A 16-YEAR PROVENANCE TEST OF LOBLOLLY PINE IN SOUTHERN ARKANSAS

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Abstract.--Loblolly pine trees from seed sources throughout the range of the species were planted at two locations in southern Arkansas. Between ages 10 and 16 years, significant differences in growth altered the ranking (by volume) of the various seed sources, The correlation between closeness to coast of seed origin and fast growth evident at age 10, had begun to weaken at age 16, although it was still significant.. The top-ranking three provenances in volume per tree and volume per plot were interior. The gain in volume of trees from interior sources over trees of coastal origin in this period was largely due to faster diameter growth. Considering both growth rate trends and susceptibility to fusiform rust, seed sources from the South Carolina Piedmont, Mississippi Central, and Mississippi Northern Coastal Plain were considered good choices for planting in southern Arkansas.

Additional keywords: *Pinus taeda,* seed source, *Cronartium fusiforme.*

Early tests of certain loblolly pine *(Pinus taeda* L.) seed sources have demonstrated substantial differences in the performance of various progenies in growth and resistance to fusiform rust, *Cronartium fusiforme* Hedg. and Hunt ex Cumin. (Wells and Wakeley 1966, Rink and Thor 1971, Goggans *et al.* 1972). These tests and others have shown that the prudent selection of seed sources can be an effective and economical way to increase yield.

The study described here was designed to test the performance in southern Arkansas of loblolly pine from seed sources throughout the range of the species. Survival, growth, and rust resistance of trees were observed and comparisons were made on data taken at ages 10 and 16 years.

METHODS

Seed samples were taken from the complete range of loblolly pine from Delaware to Florida and west to Texas (Figure l). From a state, federal, or private agency at each of 32 locations, a 113-gram lot of nonselect seed was obtained. Planting stock was grown in an Arkansas Forestry Commission nursery and then outplanted in southwestern (Hempstead County) and southeastern (Cleveland County) Arkansas.

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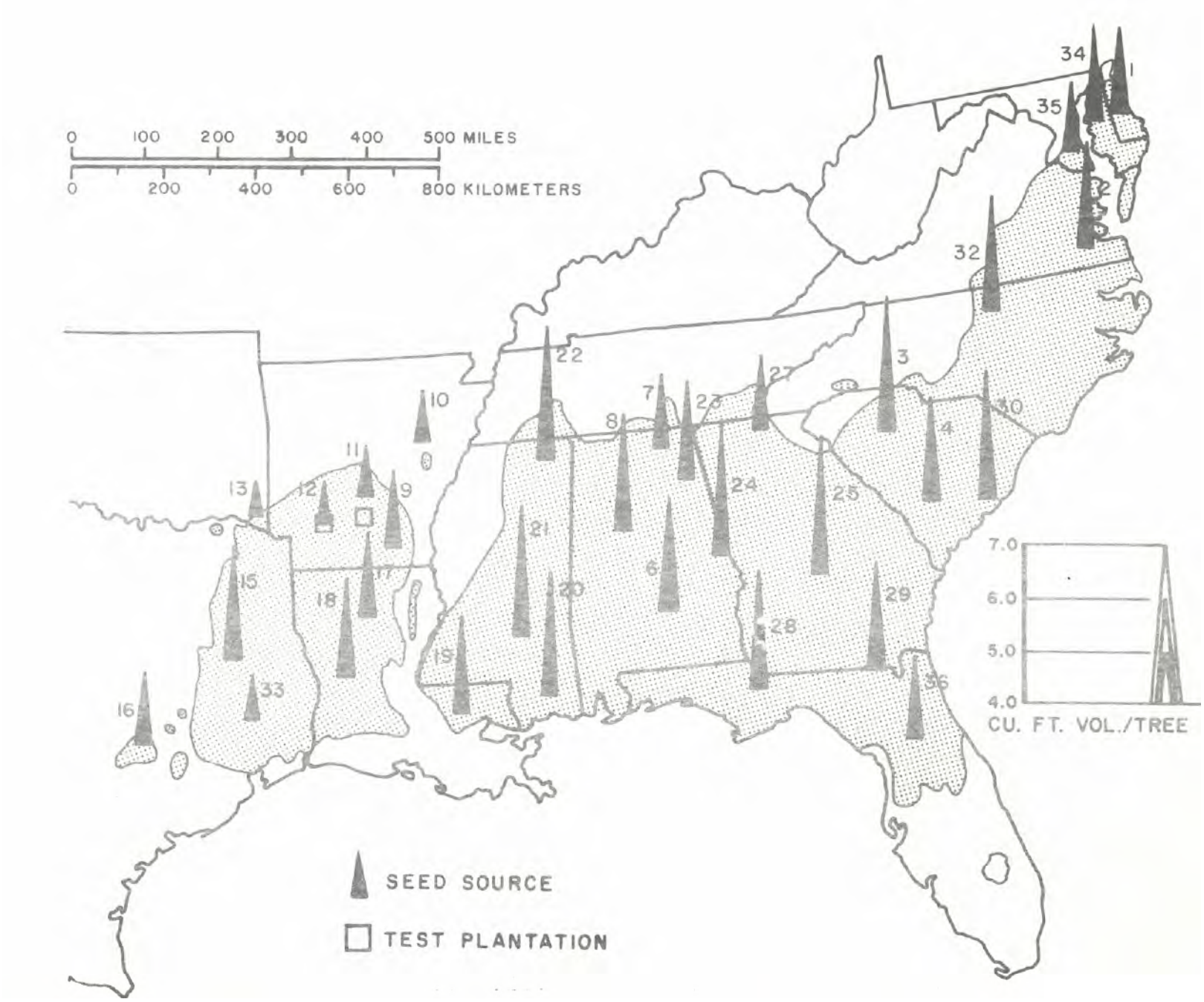

Figure 1.--Location and performance of seed sources from throughout the range of loblolly nine.

This report is based on eight plots of trees from each source--four in southwest Arkansas and four in southeast Arkansas. All plantings were arranged in randomized blocks. The southwestern plots contained 121 trees planted at a spacing of 6 x 6 feet. The 49 trees forming a square in the center of each plot were measured. The southeastern plots contained only 49 trees planted at a spacing of 8 x 8 feet, all of which were measured. Plots were contiguous and two rows of trees were planted on the outside boundary of the plantation to prevent border effects.

Field Data

About half the trees on each plot had been marked for removal at the time the 16-year data were taken. Trees to be removed were not measured. The largest and best trees were to be left and their height was measured to the nearest half-foot with telescoping poles, on alternate trees, until ten had been measured. Diameters at breast height were taken to the nearest tenth-inch on all trees to be left. Because thinning was in progress at the time of examination, survival and rust figures from data taken at age 10 were used. Trees having either stem or branch cankers were tallied as rust infected. A comparison with several unthinned plots indicated that both survival and rust percentages were relatively unchanged between ages 10 and 16.

Analyses

Survival, diameter, height, volume, and rust infection were examined by analyses of variance or covariance and multiple range tests. Volume per tree was computed with Schmitt and Bower's (1970) formula for young loblolly pines in plantations. Survival and rust data were transformed to arc sine $\sqrt{\text{percentage}}$. Differences among results from different sources were tested for statistical significance at the 0.05 level. Since radial stem growth is affected by stocking, diameter and volume per tree were adjusted by multiple covariance analysis for differences in survival. Average height was included as a second independent variable in the analysis to ensure that its impact on diameter and volume was not altered by the adjustment.

RESULTS AND DISCUSSION

Survival

Survival ranged from 64.4 to 93.4 percent, with a mean of 83.2 percent. The four provenances with the highest survival differed significantly from the one with the lowest (Table 1). In general, trees from low rainfall areas survived better than those from high rainfall areas, particularly those having mild coastal climates. No strong survival trends were apparent among sources from intermediate rainfall areas. Results from the Tennessee Valley (Zarger 1961), Georgia (Kraus 1967), and the Southwide Study (Collins 1964, Wells and Wakeley 1966), show that inland and western sources have also survived better than coastal or more eastern sources.

Table I. Measurement data 16 years after outplanting in southern Arkansas._ Sources ranked by volume.

Ident. Fig. 1	Origin of Seed	Vol. p/tree (cu. ft.)[2]	Avg. DBH[1] (inches)	Avg. Ht. (feet)	Survival (%)	Rust (%)
24	Ala. East Central	6.65	7.70	49.3	81.0	19.9
25	Ga. Upper Coastal Plain	6.64	7.71	48.2	70.7	24.4
3	S.C. Piedmont	6.58	7.65	46.6	75.5	15.0
30	S.C. Lower Coastal Plain	6.47	7.62	50.0	77.7	11.4
21	Miss. Coastal Plain Central	6.45	7.51	48.5	88.5	9.0
22	Miss. Coastal Plain North	6.45	7.62	47.6	77.0	9.3
20	Miss. Coastal Plain South	6.30	7.45	47.8	80.8	11.6
28	Fla. Northwest	6.25	7.50	47.8	80.1	34.3
2	Va. Southeast	6.23	7.39	48.4	80.6	5.3
15	Tex. Coastal Plain	6.19	7.57	44.8	84.2	4.2
32	N.C. Piedmont	6.18	7.53	48.3	87.1	14.1
8	Ala. Piedmont	6.18	7.67	47.0	81.8	17.0
6	Ala. Coastal Plain	6.09	7.55	48.2	87.3	19.2
29	Fla. Northeast	6.00	7.45	48.2	70.6	30.4
4	S.C. Lower Coastal Plain	6.00	7.48	47.9	77.3	17.2
23	Ala. Mountain	5.92	7.43	47.5	88.2	11.8
18	La. Coastal Plain Central	5.86	7.37	45.5	85.9	6.0
19	La. Southeast	5.83	7.15	48.0	74.2	7.0
34	Md. Coastal Plain	5.83	7.25	48.7	93.4	4.1
1	Del. Coastal Plain	5.59	7.23	47.1	93.4	5.1
17	La.Coastal Plain North	5.58	7.30	44.5	83.5	6.9
36	Fla. Coastal Plain	5.52	7.23	45.7	64.4	6.1
9	Ark. Coastal Plain South	5.45	7.18	44.7	89.1	5.1
16	Tex. Lost Pines	5.43	7.28	42.1	86.2	4.9
7	Ala. Mountain	5.41	7.16	45.7	87.3	16.1
27	Ga. North	5.39	7.29	45.9	85.0	15.2
35	Md. Coastal Plain	5.32	7.23	47.0	82.3	5.5
11	Ark. Coastal Plain	4.96	7.06	43.0	89.8	6.6
10	Ark. Delta	4.95	7.08	43.8	84.2	4.8
33	Tex. Coastal Plain	4.86	6.78	45.2	80.1	2.5
12	Ark. Coastal Plain West	4.80	7.27	43.0	84.5	2.4
13	Okla. Coastal Plain	4.70	7.06	41.0	88.6	3.8

[1] Adjusted for survival in the presence of height by covariance analysis.

[2] Volume means not opposite the same line differ significantly by Duncan's test (P=0.05).

Fusiform Rust

Incidence of rust varied from 2.4 percent for local trees to 34.3 percent for those from northwest Florida (Table 1). The local trees and those from 13 other sources west of the Mississippi River had significantly less rust than trees from 11 eastern provenances.

Growth

Differences in the performance of trees from various sources were more obvious in diameter than in height growth. Diameters, however, responded noticeably to spacing. DBH decreased 0.2-inch and volume per tree decreased 0.3 cubic foot with each ten percent increase in survival. To correct this, DBH and volume per tree were adjusted downward if survival was less than the mean (83.2%) and upward if survival was greater than the mean. These adjustments changed the individual tree volume ranking of most sources from one to three places, and one source (No. 36) six places. They increased volume and diameter of western and interior sources, and decreased these attributes of coastal sources (Table 2).

Table 2.--Average diameter and volume per tree by regions before and after adjustment for survival.

Item	Uni	Western Sources[1/]	Eastern Sources Interior	Coastal
Survival	Percent	85.4	82.7	79.5
Unadjusted diameter	Inches	7.16	7.49	7.43
Adjusted diameter	Inches.	7.20	7.52	7.36
Unadjusted volume	Cu.ft/tree	5.22	6.11	6.07
Adjusted volume	Cu. ft/tree	5.28	6.18	5.94

1/ All western sources are interior.

At age 16, volume per tree varied from 6.65 to 4.70 ft^3 and some differences were significant (Table 1). Trees with the greatest volumes were from east central Alabama, west central Georgia, and the Piedmont of South Carolina. The trees of lowest volume were from western sources, including trees local to the planting site. The intermediate range in volume production was made up of trees from both coastal and interior sources. Coastal sources are considered to be those from within 50 miles of the Atlantic or Gulf coasts. Interior sources are from locations more than 50 miles inland.

The Livingston Parish, Louisiana source (No. 19), well known because it performed well in the Southwide Pine Seed Source Study (Wells 1969) in the southeast, dropped from eighth place in volume at age 10 to eighteenth place at age 16. This was not due to poor height growth, but rather to a slacking off of diameter growth. Also, the eastern Maryland source (No. 34) which ranked third in height, ranked ninete enth in volume because of poor diameter growth.

At age 10, there was a tendency for sources within about 50 miles of the Atlantic and Gulf coasts to excel in growth. The growth rate of most of these sources had slowed by age 16 and that of some of the more inland sources had accelerated. At age 10, coastal provenances comprised seven of the top ten sources in volume per tree (Grigsby 1973), while at age 16, the situation had reversed, and seven of the top ten sources were from more than 50 miles inland. Despite the tendency for coastal sources to decline, trees of one South Carolina coastal source (No. 30) have remained among the best performers in volume production. However, they have dropped from first to fourth place in six years. The current trend is for trees from inland sources between the coasts and the mountains to excel in southern Arkansas plantings, but later measurements will have to be taken to substantiate the trend.

The difference in individual tree volumes between loblolly from west and east of the Mississippi River is great. This difference became more marked between the tenth and sixteenth year. Average tree volumes at 16 years were 5.28 cubic feet for the western population and 6.06 cubic feet for the eastern. Eastern trees also grew more in height.

Trees from two general areas of the eastern part of the range have produced below average growth. One area is the mountains of northern Alabama and Georgia, and the other is the northernmost extremity of the range in Maryland and Delaware. This illustrates that sources of loblolly pine, even withinthe natural range of the species, are limited in their adjustment to new environments. The same northern Alabama and Georgia sources mentioned above have outperformed Coastal Plain sources when planted in Tennessee outside of the natural range of loblolly (Thor 1967, Zarger 1961).

DISCUSSION

In the present study and the Southwide Study, sources from northern Alabama and northern Georgia are growing slowly. Also, in both studies, loblolly pine from west of the Mississippi River is slower growing, rust resistant, and survives planting relatively well.

There are a few differences between the Southwide Study and the present study, such as the growth rate of the northeast Mississippi sources (fast in the present study and slow in the Southwide Study), and of the Maryland sources (slow in the present study and fast in the Southwide Study). However, growth rankings in the Southwide Study are made only on the basis of height (Wells 1969, Wells and Switzer 1975). If the same criteria were used in both studies, there would be even more agreement between them about seed source performance.

MANAGEMENT APPLICATIONS

Both the present study and the Arkansas plantation of the Southwide Study show that the Livingston Parish loblolly source (No.. 19 in the present study) begins to lose vigor in the southern Arkansas environment after age 10. This indicates that the climate in this area, 50-75 miles from the northern limit of the natural range of loblolly, is too severe for trees from this Gulf Coast source. These results should not be viewed with alarm by those planters in the southeastern states who have elected to plant trees from this source in high rust areas in the Coastal Plain. However, it shows that caution should be used in planting seedlings from this source in the Piedmont and other areas near the interior boundary of the species' natural range.

Although trees of the four Arkansas sources had good records in survival and resistance to fusiform rust, they ranked near the bottom of the 32 sources in growth. Care should be taken when planting in Arkansas not to select seed sources from the high rust areas of Alabama, Georgia, and northern Florida.

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