SELECTING POPULATIONS OF LOBLOLLY PINE FOR RUST RESISTANCE AND FAST GROWTH

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Abstract.--Loblolly pine from Livingston Parish, Louisiana, has proven to be rust resistant and fast growing after 20 years in plantings in southern and central Mississippi, Alabama, and Georgia. Loblolly from eastern Maryland is also resistant and has grown relatively fast between the 10th and 20th year in the same plantings. Maryland seed sources would probably be best for planting in the Piedmont of Alabama, Georgia, and South Carolina, where the climate is too severe for Livingston Parish loblolly.

A useful level of rust resistance is found in the loblolly population north and west of Livingston Parish as far as Adams County, Mississippi, a distance of about 80 miles.

Additional keywords: Fusiform rust, seed source x planting location interactions, provenance selection, Pinus taeda.

Within 10 years practically all the pine seed for plantations in the South will derive from orchards of selected trees. In the meantime, selection of geographic seed source is a valid means of attaining genetic gains at minimal cost. For example, loblolly (Pinus taeda L.) from Livingston Parish (southeastern Louisiana) offers both rust resistance and fast growth when planted on high rust hazard sites along the Atlantic and Gulf Coastal Plains. This application is based on 10- and 15-year results of the Southwide Pine Seed Source Study (Wells 1969). The study has since been remeasured after 20 years in the field, and results for loblolly pine are presented here. In addition, results from an intensive sampling study of loblolly pine (Wells and Switzer 1971) are used to determine the geographic limits of the rust-resistant population near Livingston Parish, Louisiana, and in southwestern Mississippi. Results presented here should help forest managers procure the large amounts of seed they need and insure that its genetic quality is as high as practicable.

MATERIALS AND METHODS

Southwide Pine Seed Source Study

Complete details of the loblolly phase of the Southwide Pine Seed Source Study are given by Wells and Wakeley (1966) and Wells (1969). Fifteen seed sources are represented, and 16 plantings survive afer 20 years in the field (fig. 1). The seed sources and plantings are divided into two series. Series-1

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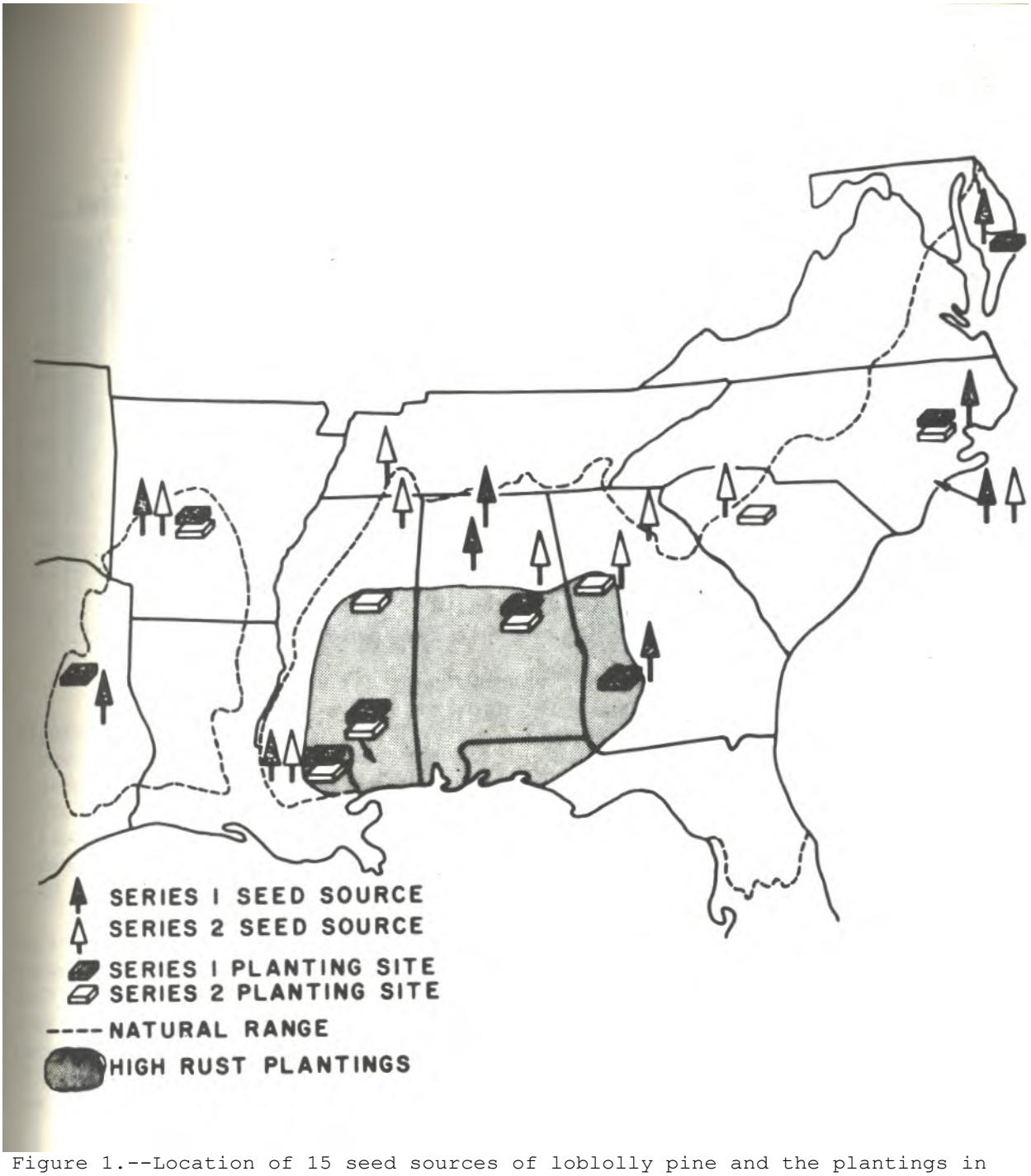

Figure 1.--Location of 15 seed sources of loblolly pine and the plantings in which they are represented. Southwestern Arkansas, southeastern Louisiana, and southeastern North Carolina sources are in both Series-1 and Series-2 plantings.

sources represent the major part of the range. Series 2, with the exception of the southeastern Louisiana seed source, is restricted to an east-west transect from North Carolina to Arkansas. Seed was collected in 1951 from at least 20 trees in each area, and seed from all trees within a source was composited. A randomized complete-block design with four replications was used for each planting. Plots consist of 121 trees at 6- by 6-foot spacing; the inner 49 trees

were periodically measured, and the outer two rows served as borders. Height, amount of rust infection, and several other traits were measured at ages 1, 3, 5, 10, 15, and 20 years. Through age 10, amount of rust infection was expressed as the percentage of trees per plot with stem or branch galls; only trees with stem galls were counted. Amount of rust infection at age 10 is considered the most reliable indicator of seed source differences since loss of galls through shedding of lower limbs is minimal at this age.

Intensive Sampling Study

In 1962 and 1963, seed was collected from five randomly selected trees at each of 115 locations in and near Mississippi. To focus attention on the loblolly population near Livingston Parish, progenies from only 35 locations are considered here. Plantings were established during the winter of 1965-66 in Livingston Parish, central Mississippi, and northwestern Alabama; each seed collection area was represented by a 10-tree row plot in each of 10 replications. Only the Livingston Parish planting survived well enough (73.4 percent after 5 years) to give statistically precise results. The average number of galls per tree was determined at age 4, and total height was measured at age 5.

In both studies, total height rather than volume is considered the most reliable indicator of genetic differences in vigor among seed sources as it is not biased by differences in stocking.

Analyses

Analysis of variance and multiple range tests at the 0.05 level of significance were performed as described in Wells and Wakeley (1966) for the Southwide Study and Wells and Switzer (1971) for the intensive sampling study. Data from the four Series-1 Southwide Study plantings in Mississippi, Alabama, and Georgia were pooled as were data from the five Series-2 plantings in the same area (shaded area, fig. 1) because seed source performance was similar in all these plantings. For convenience we refer to these plantings hereafter as the high rust zone plantings (HRZP). Seed source rankings for height differed substantially in each of the Southwide Study plantings outside the HRZP; so results in them are presented by individual plantings.

RESULTS AND DISCUSSION

Southwide Pine Seed Source Study

In the high rust zone plantings, the major geographic variation in growth rate is between trees of coastal origin on one hand and continental and western trees on the other (figs. 2 and:). After 20 years in the field, the differences in height between these two groups is about 4 feet in Series 1 and 5 feet in Series 2. Coastal trees are remarkably uniform in height whether they evolved in Maryland, North Carolina, Georgia, or Louisiana. Rust infection at age 10 was lowest among trees from Maryland, southeastern Louisiana, east Texas, and southwestern Arkansas (figs. 2 and 3), and later data (Grigsby 1973) confirmed

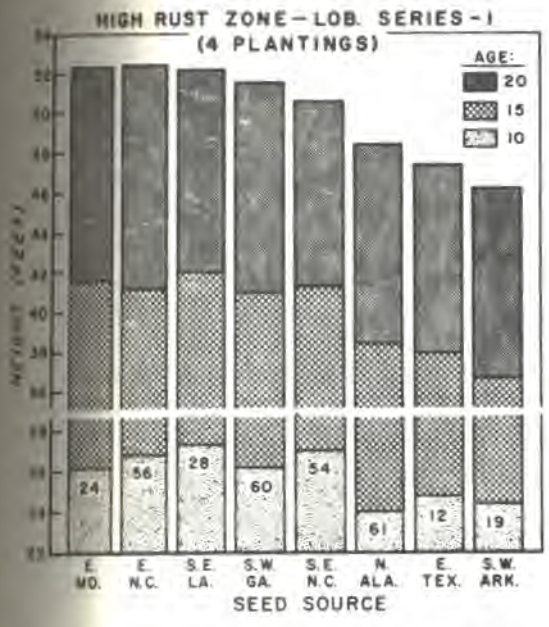

Figure 2.--Average height at three ages of loblolly pines from eight geographic seed sources. Number within bar indicates rust infection at age 10. Approximate Duncan's Least Significant Range at 20 years = 2.6 feet.

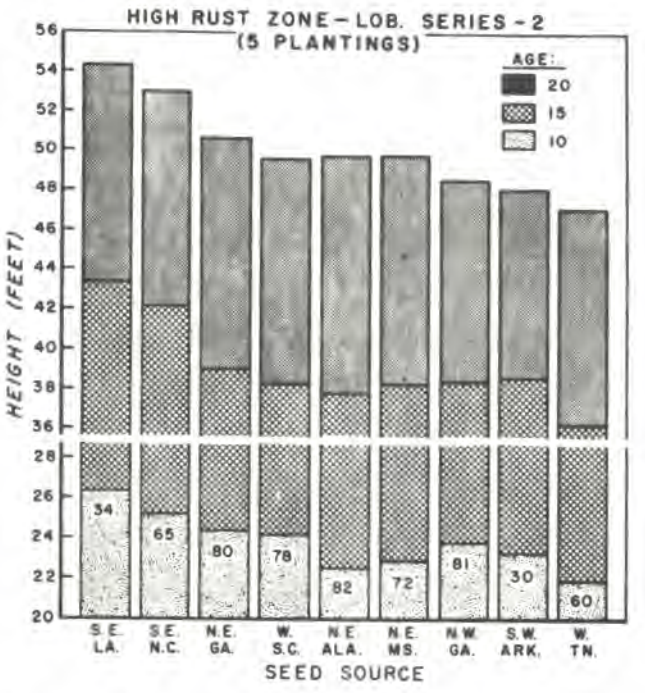

Figure 3.--Average height at three ages of loblolly pines from nine geographic seed sources. Number within bar indicates proportion of trees with rust infection at age 10. Approximate Duncan's Least Significant Range at 20 years = 2.2 feet.

their superior resistance. However, the Texas and Arkansas populations had slow growth rates. The best combination of fast growth and rust resistance in the HRZP was offered by the southeastern Louisiana trees. This population would probably perform well also in central and southern Georgia and coastal South Carolina, where the climate and physiography are similar to that in the HRZP. It is actually growing well as far north as coastal North Carolina, but unless rust is a serious threat there is no reason to move it that far.

Northeast of the HRZP are plantings in the Piedmont of South Carolina, the Coastal Plain of North Carolina, and the eastern shore of Maryland. Differences among seed sources are not significant in the South Carolina Piedmont, but as the southeastern Louisiana trees rank last it seems best to assume they should not be planted there. Instead, loblolly from the eastern shore of Maryland would be a good choice for this area and for the Piedmont of Alabama and Georgia, where rust is a serious problem. The Maryland population has considerable rust resistance, and it apparently is not cold susceptible since it does well farther inland in Tennessee (Rink and Thor 1971). In addition, it has a desirable growth rate as evidenced by its performance in the HRZP (fig. 2).

In the North Carolina Coastal Plain, coastal trees generally excell except for those from Maryland, which rank next to last. Twenty-year results in this planting show no reason to change the recommendation that Carolina loblolly seed can be moved parallel to the coast anywhere within North or South Carolina as long as Coastal Plain seed is used in the Coastal Plain and Piedmont seed is used in the Piedmont (Wells 1969).

Farther north in Maryland, the superiority of the Maryland loblolly has been striking from the start, and 20-year results in this planting strengthen this point.

West of the HRZP, coastal loblolly is also growing faster than continental or western trees, but in the southwestern Arkansas planting, growth of the Louisiana trees has slowed during the last 10 years, and they have been surpassed by trees from other coastal sources (table 1). Apparently southwestern Arkansas is just past the climatic limit at which the Louisiana trees can fully express their inherent growth potential. In this planting, trees from the Atlantic Coast are considerably taller than those from local sources, and the possibility of exploiting this geographic variation is being investigated (Grigsby 1973). However, forest managers contemplating such seed movements have to weigh the chances of poor initial survival of the Atlantic Coast loblolly against its fast growth rate. In both the Arkansas and east Texas plantings, survival at age 10 was 21.5 percent higher for local seed sources than for coastal North Carolina and Maryland seed. These plantings were established in a drought year, and mortality was heavy in both. In Texas early mortality reduced the planting to only two replications; so statistical precision is poor; but the Maryland trees appear to be poorly adapted since they are almost 10 feet shorter than the other coastal trees.

Intensive Sampling Study

Results in the Livingston Parish planting after 4 and 5 years (fig. 4) show that useful levels of rust resistance in the loblolly population extend north as far as Adams County, Mississippi, a distance of about 80 miles, although the Livingston Parish trees themselves are more resistant than those from any of the other points sampled. Resistance decreases to the east until in Washington and St. Tammany Parishes it reaches a point where the loblolly would probably not be useful for planting in high rust hazard areas (see also Crow 1964). The middle of Tangipahoa Parish would probably be a practical eastern boundary for seed collection in the rust-resistant population. To the south and west of Livingston Parish are hardwood swamps.

The pattern of 5-year height suggests genetic differences in vigor within the rust-resistant population. For example, trees from the southern portions of St. Helena and Washington Parishes are slower growing than those from other collection points. These height differences would probably not be important to a firm urgently seeking rust resistance; but if the time and effort necessary to select individual stands combining rust resistance and fast growth rate could be expended, genetic gains in both these traits could likely be made.

Table 1.--Height at age 20 of loblolly pines from various geographic seed sources. Means opposite the same line are not significantly different at the 0.05 level.

Planting location and (series)	Seed source	Height
SW AR (1&2)	SW GA	60.3
	E NC	59.9
	SE NC	59.5
	E MD	58.7
	N AL[a/]	57.9
	W SC	57.4
	NE GA	57.1
	N AL[b/]	56.8
	SE LA	56.6
	NE MS	56.2
	NE AL	54.6
	W TN	54.3
	E TX	52.0
	SW AR	50.9
E TX (1)	SW GA	60.5
	SE LA	59.5
	SE NC	57.1
	E NC	56.8
	SW AR	56.8
	E TX	55.8
	N AL	54.6
	E MD	50.9
High Rust Zone (1)	E NC	52.3
	E MD	52.3
	SE LA	52.2
	SW GA	51.5
	SE NC	50.6
	N AL[a/]	48.4
	E TX	47.4
	SW AR	46.2
High Rust Zone (2)	SE LA	54.3
	SE NC	53.0
	NE GA	50.7
	W SC	49.7
	NE AL	48.9
	NE MS	48.9
	NW GA	48.6
	SW AR	48.2
	W TN	47.2
Piedmont SC (2)	NW GA	49.1
	NE GA	48.2
	W SC	46.6
	NE MS	46.1
	W TN	46.0
	SW AR	43.8
	SE NC	43.4
	NE AL	43.0
	SE LA	40.5
Coastal NC (1&2)	E NC	57.9
	SE NC	57.5
	SE LA	56.9
	N AL[a/]	55.7
	W SC	55.2
	NE GA	54.0
	NE AL	53.8
	E TX	53.2
	SW GA	52.9
	NE MS	52.7
	NW GA	52.6
	SW AR	51.1
	E MD	51.0
	W TN	49.7
E MD (1)	E MD	53.4
	E NC	50.6
	SE NC[b/]	49.7
	N AL[b/]	47.7
	N AL[a/]	46.5
	SW AR	46.2
	E TX	45.8
	SW GA	44.7
	SE LA	42.0

a/ Jefferson County, Alabama
b/ Cullman County, Alabama

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