SHORTLEAF AND LOBLOLLY PINE SEED ORIGIN TRIALS
IN SOUTHERN ILLINOIS: 27-YEAR RESULTS

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Abstract.--Shortleaf and loblolly pines are extensively planted in southern Illinois, but since neither species is native (except for a very small area of shortleaf), there has been no basis for selecting appropriate geographic sources of seed to be used. Seed of each species was collected from six widespread locations and in 1949 seedlings were outplanted on glaciated and unglaciated sites in three counties in southern Illinois. There has been no meaningful difference in survival or growth of shortleaf pine that is related to seed origin; the southern Missouri provenance is recommended as closest to 'local'. Loblolly pine of Arkansas origin proved resistant to cold damage and produced 25 percent more volume than the plantation average; this area is recommended as a source of seed to be used in southern Illinois plantations.

Additional key words: Provenance; Seed-source, *Pinus taeda*; *Pinus echinata*; cold-temperature-damage.

Tree planting in southern Illinois is confined mostly to pines because of the depleted condition of most old field planting areas. Prior to 1950, little attention was given to the source of the seed used for planting in the area. An experiment was begun in 1948 to help determine the best geographic sources of seed of shortleaf pine (*Pinus echinata* Mill) and *P. taeda* L.) for reforestation in southern Illinois.

Pines are not native to the area except for a few patches of shortleaf pine along the Mississippi River bluffs in an area known as the Pine Hills. The largest natural stand of shortleaf pine of any consequence is located almost 10 miles west of the Pine Hills area, across the river in Missouri. The nearest natural stands of loblolly pine are about 150 miles to the south.

DESCRIPTION OF AREA

The experimental plantations are located in two physiographic divisions of Illinois (Leighton *et al*. 1948). The northern plantings are located in the glaciated Mt. Vernon Hill Country on soil that developed

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from loess. The soil in the plantation is Cisne silt loam (Mollic Albaqualfs) which has a well developed claypan underlain with glacial till. The southern plantings are in Pope and Hardin Counties in the non-glaciated Shawnee Hills division. Soils in these plantations are predominantly Grantsburg silt loams (Typic Fragudalfs) which also developed from loess, with a fragipan underlain with sandstone. Small areas of similar Alford, Baxter, and Bedford soils are included. The claypan or fragipan present on all sites inhibits both downward movement of water and root penetration, but all soils are considered suitable for planting to loblolly and shortleaf pines (Parks 1975).

Annual rainfall averages 42 inches in the northern section and 46 inches in the southern section. Precipitation during June, July, August, and September averages 14 inches in the northern glaciated area and 16 inches in the hilly southern area. Temperatures in July average about 80° but high temperatures, coupled with low rainfall usually result in a drought during July. The frost-free season averages about 190 days (Page 1949).

SEED SOURCES

Loblolly pine seed used in the study was collected in the following regions of origin:[2]

1. Worcester County, Maryland
2. Matthews County, Virginia
3. Southwestern Arkansas
4. Pender County, North Carolina
5. Throughout South Carolina, and
6. Throughout Mississippi.

Shortleaf pine seed was obtained from these regions of origin:

1. Shawnee State Forest, Scioto County, Ohio
2. Texas and Shannon Counties, Missouri
3. McCreary County, Kentucky
4. Ozark National Forest, Arkansas
5. Tishomingo County, Mississippi, and
6. Northern McCurtain County, Oklahoma.

Each seedlot included seed from many individual trees. Seedlings from all of the above seed sources, except shortleaf pine from Ohio,

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[2]Region of origin is defined by Barner and Koster (1976) as: "For an indigenous species, sub-species or distinct variety the region of origin is the area or group of areas subject to sufficiently uniform ecological conditions on which are found stands of that indigenous species etc. showing similar phenotypic or genetic characters."

were grown in a single nursery bed during the 1948 growing season at the Union State Tree Nursery near Jonesboro, Illinois. The Ohio stock was grown in the Marietta State Nursery. The planting stock was graded to eliminate culls according to the practices used at both nurseries at that time.

METHODS

The field design is a randomized block arrangement for each species. Five replications in the hill section and three replications in the glaciated section were established for each species, except that shortleaf pine of Mississippi origin was not included in the glaciated section. Since then, two loblolly and two shortleaf plots have been lost from the glaciated section and one loblolly plot lost from the upland section.

All brush more than 2 feet high was cut before seedlings were hand planted by the small-scalp-and-slit method in March 1949. Rectangular 0.179-acre plots were planted with 216 trees at 6 x 6 feet spacing.

RESULTS AND CONCLUSIONS

Loblolly Pine

For many species, trees of southern origin are adapted to longer frost-free seasons and are inherently capable of greater growth than those from more northerly sources. Loblolly pine is characterized by such a geographic variation pattern (Bethune and Roth 1960; Goggans, Lynch, and Garin 1972; Grigsby 1973). Indeed, trees in our study followed a similar trend in the nursery and through the first growing season in the field with trees of South Carolina and Mississippi origin 30 percent taller than those from Arkansas (Minckler 1950).

Strong exceptions to the rule of 'southern trees outgrow northern trees' are to be expected if seed is moved too far north of its origin. In such situations, southern trees may grow through too long a season and be subject to late spring or early autumn frosts, or may be so poorly adapted as to suffer cold damage during the dormant season. As an example, after 6 years in an eastern Maryland test, loblolly pines from Texas and Louisiana were shorter than trees from eight other sources tested and had lowest survival; Maryland (local) and North Carolina provenance trees were tallest and had notably better survival (Little and Tepper 1959).

In our study, a severe winter in 1950-51, after the trees had been outplanted for 2 years, provided the first real test of cold hardiness. Trees of Mississippi, North Carolina, and South Carolina origin suffered more than 10 percent mortality in one or more replications; Virginia, Maryland, and Arkansas trees were completely undamaged in most replications

(Minckler 1951).

By the end of the third year after planting, trees of Maryland and Virginia origin were superior in terms of survival, height growth, and appearance. Trees from the Arkansas source were intermediate in survival and also deemed to be satisfactory; those from the three "deep South" states were labelled "definitely inferior" (Minckler 1952). After 10 years, trees from the three "deep South seed sources" averaged 75 percent survival versus 92 percent for the other three; they had only 65 to 75 percent as much basal area as the promising Maryland provenance trees (Woerheide 1959).

In March 1960, eleven years after the trees were outplanted, southern Illinois received snowfall of 8 inches or more three different times, with intervening 2- to 4-inch snows. Accumulation exceeded 18 inches twice, and bent and broke limbs and tops of trees in the study plantations (fig. 1). Once again, trees from the "deep South" were more heavily damaged:

Percentage of trees damaged by snow accumulation[3]

Region of origin		Region of origin	
Maryland	1.9	North Carolina	11.3
Virginia	2.7	South Carolina	7.4
Arkansas	3.7	Mississippi	12.4

It was suggested that the generally lower survival in the North Carolina, South Carolina, and Mississippi plots might have made these trees more susceptible to bending and breakage because of reduced mutual support. To test this hypothesis, six plots were selected in the glaciated section, where damage was worst, in which survival was uniformly high (95 to 99 percent). Damage to Virginia and Maryland trees ranged from 1.9 to 3.9 percent while North Carolina, South Carolina, and Mississippi trees suffered from 16.5 to 19.8 percent bending and breakage. It appears that the more southern trees are indeed inherently weaker when grown in southern Illinois.

After 27 years, previous general trends have been confirmed, but with a number of differences in details (table 1). Height differences are no longer of any consequence, and the relatively low survival (about 42 percent) of trees from the three more southern states has been partially compensated by their increased diameter growth.4

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[3]Adapted from file report, "Mechanical damage to loblolly pine and shortleaf pine seed source trees, caused by heavy snows during March 1960," by John D. Woerheide, March 9, 1961.

4The authors thank M. S. Cook and D. S. Matis for painstaking plot measurements, and David Polak for thorough statistical analyses.

Figure 1.--Loblolly pine of South Carolina origin bent over by heavy snow in March 1960.

The superior growth and (especially) survival of the trees from southwestern Arkansas is of greater interest. This trend confirms the report by Wells and Wakeley (1966) in which loblolly pines of western origin (eastern Texas and southwestern Arkansas in their test) survived best at nearly all of 13 locations throughout the South. In our study the 25 percent survival advantage of Arkansas loblolly led to an equivalent 25 percent advantage in volume, 1100 cubic feet per acre greater than the plantation average. The ability of Arkansas-provenance trees to persist at extremely high stocking (maximum plot basal area = 242 $feet^2$/acre) may represent inherent superiority that was not apparent during earlier years when competition was much less intense (Namkoong and Conkle 1976). The study plantations have never been thinned, and we cannot be certain that southwestern Arkansas would prove to be as superior a region to obtain seed for trees to be grown under more intensive culture.

SHORTLEAF PINE

Just as with loblolly pine, shortleaf of southern origin has been found to outgrow trees of more northerly provenance--unless it is moved too far to the north. Wells and Wakeley (1970) recommend planting "local stock" for the zone including southern Illinois (this zone generally lies to the north of parallel 36° 30', plus the Appalachian mountain region of Tennessee and North Carolina and includes the three northern regions of origin in our study).

Table 1.--Loblolly pine: survival and growth from six regions of origin

(region mean as a percentage of plantation mean)

Region of origin	Height	Diameter	Survival	Basal area	Volume
Maryland	99	95	114	103	100
Virginia	101	96	111	102	101
Arkansas	102	98	125	121	125
North Carolina	101	103	82	92	92
South Carolina	96	102	85	90	86
Mississippi	100	106	83	93	96
Plantation mean[1]	(feet)	(inches)	(percent)	($ft.^2$/acre)	($ft.^3$/acre)
	61.5	7.0	50	168	4418
Probability of error due to chance less than indicated (in percent)	N.S.	3	0.05	0.05	0.2

[1]Adjusted for three missing plots.

Early results in our study tended to confirm the Wells and Wakeley recommendation. Trees from Mississippi suffered light to moderate injury during the severe winter that occurred 2 years after outplanting (Minckler 1951). In 1960 Mississippi trees also suffered somewhat more snow damage than those of other sources, but the damage was slight and the difference among sources not great.

By age 10, shortleaf pine from Oklahoma origin had grown larger and survived better than trees from other sources. Oklahoma trees produced 47 percent more basal area than those from Ohio. Oklahoma, Kentucky and Missouri seed sources were tentatively recommended for shortleaf pine plantations to be established in southern Illinois. [5]

[5]Woerheide, John D. File report, "Tenth year observations of loblolly pine-shortleaf pine seed source field tests." 37 p., November 20, 1960.

After 27 years, survival and growth differences related to provenance had diminished to the point that none of them was statistically significant (table 2). There is no basis in the results of this study to recommend a region for seed collection, but there is certainly no reason to differ with Wells and Wakeley's (1970) proposal. Their recommended collection zone includes the southern Missouri provenance that produced the trees achieving the greatest volume in our study; it should perhaps be preferred because it is closest to being "local".

Table 2.--Shortleaf pine: survival and growth from six regions of origin

(region mean as a percentage of plantation mean)

Region of origin	Height	Diameter	Survival	Basal area	Survival
Ohio	99	100	97	99	99
Missouri	100	102	101	107	106
Kentucky	101	102	90	92	91
Arkansas	103	99	99	97	102
Mississippi[1]	105	100	95	96	101
Oklahoma	97	96	113	105	102
Plantation mean[2]	(feet)	(inches)	(percent)	(ft.^{2}/acre)	(ft.^{3}/acre)
	54.3	6.2	72	188	4285

[1]Present only in 5 upland replications; survival and growth related to plantation mean on that site.

[2]Adjusted for 2 missing plots.

DIFFERENCES BETWEEN LOCATION AND BETWEEN SPECIES

Loblolly pine is the preferred species for planting on southern Illinois sites such as those selected for our study, with shortleaf pine also recommended for eroded upland sites in the Shawnee Hills section (Casey, Roth, and Fox 1974). Our results tend to confirm these recommendations, with both species making equivalent growth in the unglaciated upland section and loblolly producing about 8 percent more volume than shortleaf in the glaciated claypan area (table 3).

Table 3.--Growth and survival of shortleaf and loblolly pines on two sites

Age (years)	Site	Shortleaf pine					Loblolly pine				
		Height	Survival	Basal area	Volume		Height	Survival	Basal area	Volume	
		feet	percent	$ft.^2$	$ft.^3$	cords/acre/year	feet	percent	$ft.^2$	$ft.^3$	cords/acre/year
10	glaciated	13.5	82	50			20.9	89	98		
10	upland	15.6	89	55			22.1	84	80		
27	glaciated	55.9	74	201	4670	1.35	64.6	55	182	5060	1.46
27	upland	53.4	71	180	4054	1.17	59.6	48	160	4031	1.17

Volume yields from the two areas have not followed the expected pattern. At age 10, height growth of both species was greater on the upland sites than in the glaciated area with shortleaf also showing greater survival and basal area production in the uplands. In terms of basal area loblolly pine was outgrowing shortleaf by about 80 percent (94 $ft.^2$ vs. 52 $ft.^2$) after 10 years. But after 27 years, productivity of both species is distinctly greater on the glaciated area. These findings contrast with the timber growth estimates of Odell and Oschwald (1970): 1.0 cord/acre/year for conifers on Cisne silt loam (in the glaciated claypan area) and 1.4 cords/acre/year for Grantsburg silt loam (the predominant soil on the unglaciated upland area). The standing volume on the upland area is not as high as predicted, but would probably come close if mortality losses were added. Yield on the glaciated site is higher than predicted, averaging more than 1.4 cords/acre/year for the two species together and 1.6 cords/acre/year for loblolly pine of Arkansas provenance. The productivity value assigned by Odell and Oschwald (1970) was of course based on an average situation. But considering that our plantations might have produced even greater yields if they had been thinned, it appears that they may have underestimated the capability of Cisne soils.

Tree planting in Illinois currently averages about 7,000 acres per year, and our results suggest that meaningful gains in productivity can be made by selecting appropriate species, seed sources, and sites. The limited number of seed sources tested in this study can hardly be expected to indicate the range of genetic variability present in either species. We especially recommend follow-up testing of loblolly pine from several locations in southwestern Arkansas and perhaps nearby areas of Oklahoma, Texas, and Louisiana.

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