available for only five of these seven families, so this study was restricted to these five families. Two families (CR-BL-33 and PC-58) showed significantly better survival than the others and were considered well adapted for general planting on wet sites (Yeiser and Paschke, 1987). Their first-year survival rates were averaged to produce the survival rate for adapted families. The first-year survival rates of all five families, consisting of well adapted and poorly adapted families, were averaged to produce the survival rate for the bulked seedlot. Each family was planted as both containerized and bare-root stock. Simulations were based on actual field survival rates

Table 1. First-year survival rates after perched water tables receded in 1984.

Site	Seedling Type	
	Containerized	Bare-root
Ingalls, AR	Adapted---99.33% (676 TPA) ¹	Adapted---92.67% (631 TPA)
	Bulked---98.13% (668 TPA)	Bulked---87.20% (594 TPA)
Locust Bayou, AR	Adapted---71.33% (486 TPA)	Adapted---47.33% (322 TPA)
	Bulked---62.40% (425 TPA)	Bulked---34.93% (238 TPA)

¹TPA = Surviving trees per acre.

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as observed after perched water tables receded in 1984. Table 1 shows the first-year survival rates after perched water tables receded in 1984 and the number of surviving trees per acre by site, based on the planted stocking of 681 trees per acre.

Growth Model

Matney and Sullivan's (1982) FORTRAN stand table projection model was used to project yields based on first-year survival. Due to the different growth patterns of loblolly pine when planted on old-fields (upon which the model is based), and excessively wet sites, projected volumes are probably optimistic. However, a more appropriate model was not available. Since all families were part of a tree improvement program, use of the model's volume gain as a result of genetic improvement was possible.

Table 2 shows the origin of the volume gain for both adapted and bulked groups. This gain in terms of feet of site index was calculated by entering the base site index, then increasing the feet of site index due to the genetic gain until the desired percent volume increase was achieved. Table 3 contains the increase in feet of site index used.

Table 2. Progeny test volume growth projections of families by group showing derivation of genetic volume gains used in simulations.

Group	Family	Percent About Check lot ¹	Number of Tests ²
Adapted	CR-BL-33	17.4%	2
	PC-58	20.5%	3
	Average =	18.6%	
Bulked	CR-BL-33	17.4%	2
	PC-58	20.5%	3
	PC-62	14.6%	3
	PC-28	12.6%	1
	S4PT6	-3.5%	1
	Average =	12.3%	

¹The mean performance of the South Arkansas check lot was based on 42 tests.

²The number of progeny tests on which the average percent about the check lot was computed.

Yield Projections

Yields were projected for seven different treatment combinations based on actual first-year survival rates. Yields were projected through age 15 by entering first-year survival rates, and a number of other variables which were held constant for all projections. Table 3 shows variables used in growth simulation.

Financial Analysis

Establishment cost, and stumpage proceeds from harvests were discounted to year zero, and a present net worth calculated for all treatment combinations. Present net worth was used as an economic indicator to determine whether increased survival and growth, due to either planting adapted families, or planting containerized seedlings, increased yield sufficiently to justify these nontraditional practices. The present net worth values represent stumpage returns from harvests discounted to year zero, minus reforestation costs, based on cost of seedling type (Table 3).

Table 3. Values used during the growth simulations and economic analysis.

Variable	Value
Site Index	74 feet @ base age 25
Genetic gain--adapted families	12.424 feet of Site Index
Genetic gain--bulked families	7.756 feet of Site Index
Discount Rate	6.00 percent
Pulpwood Stumpage	\$11.50 per cord ¹
Reforestation Expense (containerized seedlings)	\$143.00 per acre ²
Reforestation Expense (bare-root seedlings)	\$129.00 per acre ²

¹Stumpage values are from August 1986 Forest Marketing Bulletin (Geisler, 1986).

²Actual reforestation expense includes \$80.00 for site preparation (herbicide), \$30.00 for planting, and seedling costs of \$19.00 for bare-root and \$33.00 for containerized (Yeiser and Paschke, 1987).

RESULTS AND DISCUSSION

Yield at Ingalls

Projected yields are presented in Table 4. Overall survival at Ingalls was 94.3% and high regardless of genetic group or seedling stock. After 15 years, families with high adaptability to wet sites averaged 8.4% more cords per acre than the bulked seedlot. This increase was due to the increased density and growth caused by planting adapted families.

Containerized seedlings produced similar though slightly less pulpwood per acre than bare-root seedlings. This is probably due to the higher survival (60 trees per acre) achieved with containerized than bare-root seedlings. The full effect of genetic adaptability and container grown seedlings was probably not realized due to high survival. If the high survival at this test site could be consistently achieved, cost-effectiveness could be increased by planting fewer seedlings per acre and reducing costs.

Table 4. Total yields after 15 years of simulated growth.

Treatment	Surviving # of TPA ¹	Total Yield in cords
Ingalls Adapted Container	676	77.5
Ingalls Bulk Container	668	71.0
Ingalls Adapted Bare-root	631	78.3
Ingalls Bulk Bare-root	594	72.7
Locust Bayou Adapted Container	486	80.8
Locust Bayou Bulk Container	425	72.9
Locust Bayou Adapted Bare-root	322	77.0
Locust Bayou Bulk Bare-root	238	Insufficient survival to project

The number of stems at age one.

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Yield at Locust Bayou

Overall survival at Locust Bayou was low, but only bare-root seedlings originating from a bulked seedlot exhibited sufficient mortality for a replant of the site. After 15 years, projected yields from planting adapted families were 8.3% greater than for a bulked seedlot. Yields from planting containerized and bare-root seedlings were very similar, excluding the planting of bare-root seedlings originating from a bulked seedlot whose survival was too low to project.

Present Net Worth

Planting bare-root rather than containerized seedlings produced similar, although slightly higher returns (present net worth values), despite lower first-year survival (Table 5). Planting families specifically adapted to survive on wet sites provided higher returns than planting seedlings from a bulked seedlot, because of increased survival and better growth.

Table 5. Present net worth values for seven alternatives when regenerating wet sites. (Discount rate = 6.00%, Projected for 15 years)

Site	Seedling Type	
	Containerized	Bare-root
Ingalls	Adapted---\$229.08	Adapted---\$246.58
	Bulked---\$197.56	Bulked---\$219.95
Locust Bayou	Adapted---\$242.71	Adapted---\$240.44
	Bulked---\$206.67	Bulked--- ¹

¹Not projected due to insufficient survival

SUMMARY AND CONCLUSIONS

Differences in volume and present net worth were relatively small when good survival was achieved. However, when survival was poor the differences in volumes and values were more evident. Therefore, a fair estimation of probable survival is necessary. If survival is likely to be poor with bare-root seedlings planted during the traditional planting season, late planting of containerized seedlings would be more cost effective than replanting. If survival is likely to be high, the benefits

of planting containerized seedlings will not be realized.

Planting families of loblolly pine well adapted to excessive moisture can increase the stand productivity on wet sites. This is attributable to augmented first-year seedling survival which allows forest managers to (1) manipulate stand density through thinnings to produce the desired product for more return per invested dollar, and (2) reduce planting costs by planting fewer seedlings per acre and increase the return per invested dollar.

Mortality resulting from excessive soil moisture justifies the planting of adapted families. Presently, containerized seedlings cost considerably more than bare-root seedlings. This difference in cost outweighs benefits derived from higher survival and yield. However, Guldin (1983) states that containerized seedlings can be produced at prices near the cost of bare-root seedlings. Where bare-root and containerized seedlings are available at similar costs, managers should plant container-grown, genetically-adapted families for cost-effective management. Without similar costs for containerized and bare-root stock, planting bare-root families with demonstrated adaptiveness to wet sites is a substantially better investment for forest managers than planting containerized seedlings.

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