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LOCAL SEED SOURCES

Recommended for Loblolly Pine in Maryland and Shortleaf Pine in New Jersey and Pennsylvania

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LOCAL SEED SOURCES

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WHAT SEED SOURCE?

LOCAL SEED SOURCES have proved best for establishing loblolly pine stands in Maryland and shortleaf pine stands in New Jersey and Pennsylvania. In studies conducted by the U. S. Forest Service, local seed sources provided trees that were better adapted to local climates than stems that had originated from seed collected at various locations in the South. And the trees from local seed sources also grew much faster than the trees from the southern seed sources.

This research was sponsored by the Southern Forest Tree Improvement Committee (SFTIC), which includes in its membership representatives from the wood-product industries, State forestry departments, universities, and the U. S. Forest Service. A SFTIC subcommittee has been conducting a study of the geographic source of seed for many years. Other subcommittees have

been studying tree selection and breeding, progeny testing, and genetic control of seed. These subcommittees have prepared publications and have suggested and supervised cooperative studies.

In 1951, SFTIC began a pine seed-source study throughout the South. As part of this study, the Northeastern Forest Experiment Station established, between 1953 and 1958, a loblolly pine plantation in eastern Maryland and some shortleaf pine plantations in south-central Pennsylvania and southern New Jersey. Each plantation contained seedlings from several geographic sources. This report describes the results obtained from measurements made between the 1967 and 1968 growing seasons in these plantations.

STUDY METHODS

Seedlings were planted at 6-foot spacings in 0.1-acre plots. One plot of each source constituted a block, and each plantation contained four blocks. We measured only the inner 49 seedlings of the 121 planted in each plot.

Seed for the loblolly pine plantation in Maryland came from one Maryland source and eight other sources in Alabama, Arkansas, Georgia, Louisiana, North Carolina, and Texas. Seedlings were grown in the Maryland State Forest Nursery at Harmans; they were then planted in 1953 as 1-0 stock in a field that had been tilled the previous year, in the Pocomoke State Forest, Worcester County.

Seed for the shortleaf pine plantation in New Jersey came from one New Jersey source and six other sources in Georgia, Louisiana, Missouri, South Carolina, Tennessee, and Virginia. Seedlings were grown at the New Jersey State Nursery at Washington Crossing and were planted in 1958 as 2-0 stock on a former nursery site in the Green Bank State Forest, Burlington County.

Seed for the shortleaf pine plantations in Pennsylvania came from one Pennsylvania county and nine other counties in Arkansas, Georgia, Oklahoma, Tennessee, and Texas. Both a 1954 and a 1958 plantation were established, with different sources for each plantation. The 1958 plantation was established because initial survival was low in the 1954 plantings. All seedlings planted in

1954 had been raised in the Mont Alto Nursery of the Pennsylvania Department of Forests and Waters. All seedlings planted in 1958 had been grown in the Washington Crossing Nursery of the New Jersey Bureau of Forestry. In both years 2-0 stock was planted in abandoned fields.

RESULTS

Loblolly Pine in Maryland

Survival of loblolly pines from certain southern sources has been relatively low, probably because of repeated winter injury and snow breakage. The two stocks most seriously affected are from Georgia and Louisiana sources, and these had survival rates of 47 and 53 percent, respectively, after 15 years (table 1). Similar, but less extensive, injuries have reduced the stocking of North Carolina and Texas sources. If the study plots had not been located well within a field that was planted to pines in 1953, even lower survival would probably have occurred.

Surprisingly, the Arkansas source has had the best survival: 84 percent. Maryland and two northern Alabama sources had 73

Table 1.—*Fifteen-year survival, and the average diameter, height, basal area, and merchantable volume of living stems, by seed source of loblolly pine*

Seed source	Survival	Average diameter[1]	Average height	Basal area per acre	Volume per acre[2]
	Percent	*Inches*	*Feet*	*Sq. Ft.*	*Cords*
Somerset Co., Md.	73	5.7	39.1	160.5	27.8
Pamlico Co., N. C.	58	6.1	38.1	141.7	24.1
Onslow Co., N. C.	62	5.7	36.4	134.7	21.5
Jefferson Co., Ala.	71	5.7	35.7	152.3	23.4
Cullman Co., Ala.	73	5.7	35.6	159.6	24.6
Clark Co., Ark.	84	5.6	34.0	176.0	25.3
Wilcox and Crisp Cos., Ga.	47	5.8	33.1	106.1	15.1
Angelina Co., Texas	67	5.8	32.5	151.5	21.5
Livingston Parish, La.	53	5.4	30.3	103.2	13.3

[1]In this and subsequent tables average diameter is that of the tree of mean basal area.
[2]Based on measured diameter and height and table 3 of U.S. Dep. Agr. Misc. Pub. 50. Volumes are in cords of rough wood above a 1-foot stump to a diameter (i.b.) of 3 inches. Trees less than 4.0 inches in diameter (b.h.) were excluded.

or 71 percent of the planted seedlings still living after 15 growing seasons.

Maryland seedlings were the tallest in the 15-year-old planting. They led in: (1) average height of all surviving seedlings, (2) average height of the tallest five trees per plot, and (3) maximum height (tables 1 and 2). In all these height characteristics, the local source was followed rather closely by the North Carolina sources and less closely by the northern Alabama sources. Trees from Arkansas, Georgia, Texas, and Louisiana seed were still shorter, the maximum difference among sources being 7 to 9 feet.

Height differences among sources did not increase in the last 5 years, even though there were some shifts in relative rankings. Maximum differences among sources in the average height of all surviving trees were 8.5 feet at 10 years and 8.8 feet at 15 years. In average height of the tallest five trees per plot, maximum differences were 7.4 and 7.0 feet, respectively.

Differences among sources in the average diameter of all surviving trees and of the tallest 123 trees per acre were not great at 15 years, the maximum difference for each group being only 0.7 inch (tables 1 and 2). Average diameters were affected by

Table 2.—*Fifteen-year average height and diameter of the tallest five trees per plot, and maximum height, by seed source of loblolly pine*[1]

Seed source	Average height	Maximum height	Average diameter (b.h.)
	Feet	*Feet*	*Inches*
Somerset Co., Md.	44.1	48	6.8
Pamlico Co., N. C.	43.0	47	6.9
Onslow Co., N. C.	41.7	45	7.1
Jefferson Co., Ala.	40.0	42	6.8
Cullman Co., Ala.	41.0	44	7.1
Clark Co., Ark.	38.4	40	6.7
Wilcox and Crisp Cos., Ga.	38.6	42	7.4
Angelina Co., Texas	38.2	41	7.4
Livingston Parish, La.	37.1	43	6.9

[1]Because measurements were limited to inner 42-foot square of each 0.1-acre plot, 5 trees per plot are equivalent to 123 per acre.

stocking, tending to be larger in sources with relatively low survival (North Carolina, Georgia, and Texas).

Basal area per acre 15 years after planting varied by source from 103 to 176 square feet. Louisiana and Georgia stocks had the lowest basal areas, while the Arkansas source had the highest. The Maryland source, with 160 square feet, exceeded North Carolina stocks by 19 to 26 square feet (table 1).

The local (Maryland) source had the greatest merchantable volume of rough pulpwood at 15 years, about 28 cords per acre (table 1). That volume was about twice the amount produced by Louisiana or Georgia sources, and 2.5 cords more than the second-best source, Arkansas (table 1).

During the 15-year tally, records were kept on: (1) trees that lacked a terminal shoot or leader; (2) those with double stems, if both shoots were still living; (3) occurrence of *Cronartium* cankers on the boles; (4) trees with crooked or very crooked boles; and (5) leaning stems. Only 26 percent of the surviving Maryland trees had such defects (table 3). The Arkansas source

Table 3.—*Proportion of living loblolly pines with various observed defects in 1967, by seed source*

Seed source	Living stems					
	Lacking terminal	With double terminal[1]	With cankers on lower bole[2]	With crooked or very crooked boles	Leaning boles	One or more defects
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Somerset Co., Md.	6	9	1	11	0	26
Pamlico Co., N. C.	5	2	25	34	0	56
Onslow Co., N. C.	7	1	17	15	1	32
Jefferson Co., Ala.	5	6	14	37	0	54
Cullman Co., Ala.	13	9	14	20	0	44
Clark Co., Ark.	3	9	1	15	0	27
Wilcox and Crisp Cos., Ga.	8	9	25	35	3	66
Angelina Co., Texas	6	10	5	21	1	41
Livingston Parish, La.	7	5	9	9	15	35

[1]Limited to stems with both shoots still living. On many of the stems that fork in the lower bole, one shoot was already dead, and these trees were not included.

[2]Caused by *Cronartium fusiforme* or *Cronartium cerebrum*. Cankers caused by both were present, but could not always be separated.

was next with 27 percent, and both of those sources excelled in low incidence of stem cankers. Cankers caused by *Cronartium fusiforme* or *C. cerebrum* were common in the North Carolina, Georgia, and Alabama sources—occurring on 14 to 25 percent of the surviving trees. Breakage at cankers had already been an important factor in reducing survival of the North Carolina sources, and more losses in the affected sources can be expected from breakage at cankers. Bending from wet snows has been most common in the Louisiana source. Crooked stems were especially prevalent, affecting 34 to 37 percent of the trees from one North Carolina source, one Alabama source, and the Georgia source.

Figure 1.—Shortleaf pines from Missouri and New Jersey seed in the New Jersey plantation after 11 growing seasons. Pipe post in the foreground marks the boundary between Missouri trees on left and New Jersey trees on the right. Note the higher survival and greater size of trees from the New Jersev source.

Table 4.—*Ten-year survival, average diameter and average and maximum heights of living trees, and basal area per acre, by seed source of shortleaf pine in the New Jersey plantation*

Seed source	10-year survival	Average diameter	Average height	Maximum height	Basal area per acre
	Percent	*Inches*	*Feet*	*Feet*	*Sq. ft.*
Burlington Co., N. J.	94	3.6	17.8	25	79.2
Anderson Co., Tenn.	70	3.1	14.2	21	43.2
Dent Co., Mo.	70	3.0	13.8	20	41.9
Southampton Co., Va.	49	2.9	13.0	19	28.4
Union Co., S. C.	34	2.6	11.5	17	14.6
Webster Co., Ga.	25	2.0	8.6	18	6.9
St. Helena Parish, La.	19	2.1	9.9	16	5.3

Shortleaf Pine

In New Jersey.—Seedlings from the local New Jersey source had the best survival, the largest stems in diameter and height, and the most basal area per acre at 10 years after planting (table 4 and figs. 1 to 3). In fact, the differences among sources are outstanding. Few stems in the two most southern sources were still living in 1968, and these were 1.5 inches smaller in diameter and 8 to 10 feet shorter than trees of local origin. Even the second-best sources, Tennessee and Missouri, had only about half as much basal area per acre at 10 years as the local trees.

Table 5.—*Ten-year average height and diameter of the tallest five shortleaf pines per plot, by seed source in the New Jersey plantation*

Seed source	Average height	Average diameter
	Feet	*Inches*
Burlington County, N. J.	22.0	4.3
Anderson County, Tenn.	18.9	4.0
Dent County, Mo.	17.4	3.8
Southampton County, Va.	16.2	3.7
Union County, S. C.	13.2	3.1
Webster County, Ga.	10.5	2.5
St. Helena Parish, La.	11.1	2.4

Figure 2.—Shortleaf pines from New Jersey and Tennessee seed in the New Jersey plantation after 11 growing seasons. Pipe post in front of the man marks the boundary between New Jersey trees on left and Tennessee trees on right. Note the higher survival and greater size of trees in the New Jersey source.

When crop trees or the largest five trees per plot (123 per acre) are considered, the local source still leads. Its crop trees were 3 feet taller than the next best source, and 11.5 feet taller than the poorest source (table 5).

Most of the differences among sources in survival and growth may be due to stem damage from wet snows or to winter injury of foliage. The southern sources have far more leaning stems from the past snow damage (table 6). Even after 10 years' growth in the New Jersey plantation, shortleaf pines of southern origin still suffer severe winter injury to the foliage. The following proportions of living stems had appreciable amounts of winter injury to foliage in April 1968:

Source	*Percent*
Burlington County, N. J.	0
Dent County, Mo.	7
Anderson County, Tenn.	18
Southampton County, Va.	28
Union County, S. C.	70
Webster County, Ga.	80
St. Helena Parish, La.	76

In Pennsylvania.—Seedlings from Franklin County, Pennsylvania, had the best survival, largest average diameter and height, and the most basal area per acre (table 7). However, they were closely followed by seedlings of the Tennessee source; and when only crop trees are considered, the Tennessee seedlings slightly outgrew the Pennsylvania trees in the 1954 planting, but not in the 1958 plantation (table 8).

Figure 3.—Shortleaf pines from Louisiana and New Jersey seed in the New Jersey plantation after 11 growing seasons. Note the very low survival and short height of Louisiana trees in the foreground, when compared with New Jersey trees in the background.

Table 6.—*Proportion of living shortleaf pines with observed defects in 1968, by seed source in the New Jersey plantation*

Seed source	Broken terminal[1]	Double terminal[2]	Crooked or very crooked boles	Leaning stems	One or more defects
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Burlington County, N. J.	5	6	3	4	17
Anderson County, Tenn.	6	4	1	11	21
Dent County, Mo.	0	4	1	2	7
Southampton County, Va.	4	11	1	15	30
Union County, S. C.	3	8	0	21	30
Webster County, Ga.	0	4	6	24	33
St. Helena Parish, La.	0	8	8	16	32

[1]Mostly of recent occurrence, from wet snow in winter of 1967-68.
[2]Limited to stems with both shoots still living.

Table 7.—*Survival, average diameter, and average and maximum heights of living shortleaf pines, and basal area per acre (after 10 or 14 years), by seed source in the Pennsylvania plantations*

Plantation and seed source	Survival	Average diameter (b.h.)	Average height	Maximum height	Basal area per acre
1958 Plantation	*Percent*	*Inches*	*Feet*	*Feet*	*Sq. ft.*
Franklin County, Pa.	41	1.8	8.5	14.0	8.8
Anderson County, Tenn.	36	1.3	7.5	13.6	3.7
McCurtain County, Okla.	27	1.0	6.5	12.1	1.7
Clarke County, Ga.	22	.9	6.1	11.8	1.2
Cherokee County, Texas	7	1.0	6.1	11.1	.4
Ashley County, Ark.	3	.3	4.6	6.3	.01
1954 Plantation					
Franklin County, Pa.	35	2.3	9.8	16.3	11.7
Morgan County, Tenn.	31	2.1	9.8	16.1	9.2
Stone County, Ark.	11	1.6	8.2	12.1	2.0
Pushmataha County, Okla.	5	.8	5.5	8.8	.2
Ashley County, Ark.	3	1.3	7.5	9.0	.3
Angelina County, Texas	1—	.6	6.6	6.6	.0+

In both the 1954 and the 1958 plantations two or three of the southernmost sources had very poor survival—less than 10 percent in 1968. Deer browsing may have affected the survival and growth of seedlings from all sources, but it is considered less important than winter injury.

Winter injury was still a common occurrence 10 or 14 growing seasons after planting on seedlings from out-of-state sources (table 9). All surviving seedlings in the Texas and the Ashley County, Arkansas, sources in both plantations had severe winter injury in 1968. Not only was most of the foliage killed, but the terminal shoots of some seedlings were also killed. Tennessee trees were noticeably less affected than other out-of-state sources, but about 95 percent of the Tennessee stems had conspicuous damage in both plantations. In contrast, only 5 to 15 percent of the Pennsylvania trees suffered winter injury, which was light and affected only some of the foliage on these stems.

Table 8.—*Average height and diameter of tallest five shortleaf pines per plot after 10 or 14 years, by seed source in the Pennsylvania plantations*[1]

Plantation and seed source	Average height	Average diameter (b.h.)
1958 Plantation	*Feet*	*Inches*
Franklin County, Pa.	10.8	2.4
Anderson County, Tenn.	9.4	1.6
McCurtain County, Okla.	7.0	1.2
Clarke County, Ga.	7.5	1.3
Cherokee County, Texas	6.3	1.0
Ashley County, Ark.	4.6	.3
1954 Plantation		
Franklin County, Pa.	12.1	2.9
Morgan County, Tenn.	12.9	3.0
Stone County, Ark.	8.9	1.8
Pushmataha County, Okla.	5.5	.8
Ashley County, Ark.	7.5	1.3
Angelina County, Texas	6.6	.6

[1]In plots containing less than 5 trees, averages are based on all living trees.

Table 9.—*Proportion of living shortleaf pines with observed defects or winter injury in 1968, by seed source in the Pennsylvania plantations*

Plantation and seed source	Double terminal	Crooked or very crooked boles	Winter injury	
			Severe	Light
1958 Plantation	*Percent*	*Percent*	*Percent*	*Percent*
Franklin County, Pa.	2	0	0	5
Anderson County, Tenn.	0	0	30	64
McCurtain County, Okla.	8	0	69	27
Clarke County, Ga.	0	2	61	34
Cherokee County, Texas	0	0	100	0
Ashley County, Ark.	0	0	100	0
1954 Plantation				
Franklin County, Pa.	0	0	0	15
Morgan County, Tenn.	3	0	8	89
Stone County, Ark.	5	0	64	36
Pushmataha County, Okla.	0	0	80	20
Ashley County, Ark.	0	0	100	0
Angelina County, Texas	0	0	100	0

DISCUSSION

The 15-year results on planting loblolly pine in Worcester County, Maryland, verify these earlier conclusions:

- Trees from the westernmost sources and from the northeastern source were least infected with stem (fusiform) rust *(Wells and Wakeley 1966)*. In the Maryland planting this was true: 1 percent of the Maryland and Arkansas trees, 5 percent of the Texas trees, and 9 percent of the Louisiana trees had stem cankers in 1968, compared with 14 to 25 percent of the living trees in the Alabama, North Carolina, and Georgia sources. Wells and Wakeley *(1966)* suggested that the resistance of Maryland trees might be due to introgression with pond or shortleaf pines, which are resistant species. I feel that there might be such introgression even though no characteristics of pond or shortleaf have been observed in the planted trees of Maryland source.

- Trees of western origin survived best in most plantings *(Wells and Wakeley 1966)*. This was partially true in that highest sur-

vival was in the Arkansas source. However, Texas and Louisiana trees had lower survival than Maryland or Alabama trees.

- Local seed can be recommended without qualification for plantings in Maryland *(Wells and Wakeley 1966; Little and Somes 1964)*. Trees of local origin have survived well, are taller, have the most volume per acre, and had the fewest defects at 15 years; so they continue to look far more promising than stems from the out-of-state sources.

Ten-year results from planting shortleaf pines in southern New Jersey are similar to the Maryland results with loblolly pine although the advantages of using local seed sources in New Jersey are even more striking. The local shortleaf seed source has provided: (1) seedlings with an appreciably higher rate of survival (94 percent compared to 70 percent for the next best source), (2) taller stems with larger diameters, (3) almost twice as much basal area per acre as the second-best sources, and (4) stems more resistant to winter injury of foliage. Tennessee and Missouri sources did seem about as resistant to damage from wet snows as the local stock, but were appreciably behind the New Jersey trees in all other respects.

Shortleaf pine growth in the Pennsylvania plantations near Blain has been unusually slow. Even the local sources have attained an average height of only 8.5 feet and a maximum height of only 14 feet after 10 years—compared with 17.8 and 25 feet, respectively, in the New Jersey plantation. The heights at Blain indicate a site index of only about 30 feet at 50 years, when the curves of Coile and Schumacher *(1953)* are applied. In comparison, data from natural stands of shortleaf pine near Mont Alto in Franklin County *(Aughanbaugh 1950)* indicate site index there of 55 to 60 feet at 50 years.

The fact that volunteer Virginia pines have outgrown the planted shortleaf pines at Blain is a further indication that shortleaf growth there has been below normal. From my observations, shortleaf pine in its early life grows just as rapidly as Virginia pine in sections where both occur. Aughanbaugh *(1950)* has

stated that shortleaf pine is generally dominant in mixtures with Virginia pine on favorable sites in southeastern Pennsylvania.

The poor behavior of shortleaf pine near Blain raises questions as to the cause. Part of the slow growth of Pennsylvania trees there may be inherent: Dr. O. O. Wells, of the Southern Forest Experiment Station, reports that shortleaf pines of the Pennsylvania source have had considerably slower growth than the shortleaf pines of New Jersey stock in all plantings of the southern pine seed source study.[1] However, such an explanation does not account for the observed difference in growth between the Mont Alto and Blain areas. Deer browsing is another factor that may have reduced survival and growth of the Blain shortleaf pines, but the surviving trees that have outgrown the reach of deer are still growing at a very slow rate.

Is Blain outside the natural range of shortleaf pine, thus accounting for the slow growth? According to a map prepared by Elbert Little and published by Fowells *(1965),* shortleaf pine occurs rarely in Pennsylvania—mostly near the southern border in Franklin and Adams Counties. However, four small outlying occurrences are indicated north of Blain.

Although there seems to be general agreement that the best shortleaf pines occur in Franklin and Adams Counties, several investigators have reported trees or stands outside these counties. Aughanbaugh *(1950)* reported outlier stands or specimen trees as far north as Mifflinburg, Selinsgrove, and Sunbury. Professor Rex Melton of The Pennsylvania State University indicated that shortleaf pine has been found in Bedford County, and in one area in central Huntingdon County.[1] Perry *(1924)* reported the occurrence of shortleaf pine near McConnellsburg in Fulton County, while Shafer and Chisman *(1957)* found two trees in Montour County and excellent stems on Warriors Ridge in Huntingdon County.

Nevertheless, the occurrence of this species in Pennsylvania is discontinuous, and limited to sites that have favorable soils and microclimate. Shafer and Chisman *(1957)* suggested that in Huntingdon County shortleaf pine is confined to southern aspects on

[1]In personal correspondence with the author.

sandstone soils. Professor Melton stated that sandy soils seem necessary for shortleaf pine in Pennsylvania; and only on such soils is shortleaf more productive than pitch, Virginia, or table-mountain pines.[1] In his opinion, valleys that form frost pockets, and high elevations, should be avoided in the Ridge and Valley Province. Aughanbaugh *(1950)* recommended planting shortleaf pine in Perry County and certain other counties only at elevations of less than 1,000 feet in intermountain valleys.

Although Blain is in one of the intermountain valleys of Perry County recommended by Aughanbaugh, it seems probable that the poor performance of our planted pines there is due to a combination of unfavorable soil and microclimate. The 1954 plantation is on a gently sloping portion of the valley floor; the 1958 plantation is on a small knoll. Both are on shale soils: the 1954 plantation on a cobbly loam with fair surface drainage and imperfect-to-poor subsurface drainage; the 1958 planting on a shallow shaly slit loam that has good surface and subsurface drainage. Sandy soils might have permitted better growth. Microclimate at Blain may also have favored more winter injury than would have occurred in protected locations on southerly aspects.

Both Professor Melton and I recommend that any plantings of shortleaf pine in the Ridge and Valley Province of Pennsylvania be experimental until their value is demonstrated. On the basis of the 1968 results reported in this paper, and other observations, more extensive use of this species should be limited largely to sandy soils of southeastern Pennsylvania, especially to such sections as Franklin County where shortleaf pine occurs naturally and has produced good stands.

In southeastern Pennsylvania, local trees probably form the best seed source. Seed from Morgan County, Tennessee, might also be satisfactory; this Tennessee source performed well both in our present study and in Aughanbaugh's *(1950)* study, which included 80 trees from each of six sources planted in Franklin County. Although Aughanbaugh's study did not include planted trees of a local source, he did state that native Franklin County shortleaf pines grew much faster than trees from out-of-state sources.

CONCLUSIONS

Local seed should be used in establishing loblolly pine stands in Maryland and shortleaf pine stands in southern New Jersey or southeastern Pennsylvania. Local sources provide trees adapted to the local climates, and these trees usually grow much faster in the Northeast than stems that originate from seed collected farther south.

In Pennsylvania, only experimental plantings of shortleaf pine seem advisable in the Ridge and Valley Province, and these should be restricted to apparently favorable site and climatic conditions. More extensive plantings of shortleaf pine should be limited to areas southeast of that province, and mostly to the southernmost counties.

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