SOUTHERN FOREST EXPERIMENT STATION

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

EARLY YIELD OF EROSION-CONTROL PLANTATIONS IN NORTH MISSISSIPPI

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A survey of 8,005 acres of pulpwood-size pine plantations on eroded sites showed that survival was 38 percent in loblolly, 48 percent in shortleaf, and 29 percent in slash. Average annual growth per acre was 0.89 cord for loblolly, 0.58 cord for shortleaf, and 0.88 cord for slash. Form class was 2 to 3 percentage points better in loblolly than in shortleaf. Estimates of rough cord volume per acre of loblolly and shortleaf can be made with the regression equations and tables based on this sample. Case histories and observations suggest how plantations can be managed for timber as well as for site protection and improvement.

This note reports the results of a survey of pulpwood-size pine plantations on eroded sites in the Yazoo-Little Tallahatchie watershed of north Mississippi. The purpose of the survey was to answer questions being asked by foresters and landowners: What is the survival and general condition of these plantations? What volume have they produced? How does loblolly compare with shortleaf pine?

METHODS

With the aid of aerial photos, 199 locations were selected. To qualify, a location had to be in a stand of pine that had been planted in March 1947 or earlier and that did not contain ribbons of hardwoods. At each one the sample point *(2)* [2] that was closest to an identifiable geographic feature (road intersection, fence corner, numbered power or telephone pole) was located on the photo and related to the feature by compass direction and distance. Any additional sample points falling within the same sample plantation were then gridded out in cardinal directions at spacings of 550 feet. Each sample point was monumented as a permanent growth plot, for which soil type, slope, topographic position, and need for stand improvement were recorded.

The soils within the Project area are extremely varied. Of the loblolly plots, 70 are on loessial soils, 20 on Coastal Plain soils. Of the shortleaf plots, 59 are on loessial soils, 28 on Coastal Plain soils. Nineteen plots are on mixed alluvium. The soil series most frequent-

[1] The author is in charge of the project on management of erosive watersheds. This project is maintained at Oxford, Mississippi, in cooperation with the University of Mississippi. The Yazoo-Little Tallahatchie Flood Prevention Project and the Soil Conservation Service, U. S. Department of Agriculture, assisted with the field work of the survey reported here.

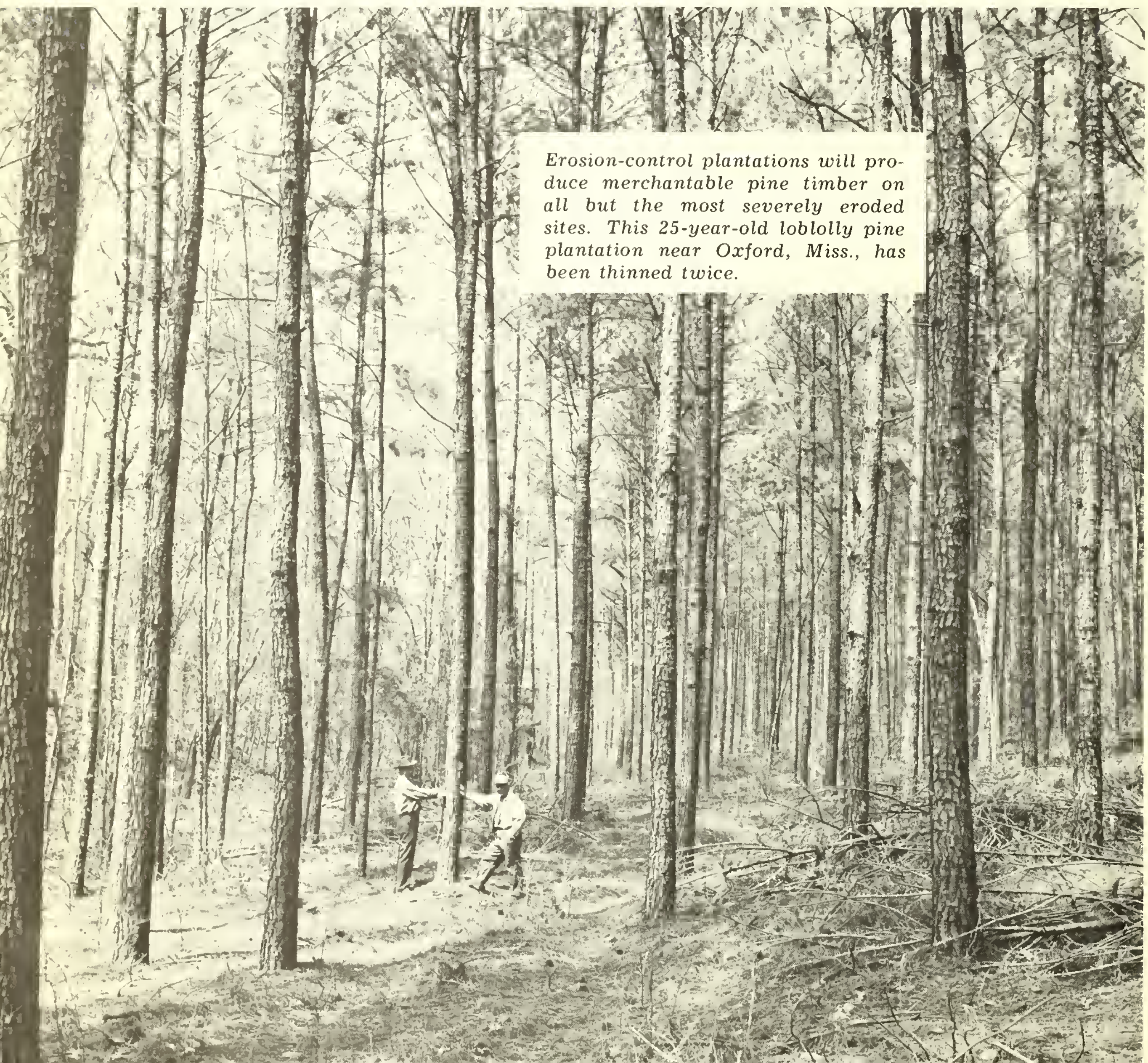
[2] Italic numbers in parentheses refer to Literature Cited, at the end of this note.

ly recorded in this survey were Loring, 26 plots; Providence, 34; Grenada, 21; Ruston, 19.

From the sample points, trees were selected for measurement with a prism having a basal area factor of 10. Increment cores were taken to pith center at stump height on two or more trees selected from each sample point. Tree age was estimated as the ring count plus one. Wherever possible age was verified with planting records. Loblolly ranged from 16 to 26 years, shortleaf from 16 to 24. For each cut pine a record was made of stump diameter, age of tree when cut, and cutting date.

Volumes in rough cords per acre (in trees 5 inches and larger) were determined from Minor's merchantable-length tables *(3)*. It was necessary to extend these tables downward to include form class groups 45 to 49, 50 to 54, 55 to 59, and 60 to 64, and merchantable lengths of 10 and 15 feet. Minor's bark-thickness values *(4)* were employed in determining butt-log volumes by Huber's formula. Upper-log volumes were computed with Smalian's formula. A conversion factor of 75 cubic feet = 1 cord was applied in extending the original tables. Trees with form classes of less than 45 were ignored in the volume computations.

Volume computations of the cut trees were based upon stump data. D.b.h. values for the various stump diameters were read from table 172 of Miscellaneous Publication 50 *(5)*. Merchantable height of a cut tree was assumed to be the average for standing trees of the same diameter.



Erosion-control plantations will produce merchantable pine timber on all but the most severely eroded sites. This 25-year-old loblolly pine plantation near Oxford, Miss., has been thinned twice.

The heights of the five trees of largest d.b.h. on each plot were used in determining site index from Coile and Schumacher's curves *(1)*.

RESULTS

In the 4.2 million acres of the Y-LT Project, the area and volume of pulpwood-size plantations in August 1959 were estimated to be:

Species	Acres	Cords
Loblolly	3,982	63,314
Shortleaf	3,540	42,126
Slash	483	7,631

Of the 199 point samples established, 99 were loblolly, 88 were shortleaf (7 of which had no merchantable trees), and 12 were slash. Average site index for loblolly and slash was 70; for shortleaf, 54. Ranges in site index were 40 to 100 for loblolly, 24 to 81 for shortleaf, and 58 to 79 for slash.

Survival.—Eighty-eight percent of the loblolly plots and 92 percent of the shortleaf had been planted at a spacing of 6 by 6 feet. Survival calculations were based upon the number of trees per acre supposedly planted at the various spacings. Survival for all spacings averaged 38 percent in loblolly, 48 percent in shortleaf, and 29 percent in slash. In plantations established at 6- by 6-foot spacing, average number of trees per acre before thinning was 494 loblolly and 633 shortleaf.

Growth.—Average annual growth per acre was 0.89 cord for loblolly, 0.58 cord for shortleaf, and 0.88 cord for slash. Here is additional evidence *(6)* that in north Mississippi, as well as in west Tennessee *(7)*, the early volume growth of loblolly pine is approximately 50 percent more than that of shortleaf. Individual loblolly and shortleaf plots had grown as much as 2.36 and 2.05 cords per acre per year, respectively. For the best 25 percent of the plots annual growth per acre averaged 1.65 cords for loblolly, 1.17 cords for shortleaf. On the poorest 25 percent of the plots it averaged 0.20 cord for loblolly and 0.11 cord for shortleaf.

For loblolly and shortleaf pines, regressions were fitted of rough cords (in trees 5 inches d.b.h. and over) as a function of the following independent variables:

Stand age
Height of dominants
Soil group
Topographic position
Number of trees 1 inch d.b.h. and over per acre
Sum of diameters for trees 1 inch d.b.h. and over
Basal area per acre in trees 1 inch d.b.h. and over
Mean diameter

$$\frac{\Sigma\,(\text{Diameter}^2)}{\Sigma\,(\text{Diameter})}$$

The table below summarizes the regression equations—significant at the 0.01 level—which were the most practical for determining rough cord volume per acre.

The last two are considered most convenient for field use and account for 88.5 and 81.6 percent of the variation, respectively. The equations are:

Loblolly cord volume per acre = 0.4603 height of dominants + 0.1673 B.A. − 19.66

Shortleaf cord volume per acre = 0.5423 height of dominants + 0.1242 B.A. − 20.06

Species	Height of dominants	Sum of diameters	Basal area	Mean diameter	Constant	Mean square residual	R^2
			Regression coefficients				
Loblolly	0.2847	—0.0063	0.3364	—0.9164	—5.8042	10.95	0.92
Shortleaf	.2901	—.0072	.3531	—1.0557	—4.5306	5.81	.92
Loblolly	.2277	—.0044	.2940		—10.6225	12.15	.92
Shortleaf	.2607	—.0054	.3051		—11.0318	6.48	.92
Loblolly		—.0061	.3580		—2.2949	14.06	.90
Shortleaf		—.0068	.3597		—1.8312	8.54	.90
Loblolly	.4603		.1673		—19.6599	17.28	.885
Shortleaf	.5423		.1242		—20.0649	13.05	.816

Volumes computed from these regressions are given in tables 1 and 2. Foresters in north Mississippi can estimate the stand basal area with a wedge prism, determine the height of the dominants with an Abney level or Suunto clinometer, and then look up the volume of the stand in the applicable table.

Form class.—Form class measurements were taken on 802 loblolly, 680 shortleaf, and 93 slash pine trees. The form class of loblolly was consistently 2 to 3 percentage points better than that of shortleaf. On loblolly sites with an index of 70 or more the form class averaged about 4 points per diameter class better than on sites of less than 70. Loblolly 20 years and older averaged about 6 points better than younger stands in form class. On shortleaf sites of 60 or more, the form class averaged about 6 points per diameter class better than on sites of less than 60. Differences between shortleaf trees older and younger than 20 years were minor, probably because age was confounded by site differences. Table 3 was computed for use in constructing local volume tables for north Mississippi.

The form class of young pine plantations improved rapidly after the first thinning and with increasing age. Numbered trees in loblolly plantations thinned at 17 and 19 years improved 7 points in 5 years. In a shortleaf stand thinned at 23 years trees were 4 points better 5 years after thinning.

Table 1.—*Loblolly pine volume*

(In rough cords per acre)

Basal area per acre (square feet)	Height of dominants in feet							
	25	30	35	40	45	50	55	60
20	...	...	...	2.10	4.40	6.70	9.00	11.30
40	...	0.83	3.14	5.45	7.75	10.05	12.35	14.65
60	1.89	4.18	6.49	8.80	11.10	13.40	15.70	18.00
80	5.23	7.53	9.84	12.14	14.44	16.75	18.05	21.34
100	8.58	10.88	13.19	15.48	17.78	20.09	22.39	24.69
120	11.92	14.23	16.54	18.83	21.13	23.44	25.73	28.04
140	15.27	17.58	19.89	22.18	24.48	26.79	29.08	31.39
160	18.62	20.94	23.24	25.53	27.83	30.14	32.42	34.74
180	21.96	24.29	26.59	28.87	31.17	33.49	35.77	38.09
200	25.31	27.64	29.95	32.24	34.52	36.83	39.12	41.42
220	28.65	31.00	33.26	35.56	37.86	40.17	42.46	44.76

Table 2.—*Shortleaf pine volume*

(In rough cords per acre)

Basal area per acre (square feet)	Height of dominants in feet							
	25	30	35	40	45	50	55	60
20	.	..	1.40	4.11	6.82	9.53	12.25	14.96
40	.	1.17	3.88	6.59	9.30	12.01	14.73	17.44
60	0.94	3.66	6.37	9.08	11.79	14.50	17.22	19.93
80	3.43	6.14	8.85	11.56	14.27	16.98	19.70	22.41
100	5.91	8.62	11.34	14.05	16.76	19.47	22.18	24.89
120	8.40	11.11	13.82	16.53	19.24	21.95	24.66	27.37
140	10.88	13.59	16.31	19.02	21.73	24.44	27.15	29.86
160	13.37	16.07	18.79	21.50	24.21	26.92	29.63	32.34
180	15.85	18.56	21.27	23.99	26.70	29.41	32.12	34.83
200	18.34	21.04	23.75	26.47	29.18	31.89	34.61	37.31
220	20.82	23.52	26.24	28.95	31.66	34.37	37.09	39.80

Table 3.—*Form classes for pine plantations in north Mississippi*

D.b.h. (inches)	Group I[1]	Group II[2]	Group III[3]
	---- Percent ----		
5	57	57	62
6	62	62	67
7	62	67	67
8	67	67	72
9	72	72	72
10	67	72	72
11	62	72	77
12	..		77

[1] Applicable to shortleaf on sites of less than SI (site index) 60, younger than 20 years, or never thinned.
[2] Applicable to shortleaf on sites of SI 60 or more, 20 years or older, or younger stands previously thinned; and loblolly on sites of less than SI 70, younger than 20 years, or never thinned.
[3] Applicable to slash and loblolly on sites of SI 70 or better, 20 years or older, or younger stands previously thinned.

Soils.—Loblolly has been successfully established on a wider range of sites than shortleaf and has been more adaptive to poor sites. Shortleaf has not grown well on bottom-land soils.

It was impossible to detect a relationship between site index and any of the following soil variables: depth of the A horizon, depth to the least permeable layer, texture of the least permeable layer, and depth to the least permeable layer $\times$ texture of the least permeable layer. The most obvious explanation is that the trees may have been too young to fully reflect site quality. Uniformity of soil, topography, and stand was not a requirement of the sampling design. It is also possible that the site index curves used are not entirely suitable for such young stands or that varying degrees of erosion confused the picture.

Thinning.—Eighty-four plots (42 percent) had basal areas of 110 square feet or more and probably should be thinned. Forty-two plots (26 percent) had basal areas of less than 60 square feet, which is probably too low for maximum returns.

Twenty-nine percent of the study plots had been indiscriminately thinned prior to this survey. Some spots with initial basal areas of 20 square feet per acre had been thinned; others had 200 square feet of basal area per acre after thinning. The average thinning had removed 38 square feet of basal area or 6.2 cords per acre.

Timber stand improvement.—Most of the study plantations had been established in bare, eroding fields on which only a few hardwood sprouts were growing. Only 19 percent of the plots needed any release from competition. These were along intermittent streams, in minor stream bottoms, and wherever there was a luxuriant growth of kudzu, muscadine, or cow-itch vines.

MANAGED PLANTATION GROWTH

Most of the stands that were sampled had received little or no management. What would be the effect of careful thinning on the growth of some of the well-stocked plantations? The three case histories cited below are of plantations under the management of experienced foresters.

Cases 1 and 2.—In 1955 a plantation management study was established near Lexington, Tenn., in a 19-year-old loblolly pine plantation on Providence soil with an average site index of 77. A similar study was installed in 1956 near Oxford, Miss., in 23-year-old shortleaf pine plantations with an average site index of 64. Seven thinning treatments were applied, and unthinned check plots established. Basal areas after thinning ranged from 67 to 144 square feet for loblolly and from 64 to 130 square feet for shortleaf.

Average annual growth per acre before thinning was 1.10 cords for loblolly and 0.89 cord for shortleaf. Results 5 years after thinning are shown in table 4. The loblolly stands have produced an average of one-half cord per acre per year more than the shortleaf. Thinning salvaged trees that were beginning to die and released selected saw-log crop trees from competition. The full effects of treatment or of basal area left at the beginning of the 5-year cutting cycle are not yet apparent.

Case 3.—In March 1957 a study was established in 17-year-old loblolly pine plantations near Oxford, Miss., to determine the effect of stand density and site on volume growth per acre. Six plots were laid out in plantations which 5 years later had a site index of 86, and six in plantations with a site index of 74. Three plots on each site were thinned to leave 70 to 75 square feet of basal area per acre, and three were thinned to leave 100 to 105 square feet.

Average annual growth per acre on the better sites before thinning was 1.05 cords, on

Table 4.—*Pine volume growth per acre by treatments*

Treatment	Loblolly		Shortleaf	
	Residual basal area in 1955	Annual growth, 1955-60	Residual basal area in 1956	Annual growth, 1956-61
	Sq. ft.	*Cords*	*Sq. ft.*	*Cords*
D+6	67	1.78	64	1.43
Thinned to 70-75 sq. ft.	74	2.05	73	1.28
Every third row removed	85	1.78	88	1.03
Every fourth row removed	96	1.89	100	1.72
Thinned to 120 sq. ft.	120	2.41	120	2.05
Thinned to 120 sq. ft. decreasing by 5 sq. ft. at each thinning	120	1.91	120	1.26
7 diopter prism—excess over 2 trees per point removed	107	2.34	94	1.72
Check—no thinning	144	2.11	130	1.59

the poorer sites 0.76 cord. Annual growth during the 5 years after thinning was:

Residual basal area	Growth	
	Site 74	Site 86
	— — — *Cords* — — —	
70	2.27	3.23
100	2.50	4.05

These early data suggest the importance of leaving heavier basal areas on the better sites if maximum volume growth is the goal.

SUGGESTIONS FOR MANAGEMENT

While the data are too incomplete for firm conclusions to be drawn, some tentative observations may be made on managing erosion-control plantings.

Pine plantations improve the characteristics of the upper soil profile *(6)*. They not only protect the site with their heavy litter but also gradually improve infiltration rates and the moisture-holding capacity of eroded soils. Ultimately the productivity will be improved.

Care of pine plantations during the first 5 years is extremely important. All failed areas of one-tenth acre or larger should be promptly replanted. If undesirable hardwoods are growing within the plantation, they should be deadened soon after the pines are planted. A follow-up killing of hardwood sprouts is frequently needed 3 to 5 years after planting. Firelines should be plowed between the plantation and all adjacent roads. Large plantations should be broken into 40-acre blocks with natural barriers and plowed firelines.

Site protection as well as maximum timber production should be primary objectives in managing pine plantations established on highly erosive soils. To meet these objectives, thinning should be primarily from below. Very little thinning, except for salvage, should be done in gullies or on gully edges. Close spacing of logging roads will prevent overuse and thus minimize rutting and soil exposure. Logging crews should be trained in site-protection practices and closely supervised.

If quality saw logs are the primary objective of management, stands should be thinned to a basal area of approximately 85 square feet per acre on good sites and 70 square feet on fair sites. Basal areas 15 feet greater than these should be left if maximum pulpwood production is desired. The minimum operable cut per acre is 3 cords. On sites with an index of 80 or better a 3-year cutting cycle is feasible for loblolly pine; on poorer sites, a 5-year cutting cycle. Cutting cycles for shortleaf pine should be 5 years on sites of 70 or better and 7 years on poorer sites. Heavy cuts increase erosion risks, but involve longer cutting cycles with less frequent site disturbance.

On all but the most severely eroded sites, erosion-control plantations will produce merchantable wood. Annual volume growth of a stand generally increases substantially following the first thinning, because of rapid increases in diameter, form class, and merchantable height. Gross returns from clear cutting loblolly plantations at 20 years of age will approximate 20 cords per acre. But three thinnings made at 5-year intervals starting at age 20 will return this much and leave the landowner with a stand worth as much as or more than the wood removed—a stand increasing in value each year as it approaches saw log size.

LITERATURE CITED

(1) Coile, T. S., and Schumacher, F. X.
1953. site index of young stands of loblolly and shortleaf pines in the piedmont plateau region. Jour. Forestry 51: 432-435, illus.

(2) Grosenbaugh, L. R.
1958. point-sampling and line-sampling: probability theory, geometric implications, synthesis. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 160, 34 pp., illus.

(3) Minor, C. O.
1950. form class volume tables for use in southern pine pulpwood timber estimating. La. Agr. Expt. Sta. Bul. 445, 39 pp.

(4) ———
1953. loblolly pine bark thickness. La. State Univ. Forestry Notes 1, 2 pp., illus.

(5) U. S. Forest Service.
1929. volume, yield, and stand tables for second-growth southern pines. U. S. Dept. Agr. Misc. Pub. 50, 202 pp., illus.

(6) Ursic, S. J.
1963. planting loblolly pine for erosion control in north mississippi. U. S. Forest Serv. Res. Paper SO-3, 20 pp., illus. South. Forest Expt. Sta., New Orleans, La.

(7) Williston, H. L.
1959. growth of four southern pines in west tennessee. Jour. Forestry 57: 661-662.

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RESEARCH NOTE

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CARE OF PINE SEEDLINGS USED IN BREEDING AT INSTITUTE OF FOREST GENETICS

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This note describes methods developed and practiced by the Institute of Forest Genetics to insure the high survival and thrifty seedlings needed for some types of research. The special care begins with seed extraction and extends through the early years in plantation. While the methods were developed primarily for longleaf, which in ordinary practice is notorious for poor survival and slow height growth, they are also applicable to other tree species or hybrids.

The essentials are: transfer of nursery seedlings to pots for a few months between lifting and outplanting, clean cultivation of plantations, and control of diseases and insects. Over several years 11,000 longleaf pines have been planted by this method. First-year survivals have ranged from 95 to 97 percent, and 94 percent of the trees have begun height growth their second year in the field. In July of their fourth year the tallest trees were more than 10 feet in height.

In comparison, barerooted seedlings, planted directly from the nursery bed, had first-year survivals of 82 percent and averaged 7 feet tall after 4 years on an exceptionally productive site that was thoroughly cultivated. For barerooted stock planted on unprepared sites, average height at 4 years was only 1 foot, even though the brown spot disease had been controlled.

These longleaf pines were planted from pots on a prepared site, cultivated 2 years, and mowed the third. This photo was taken in July of the fourth year.

Seed Handling

Cones are dried and seeds extracted in a 28-bushel kiln designed by McLemore.[1] The Institute's model is modified to hold 48 small lots, and the drawers are additionally screened on the top to prevent loss of seeds. After extraction, seeds are dewinged by hand and partially cleaned in a fanning mill.

Final separation of sound from hollow seed without loss of some of the sound seed requires a more sensitive device than the fanning mill. Electronic methods are under development but meanwhile alcohol flotation is practiced for all but longleaf seed, which is separated on a sensitive balance.

Nursery Practice

The nursery beds are 4 feet wide, elevated to provide drainage, and enclosed with side boards. Each year before sowing begins, old roots and other trash are removed and the beds are fertilized and reworked. Applications per acre of bed area (excluding paths) consist of 2,000 pounds of 20-percent superphosphate, 200 pounds of 50-percent muriate of potash, and 50 pounds of nitrogen in urea form. After these are distributed uniformly over the beds, the soil and fertilizers are mixed to a depth of 8 inches with a small rototiller and the beds are raked level. Every three to four years pine sawdust, four to five years old, is applied ¾-inch deep along with the fertilizers.

Allyl alcohol is applied to the beds for pre-sowing weed control and to combat early damping-off[2] One quart is mixed in 50 gallons of water and applied uniformly over 200 square feet of bed area with a sprinkling can. Sowing is deferred until at least 3 days after the alcohol application.

Every third year one-fourth pint of 75-percent emulsifiable chlordane is added to each 50 gallons of the allyl alcohol solution to control white grubs.

Sufficient seeds are sown to produce nursery densities of 15 seedlings per square foot for longleaf, 25 for slash and loblolly, and 30 for shortleaf and spruce pines. Seeds of loblolly, shortleaf, and spruce pines (and of hybrids whose female parent belongs to one of these species) are stratified at 40° F. for 30 to 60 days. Seeds from longleaf and slash trees are not stratified, though slash seeds are sometimes soaked in water for 6 hours prior to sowing to hasten germination. In sowing, the seeds are equally spaced with a seedboard in drills 6 inches apart across the bed. They are then pressed into the soil and covered with fine-mesh burlap or loblolly pine needles. The cover is removed after seeds germinate.

During the growing season the beds are watered with an overhead sprinkler system and weeded by hand.

Post-sowing applications of nitrogen are made by dissolving ammonium nitrate in water and applying it as a side dressing at the rate of 25 pounds of elemental nitrogen per acre per application. Two, or occasionally three, applications are made per year, with the last one completed by mid-September. Immediately after each application the trees are sprinkled to rinse all salts off the needles.

Potting

Planting shock is minimized by growing the seedlings in individual pots for 1 to 4 months after they are lifted from the nursery bed. Potting begins early in December after the seedlings have hardened off in the nursery and may continue until about March 1. As the root system formed in the pots is not disturbed during outplanting, field growth of the seedlings is prompt.

When the seedlings are to be kept in containers less than 4 months, they are potted in standard quart milk cartons 2¾ inches square and 7 to 10 inches deep. The cartons are easy to store and handle, and their cost is low. They must either be waxed or plastic-coated, since chemicals from uncoated paper will poison the seedlings. Waxed cartons, shaped for planting, are available at about 3 cents each from local milk plants. Collapsed plastic-coated cartons may be purchased from paper companies for about 2 cents apiece, but the bottoms must be shaped and heat-sealed by the potter. The additional operation brings the total cost to about 3 cents also. In either case, four ¼-inch drain holes are punched in the bottom of the cartons. Semi-automatic machines are being developed to heat-seal cartons and punch the holes. If the seedlings are to be held longer

[1] McLemore, B. F. 1960. Small, fast-drying cone kiln. Forest Farmer 19(13): 10-11, 15, illus.

[2] Lindgren, R. M., and Henry, B. W. 1949. Promising treatments for controlling root disease and weeds in a southern pine nursery. U. S. Dept. Agr. Plant Dis. Rptr. 33: 228-231.

than 4 months, large tar-paper pots 6½ to 9½ inches deep, costing about 7 cents each, are obtained from nursery supply houses.

Topsoil with about 60 percent sand is used in the potting mixture. It is screened through ½-inch mesh hardware cloth. One cubic yard of soil is mixed with 9 cubic feet of peat moss and 2 pounds of 5-10-5 fertilizer. To control root diseases, the soil mixture is fumigated under polyethylene sheeting by applying 1 pound of methyl bromide to each cubic yard.

For the potting operation the soil is loaded on a pickup truck, which is driven as close as possible to the concrete troughs in which the potted seedlings are held until ready for field planting. A five-man crew is efficient. Two men lift the seedlings from the nursery beds, prune their roots, and bring them to the truck, along with the empty pots. Longleaf needles are pruned to about 5 inches to ease handling and spraying the potted stock; other species are not top-pruned. The two potters work at the back of the truck, whose rear wheels are run up on ramps until the bed is at convenient height. The potters fill the cartons completely and vigorously jar them to prevent the soil from settling appreciably after it is wetted. The fifth man places the potted plants in the concrete troughs. In a day, the crew can pot 2,000 seedlings in milk cartons or 750 in tar-paper pots. This includes lifting, sorting, tagging, pruning, and transport.

The concrete troughs (8 inches deep, 50 inches wide, and 35 feet long) are designed for watering potted plants from below. Their slightly sloping bottoms are covered with gravel; a water faucet and drain plug are at the lower end.

Site Preparation

The areas selected for experimental plantations are recently cleared pine forest land or formerly cropped fields that have been abandoned. Sites are chosen for uniformity in desirable soil properties such as depth, texture, and fertility. Relatively level areas are selected, so that erosion will be at a minimum.

The stumps and logging debris on cutover pine sites are removed with land-clearing equipment. Clearing is contracted for, at $50 to $75 per acre. The land is then leveled by plowing and disking. To insure that the site will be in suitable condition at planting time, clearing and leveling are done about 1 year in advance.

Abandoned fields that are free of woody vegetation are much less expensive to prepare, since plowing and disking with light equipment usually suffice. However, if long-time studies are contemplated, the lower cost on old fields should be weighed against the higher hazard from *Fomes annosus* root rot.[3]

Triangular Spacing

In most of the Institute's experimental plantations on prepared sites, rows are spaced either 10 or 12 feet apart. These distances provide ample space for root and crown development and afford clearance for cultivation for 2 or 3 years with a 6- or 8-foot tandem disk.

Equilateral triangular spacing has certain advantages over square spacing and has been used in recent plantings at the Institute. It provides more uniform space for crown and root development both within and between rows. It also permits cultivation in three directions, which aids in erosion control and reduces the area adjacent to the trees that requires hoeing. Distances on the row spacing line should be set at intervals which are 0.866 times the designated tree spacing. Spacing tapes can be made or acquired commercially.

After the field has been surveyed the ends of the rows are located and marked with stakes. Spacing lines with anchor rods at each end are suspended between two end stakes to locate the trees in the row. These spacing lines are moved across the field from row to row as planting progresses. When large areas are being planted, however, tree locations are premarked with 10-inch pot labels.

Transplanting Seedlings in Field

At the Institute the season for field-planting potted seedlings is January through June. So far, June planting has given nearly as good survival as earlier planting.

A six-man planting crew is employed. The potted trees are hauled to the field on a truck. While three men distribute trees to the planting points, the other crew members begin planting. One man digs holes with a 6-inch power-driven auger and two men plant. After they have distributed the seedlings the three

[3] Powers, H. R., Jr., and Verrall, A. F. 1962. A closer look at Fomes annosus. Forest Farmer 21(13): 8-9, 16-17, illus.

men on the truck form a second planting crew. To reduce fatigue, workers alternate in operating the auger.

The planting hole is dug about 10 inches deep to provide space for rapid root growth, and then is partly back-filled with topsoil. The carton is taken from the seedling roots by ripping off the bottom and sliding out the block of soil. Approximately 200 seedlings potted in milk cartons can be planted per man-day. Considerably fewer transplants from tar-paper pots can be made, because the pots require more time for transport. Three man-days are required to pot 400 seedlings in milk cartons and subsequently plant them on an acre of prepared site.

Cultivating the Plantations

The plantations are cultivated with a 6-foot tandem disk operated from a light tractor equipped with hydraulic lift. Shallow disking within 1 foot of the young trees has not appreciably damaged the roots. The direction of disking is alternated in successive operations to destroy vegetation in the tree rows. The small areas surrounding the trees are hoed by hand. Normally three or four diskings per season have been adequate to control grasses and weeds.

After cultivation is discontinued the plantation may be seeded to carpetgrass to aid in erosion control and mowed to keep down unwanted vegetation. The sod reduces fire hazard and improves accessibility. A 5-foot rotary mower drawn by a light tractor is used.

Disease and Insect Control

To control brown spot disease, bordeaux mixture is applied when the secondary needles of longleaf appear in the nursery—about June 15—and thereafter at 6-week intervals: August 1, September 15, November 1. Slash and loblolly pines also receive the August and November sprays. Outplanted longleaf is sprayed May 1, July 1, and September 1. Applications are made routinely until seedlings are 18 inches tall and if necessary continued until the disease is no longer damaging. The bordeaux is prepared by dissolving 5 pounds of copper sulfate in 25 gallons of water, and 1.6 pounds of lime (freshly slaked quicklime or fresh, finely divided hydrated lime) in another 25 gallons of water. The two solutions are then mixed, and ½ pint of Santomerse S is added. It is also desirable to add 3.2 ounces of sugar to the copper sulfate solution if the sprayer lacks adequate agitation or if there is a chance the fungicide will be stored overnight.

Loblolly and slash pine are sprayed weekly for fusiform rust from the time of their germination until June 15. (In some areas with high infection rates nurseries regularly spray 2 or 3 times a week.) The rate per acre for each application is 2 pounds of ferbam and 1/3 pint of Santomerse S in 75 gallons of water. If one of the objectives is to bring the trees through free of fusiform rust, special control measures are justified for the outplantings subject to high rust infection. These measures include pruning of infected branches and sprays as proposed by Foster and Krueger.[4]

Loblolly and shortleaf pine plantations are sprayed against tip moth monthly from mid-February to mid-September, inclusive. The formulation is 4 gallons of 25-percent DDT emulsifiable concentrate in 100 gallons of water.

Red spiders appear most years in the nursery and sometimes on recently planted trees. When spider damage is seen, trees are sprayed with a malathion formulation of 2 tablespoonfuls of 57-percent concentrate per gallon of water. The application is repeated in 10 days.

Precautions additional to those mentioned above are sometimes necessary. For example, where pine trees on or near the planting site have recently been cut, the pales and other weevils may cause a plantation failure. Similarly, white grubs may be destructive if the planting site is or was recently in sod. Webworms and sawflies sometimes build up on longleaf and slash pines because seedlings of these species do not regularly receive the DDT spray.

[4] Foster, A. A., and Krueger, D. W. 1961. Protection of pine seed orchards and nurseries from fusiform rust by timing ferbam sprays to coincide with infection periods. Ga. Forest Res. Paper 1, 4 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1963

U.S. FOREST SERVICE RESEARCH NOTE

SO-3

Forest Service, U. S. Dept. of Agriculture

-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LONGLEAF PINE SEED DISPERSAL

William D. Boyer

SOUTHERN FOREST EXPERIMENT STATION

Production and dispersal of longleaf pine (*Pinus palustris* Mill.) seeds were sampled in 1955, 1957, and 1958 on the Escambia Experimental Forest in southwest Alabama.

Two transects of seed traps were established at right angles to each of four forest walls enclosing a rectangular 80-acre clearing. Walls were oriented in the cardinal directions, and consisted of second-growth longleaf pines 40 to 50 years old. Dominant trees averaged 65 feet in height.

Each transect consisted of 15 quarter-milacre paperboard seed traps spaced ½ chain apart. Transects began ½ chain inside forest walls and extended 6½ chains into the clearing. All traps were visited at least once a week during seedfall. Seeds were removed, counted, and cut to determine soundness. Counts of both total seeds and sound seeds were recorded for each trap at each visit.

In 1955 cones were counted on all trees in a 0.6-acre area at the head of each transect.

Seed production.—As sampled by traps under and within the walls, the crop averaged 104,000 sound seeds per acre in 1955 and 1958, and 19,000 per acre in 1957. There was no longleaf seed crop in 1956. Each year, seedfall began in October and peaked in November. Weekly totals of sound seeds trapped are shown in figure 1.

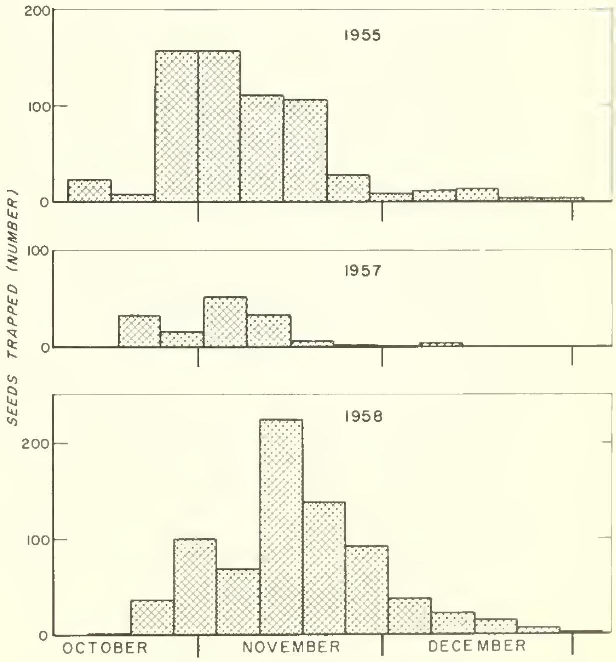

Figure 1.—*Time of longleaf pine seedfall. Data are from 120 quarter-milacre traps, and include sound seeds only.*

Production by forest walls varied considerably from year to year and wall to wall. Each year, different walls were the best and poorest producers, but the 3-year average did not differ significantly among the four walls.

Cone count in 1955 rose rapidly with tree size, going from an average of 7 cones per tree in the 8-inch d.b.h. class up to 67 cones per tree in the 13-inch d.b.h. class, at which point it leveled out.

Distance of seed dispersal.—Of all sound seeds trapped beyond the edge of forest walls, 71 percent fell no farther than one chain from the base of parent trees. Trap catches followed an exponential curve. The computed regression, for all years and walls combined, was significant at the 0.01 level, with a coefficient of determination $r^2 = 0.9932$ (fig. 2). According to the curve, the number of sound seeds dispersed was halved with each 55-link increase in distance from the seed source.

The dispersal curve is based on data from all four walls, and thus minimizes the effects of winds. The east wall dispersed a much lower proportion of seeds into the clearing than did the other walls, because the prevailing winds were westerly. While the regression formula estimates dispersal under the conditions of this study, its applicability is limited because tree heights and prevailing winds vary from place to place. The analysis does, however, define the model for the relationship of seed dispersal and distance from the forest wall: Log $Y = a + bX$.

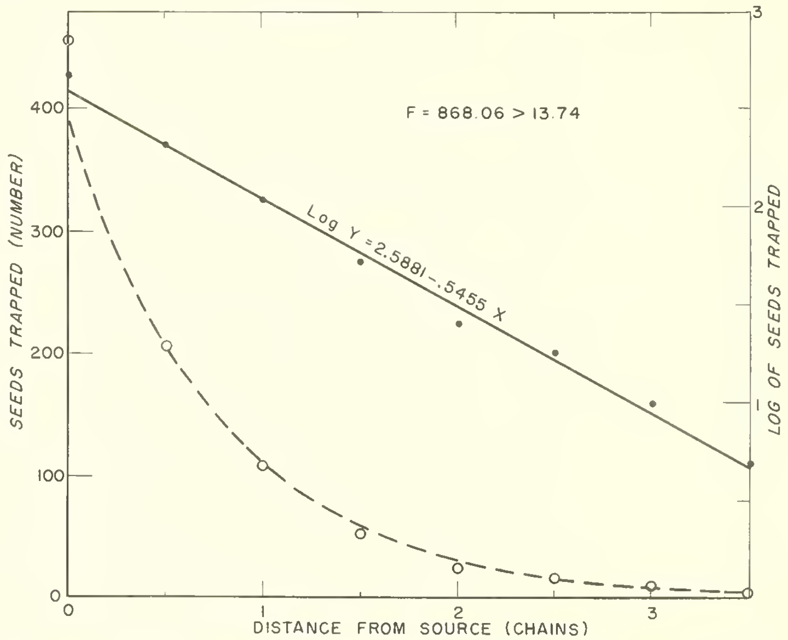

Figure 2.—*Dispersal of sound longleaf pine seeds from forest walls; 3-year total for 16 seed traps at source, and 8 traps at each location beyond source.*

SOUTHERN FOREST EXPERIMENT STATION

1963

U.S. FOREST SERVICE RESEARCH NOTE

SO-4

Forest Service, U. S. Dept. of Agriculture

10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

CONTROLLING SHRUBS ON WET SLASH PINE SITES

Lloyd F. Smith

SOUTHERN FOREST EXPERIMENT STATION

Cutting stems near groundline and spraying the fresh stumps with 2,4,5-T in diesel oil killed 99 percent of the plants within 2 years, but cost twice as much as a foliage spray with 2,4,5-T in water, which killed 66 percent.

This paper reports the effects of five 2,4,5-T spray treatments on understory shrubs bordering a stream in south Mississippi. The bottoms and terraces of small streams in the longleaf-slash pine type are among the most productive sites for slash pine, but in many places a heavy shrub understory prevents the establishment of pine seedlings. Prescribed burning is often impractical, because the soil usually is too wet for winter burning, and summer fires hot enough to kill the shrubs are likely to damage seed trees.

STUDY AREA AND METHODS

The study was installed on a stream bottom on the McNeill Experimental Forest. The soil is a deep, fine, sandy loam, well adapted for rapid growth of slash pine. Usually flowing water is present only for short periods after heavy rains, when the stream overflows onto the study site. A stand of slash pine, sweetbay, and swamp tupelo had been logged off 11 years before the study began, but scattered slash pines were left for seed production. The most abundant weed species were swamp cyrilla (*Cyrilla racemiflora* L.), large gallberry (*Ilex coriacea* (Pursh) Chapm.), common gallberry (*Ilex glabra* (L.) Gray), southern bayberry (*Myrica cerifera* L.), red maple (*Acer rubrum* L.), and common sweetleaf (*Symplocos tinctoria* (L.) L'Her). Several other shrubs and vines were present in smaller numbers.

Plots of 0.1 acre were located in a randomized block design with five replications. Five plants of each of the most abundant weed species, or 30 in all, were tagged on each plot for assessment of spray effects. Average heights of sample shrubs were: cyrilla 9.3 feet, large gallberry 9.3 feet, common gallberry 3.8 feet, bayberry 3.0 feet, red maple 6.7 feet, and sweetleaf 7.3 feet.

The spray formulations were:

1. Foliage spray of 1 gallon of 2,4,5-T (4 pounds acid) in 49 gallons of water.
2. Foliage spray of 1 gallon of 2,4,5-T in 49 gallons of a 75-25 mixture of water and No. 2 diesel oil.
3. Rootcollar spray of 1 gallon of 2,4,5-T in 19 gallons of No. 2 diesel oil.
4. Stem and rootcollar spray of 1 gallon of 2,4,5-T in 19 gallons of No. 2 diesel oil.
5. Stump spray of 1 gallon of 2,4,5-T in 19 gallons of No. 2 diesel oil. This treatment was applied to freshly cut stumps.

A single application of each spray formulation was made in August 1959, with a gear-type pressure pump operated from the power takeoff of a tractor. In all treatments the plant surface was wet to the point of runoff. Quantity of spray used ranged from 54 gallons per acre in treatment 5 to 110 gallons in treatment 2. All understory plants were sprayed on all plots in the various treatments.

EFFECTS OF TREATMENTS

Treatment 5—2,4,5-T in oil, sprayed on fresh stumps—gave the highest average kill, as measured 2 years after application (table 1). The foliage

Table 1.—*Percent of sample plants dead 2 years after treatment*

2,4,5-T treatment	Cyrilla	Large gallberry	Common gallberry	Southern bayberry	Red maple	Common sweetleaf	All species
	Percent						
1. Foliage spray in water	60	84	76	84	20	73	66
2. Foliage spray in water and oil	44	44	68	96	32	93	61
3. Rootcollar spray in oil	56	84	72	96	56	70	72
4. Stem and rootcollar spray in oil	84	88	96	96	84	100	91
5. Stump spray in oil	100	100	96	100	100	96	99
Average	69	80	82	94	58	86	78

spray of treatment 2—a 2-percent solution of 2,4,5-T in a mixture of water and oil—yielded the lowest average kill. With oil solutions, spraying both the stem and rootcollar (treatment 4) was more effective on all species except bayberry than spraying the rootcollar only (treatment 3). Plants were judged dead if stems were defoliated and no living root sprouts were present 2 years after treatment. Except for red maple, which sprouted the most vigorously, early defoliation was an index of treatment results at 2 years.

The six species varied in resistance. For all treatments, they were rated in the following order ranging from the highest to lowest kill in 2 years: bayberry, sweetleaf, common gallberry, large gallberry, cyrilla, and red maple. On cyrilla and the two gallberry species the foliage spray with 2,4,5-T in water only, in treatment 1, was more effective than the mixture of water and oil in treatment 2. The water-oil mixture was more effective on bayberry, red maple, and sweetleaf. In other studies *(2,3,4)* [1] with broad-leaved trees 2,4,5-T has usually been more effective in an oil-water mixture than in water alone. In preliminary trials on the control of gallberry, Halls *(1)* reported that 2,4,5-T in oil was superior for fall and winter sprays, but that a water carrier was more effective for spring and summer sprays. In the present study, treatment differences were significant at the 5-percent level in large gallberry and sweetleaf and at the 1-percent level in red maple. Difference in mortality due to treatments was not significant in the other species.

[1] Italic numbers in parentheses refer to Literature Cited.

COSTS

Average costs per acre ranged from $24.14 i treatment 1 to $48.24 in treatment 5. The oth treatments were intermediate. The major expendi ture in all treatments was for materials, but treatment 5 the labor of brush-cutting added costs. If the treatments were applied to large area costs probably would be substantially reduced.

LITERATURE CITED

1. Halls, L. K.
   1959. Gallberry (Ilex glabra [L.] Gray Handb.: Chemical Control of Rang Weeds, pp. W-5, W-6. Range Seec ing Equip. Com. U. S. Depts. Ag and Int.
2. Peevy, F. A.
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3. ————
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SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

1964

SO-5

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

TWO H-C FURROW SEEDERS

Thomas C. Croker, Jr.

SOUTHERN FOREST EXPERIMENT STATION

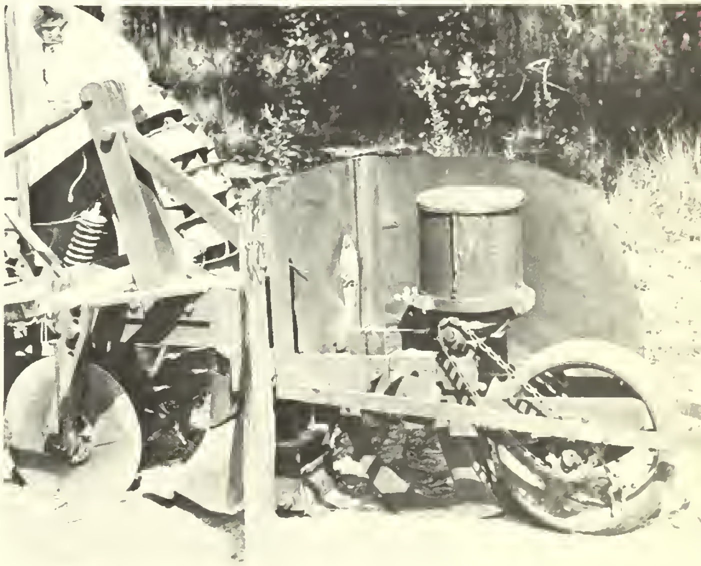
Furrow seeding is a one-man, one-trip operation designed to prepare a favorable seedbed on forest sites and sow pine seed in rows. Many machines have been developed for the job. This note illustrates and gives operating instructions for two of them, the compact H-C furrow seeder and an adaption for use behind a fireplow.[1] For those wishing to build one of the machines, a complete set of detailed drawings is available on request.

The compact model has all the components for the four basic functions in site preparation and seeding—scalping, bedding, sowing, and packing. It is designed for a three-point hitch and is ideally suited for moving from one small job to another. Its light draft enables it to be used with farm tractors.

In the other machine, the fireplow does the scalping and hillers throw up a raised bed; the sowing and packing units are largely the same as in the compact model. This machine requires more power than the compact model, is less wieldy, and is somewhat more difficult to keep in adjustment.

The compact machine prepares a narrow bed that is adequate for seedling establishment. Precautions must be taken, however, to prevent the seed or seedlings from being washed out or buried under sand, leaves, and other debris. The scalper should be set to run as shallow as possible, and the rows should follow close to the contour. Where smothering by leaves may occur, a thorough job of hardwood control should be done at least a year ahead, and the area burned before seeding. In heavy accumulations of pine needles the scalper may

FIGURE 1.—*Compact model.*



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SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-5

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

TWO H-C FURROW SEEDERS

Thomas C. Croker, Jr.

SOUTHERN FOREST EXPERIMENT STATION

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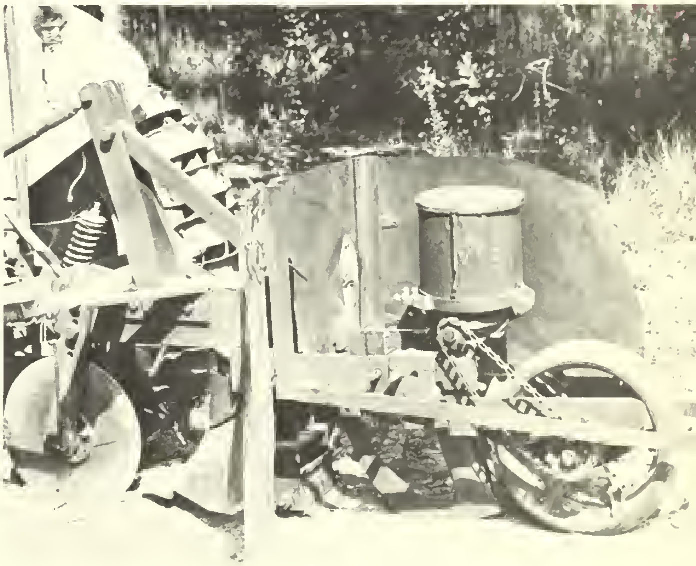

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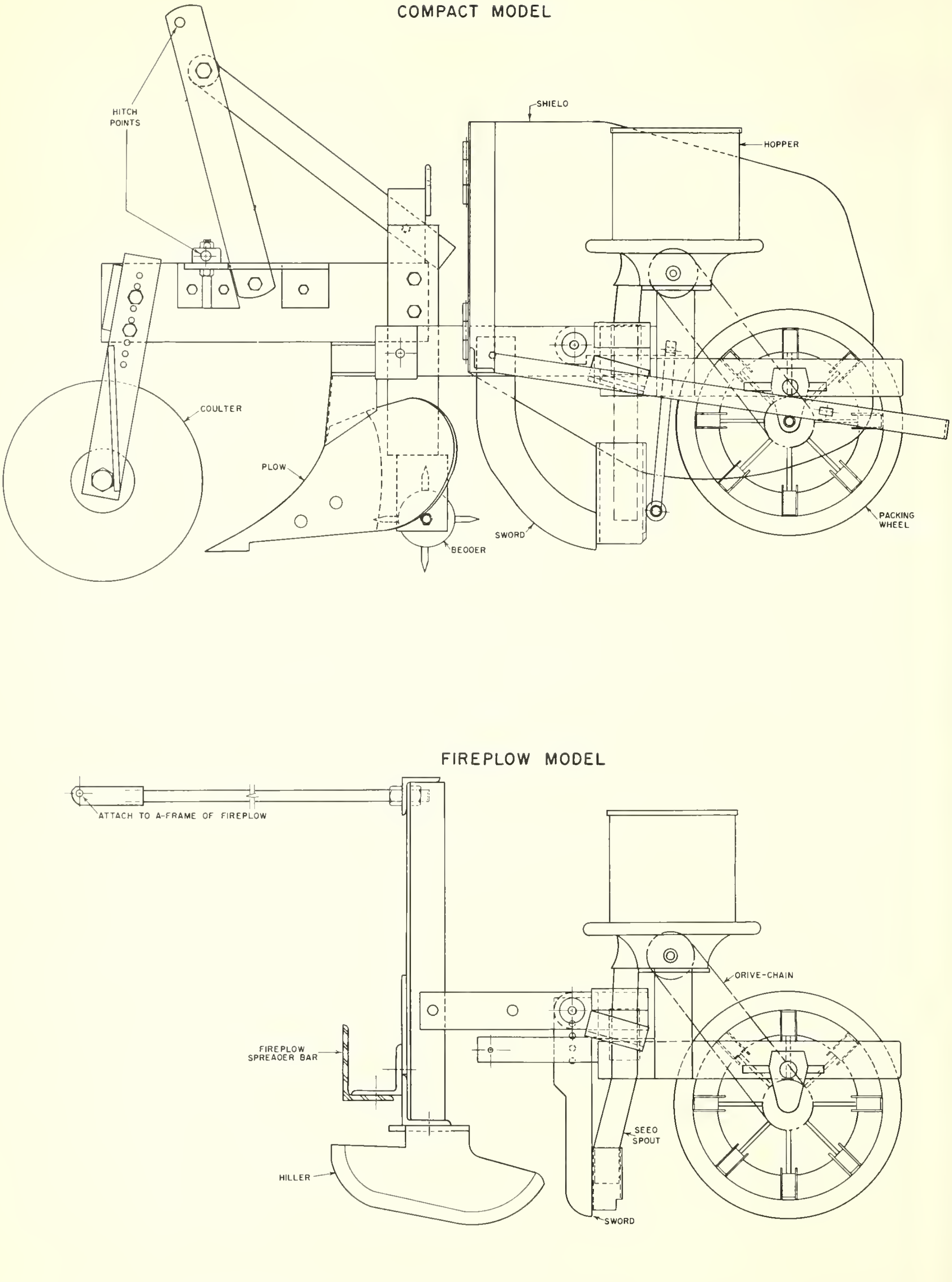

FIGURE 2.—*Construction details. Scale: 1 inch = 1 foot.*

not clear the furrow adequately; a prescribed burn may be necessary in advance of seeding to reduce the needle mat.

The raised bed created by the fireplow model is less vulnerable to washing and silting, and the scalped strip is wide enough so that hardwood leaves and pine needles are not apt to smother the seed.

ADJUSTMENT AND OPERATION

Scalper.—The scalper of the compact model consists of a coulter blade and a specially modified middlebuster plow. Its function is to clear a row about 8 inches wide without cutting a deep trench or displacing much topsoil. In a deep trench the seed is endangered by silting or erosion. On the other hand, if the plow is set too shallow the moldboards may fail to throw the debris clear—it will spill back and interfere with the bedder and the sword.

Three adjustments are needed to insure proper functioning of the scalper: the coulter should be set to cut through the litter; the turnbuckle link on the three-point hitch should be adjusted to set the plow point flat; and the bedder should be low enough to keep the plow level and at proper depth.

In the fireplow model the plow should be set to skim away debris without removing much topsoil.

Bedder.—The bedder, sometimes called the chopper, consists of a hub with four 6-inch-wide steel blades welded to it. It loosens the seedbed and makes small dams across it to prevent flow of water that would wash out seed and soil. It also backfills the groove cut by the coulter. It should be set low enough to make definite chops in the soil, but not so low that it holds the plow out of the ground. The most common malfunction, failure to turn, is usually caused by lack of grease on the axle or improper vertical adjustment. If litter or roots ball up on the bedder, the scalper probably is functioning incorrectly. Blades should be left dull to avoid the possibility of picking up chunks of wood. In heavy, wet soils, mud may pack between the blades. If such soils must be seeded, the bedder should be raised and seeding done without it.

In the fireplow model bedding is accomplished by a pair of hillers mounted on a special frame attached to the spreader bar of the fireplow. Angle and depth of the hillers are adjusted as needed to elevate a bed in the center of the cleared strip.

Sword.—In the compact model the sword is a crescent-shaped blade swinging from a vertical adjustment link. Its function is to make a small, shallow groove in the bed, and to guide the seed from the seed spout into this groove. It should be set so that it rides lightly on the ground and swings up if it hits a root or trash. Depth of the groove is determined by the desired depth for planting the seed. To deepen the groove, the front end is moved down and the lower end can be weighted as necessary.

The most common and serious error is cutting the groove too deep. Pine seed should ordinarily be planted ¼- to ½-inch deep, but best depths for various soil types and pine species remain to be determined. Trash catching on the bottom of the sword may prevent seed from reaching the ground; proper adjustment minimizes such malfunctions.

The sword on the fireplow machine is bolted rigidly in place but can be adjusted vertically for depth of groove.

Sower.—The sower for both compact and fireplow models consists of a McCormick No. 184 planter unit with combination hopper and brush cutoff. For longleaf pine, plate 1977AB is used with knocker 1223AA; for slash and loblolly, plate 3109A with filler ring 3447AB and knocker 3460AA. For other pine species, the local dealer can help select plates. Plastic plates are preferable to metal. If the plates are not seated properly, or if the knockout pawl is left off, the seed will be cracked or ground up. Before starting a sowing job it is well to run out a few seeds and check to see that no damage is occurring.

Rate at which seed is dispensed is determined by running the machine a measured distance and counting the number of seeds dropped. For this purpose the sword can be removed and the seeds caught in a bag tied to the spout. Sprockets, gears, and plates are changed as needed to secure the desired rate.

Seed supply should be checked frequently during operation, and a tight-fitting cover should be in place at all times to keep out trash and moisture. Coating the seed with aluminum flakes makes it flow smoothly.

The seed spout must be kept clear. It does not often block up, but the possibility should be kept in mind.

No seed will be dispensed if the plates fail to rotate. The causes of plate stoppage range from a limb caught crossways in the packing wheel to a displaced drive chain.

Packer.—To insure enough capillarity to provide moisture for germination, soil is packed about the seed by a wheel equipped with a zero-pressure tire. The packing wheel also drives the sower.

The wheel's most common malfunction is failure to turn, usually because trash has caught in the spokes or the axle has stuck. The drive chain is kept at proper tension by adjusting the wheel backward on the frame; this adjustment should be checked occasionally. Welding a cover plate to the spokes almost eliminates the chance of trash catching in the wheel. A stuck axle is usually due to lack of grease. This and all other moving parts of the seeder should be greased once or twice daily.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-6

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LONGLEAF SEED LOSSES TO ANIMALS ON BURNED SEEDBEDS

William D. Boyer

SOUTHERN FOREST EXPERIMENT STATION

Losses of longleaf pine seeds to animals (mostly mice, Peromyscus *spp.) in well-stocked, second-growth stands were about the same on fresh fall burns as on old roughs, worse on winter burns than on old roughs. Tree percents (the number of seedlings per 100 seeds) were low, but uniformly higher in the roughs.*

The seed crops of longleaf pine (*Pinus palustris* Mill.) are seldom large enough to feed native populations of seed-eating animals and still produce acceptable stands of seedlings. Since burning is often necessary in preparing an old rough for seedling establishment, two studies were conducted on the Escambia Experimental Forest in southwest Alabama to learn what effect fire might have on losses of seed to animals.

PROCEDURE

Small burns.—One study was in well-stocked, 40- to 60-year-old longleaf stands that had not been burned for 5 or 6 years. Two 40-acre blocks were quartered into square 10-acre plots. In each plot 24 seed-spot locations were systematically established, with three spots per location. The three spots were 18 to 24 inches apart. On each spot 10 untreated longleaf pine seeds were placed on mineral soil. All animals except insects or equally small creatures were excluded from one spot by a ¼-inch mesh wire cone about 5 inches in diameter at the base. The second spot admitted small mammals but was protected from birds and large mammals by a cage made from ¾-inch mesh hardware cloth. In this cage openings of about 1½ by 2¼ inches were cut on opposite sides to allow entrance of mammals as large as cotton rats or wood rats. The third spot was unprotected.

The spots were observed from August 24 to September 4, 1959. Two randomly selected plots in each block were burned on October 19. All spots were reestablished 2 weeks after burning, during the peak of a light seedfall.

The exclusions made it possible to estimate the seed losses to three classes of animals—insects, small mammals, and birds plus large mammals. Spots were checked 10 times between establishment and January 25, 1960.

Small-mammal populations were sampled by snap traps. One trap was placed at each of the 192 seed-spot locations and run 4 successive nights in August 1959 (before burning), February 1960, October 1960, and February 1961.

Large winter burn.—The second study was in a longleaf pine stand that had been unburned for 7 years. A 160-acre block was burned on January 16, 1962. Since no streams run through the area, the burn was complete.

Five transects were located at right angles to the control line that divided the burned from the unburned part of the stand. Each transect was 24 chains long, with half its length in the fresh burn and half in the old rough.

Six days after the fire, groups of three seed spots were placed along each transect at 1, 3, 7, and 11 chains from the fireline, in both the burn and the rough. The layout of each group, with the exclusion devices, was the same as in the first study. The spots were checked seven times through March 16, 1962.

Thirteen trap locations were established along each transect, at intervals of 2 chains. One small-mammal live trap was set at each location and run 6 nights for a total of 390 trap nights during each of three trapping periods, which began 2 months before burning and 6 days and 4 weeks after burning. Two snap traps were set at each location for a final 4-night trapping period that began 8 weeks after the fire.

RESULTS

Small burns.—On the spots sown before burning, predators destroyed or removed about 73 percent of the unprotected seeds. Differences in losses between plots scheduled for burning and those to remain unburned were not significant.

The unprotected seeds sown after burning were quickly attacked, and very few survived to become seedlings. The cumulative loss to animals (fig. 1) was similar on burned and unburned plots. However, in January the tree percent of 2.6 in the rough was significantly greater than the 0.2 percent on burned plots. Small mammals destroyed most of the seeds. Birds and large mammals, primarily birds, were more active on burned than unburned plots. Losses to insects were minor (table 1).

During the four trapping periods 46 small mammals were caught. Catches were highest in February 1960, 4 months after burning (table 2), when 27 small mammals were caught on the burns and only 10 in the roughs. The difference was significant at the 0.05 level. Small mammals were much more active on the fresh burns than in the old roughs during the winter. But November seed losses did not show any great difference in activity between burned and unburned plots.

The catch comprised 25 oldfield mice *(Peromyscus polionotus* Wagner), 14 cotton mice *(P. gossypinus* Le Conte), 4 least shrews *(Cryptotis parva* Say), 2 harvest mice *(Reithrodon-*

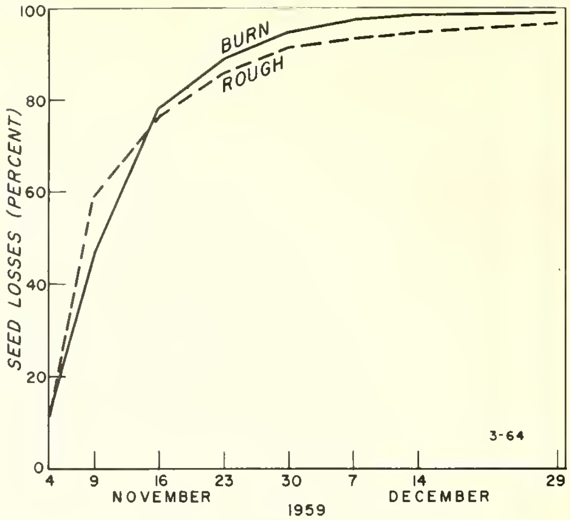

FIGURE 1.—*Cumulative loss to animals of sound, unprotected longleaf pine seeds on fresh 10-acre burns and on old roughs.*

TABLE 1.—*Proportion of unprotected seed losses caused by animals of various classes*

Animal class	Small fall burns		Large winter burn	
	Fresh burn	Old rough	Fresh burn	Old rough
	Percent			
Insects	5.5	5.3	0.5	2.0
Small mammals	68.6	78.2	87.0	81.4
Birds, large mammals	25.9	16.5	12.5	16.6

TABLE 2.—*Small mammals caught per 100 trap nights during each trapping period* [1] *on small burns*

Trapping period	Burned plots	Rough plots
August 1959 (preburn)	0.26	0.26
February 1960	7.03	2.60
October 1960	.26	.26
February 1961	.78	.52

[1] From total of 768 trap nights in a trapping period (384 burn, 384 rough).

tomys humulis Audubon and Bachman), and 1 golden mouse (*P. nuttalli* Harlan).

Arata[1] also trapped nearly three times as many *Peromyscus* (primarily *P. polionotus*) on a 150-acre winter burn as in nearby unburned areas, and trapped cotton rats in unburned areas only.

Large winter burn.—Animals, especially small mammals (table 1), destroyed unprotected seeds more rapidly and completely on the fresh burn than in the old rough (fig. 2).

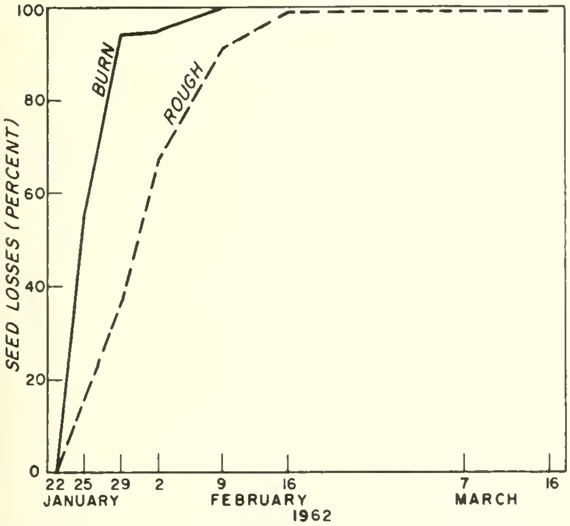

FIGURE 2.—*Cumulative loss to animals of sound, unprotected longleaf pine seeds on a fresh 160-acre burn and on old roughs.*

[1] Arata, A. A. Effects of burning on vegetation and rodent populations in a longleaf pine-turkey oak association in north-central Florida. Quart. Jour. Fla. Acad. Sci. 22: 94-104. 1959.

Within a week of seeding, they had eaten or removed 94 percent of the sound, unprotected seeds in the burn, as compared with 36 percent in the rough. Seeds were destroyed sooner 11 chains inside than 1 chain inside the burn. At the final examination, 53 days after seeding, all unprotected seeds in the burn had been destroyed. In the rough 0.5 percent survived to become established seedlings.

Despite the rapid seed loss, only five small mammals were caught in 1,690 trap nights: three cotton mice and two least shrews, not enough to show the effect of fire.

DISCUSSION

Under the conditions of the studies reported here, burning shortly before seeding may increase losses of longleaf pine seeds to animals.

Loss of seeds on the large burn, rapid compared with that in the rough, apparently was caused not by more but by hungrier animals, since normal food supply had been almost completely destroyed in the fire. Pine seed losses were affected more by availability of food than by number of animals per acre.

Seeds were sown on the large burn too soon after the fire for either a natural increase in the population of resident small mammals or an invasion from the outside to have occurred, although neither could be ruled out on the small burns.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-7

Forest Service, U. S. Dept. of Agriculture

-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

COTTONWOOD IMPROVEMENT SYSTEM FOR COMMERCIAL PLANTERS

Robert E. Farmer, Jr.,[1] **and James R. Wilcox**[2]
SOUTHERN FOREST EXPERIMENT STATION

This publication outlines a simple, inexpensive system of cottonwood *(Populus deltoides* Marsh.) improvement which can be easily and immediately incorporated into an industrial or State planting program. It is recommended for use until improved trees can be bred by more sophisticated but necessarily slower methods.

Cottonwood is currently being planted in the Lower Mississippi Valley on a moderate scale, and expanded industrial investment in plantations is expected during the coming decade. In view of this expansion it becomes increasingly important that planting stock have good genetic potential for growth rate, form, wood qualities, and pest resistance. Because of its capability for vegetative propagation, cottonwood is especially adaptable to genetic improvement through phenotypic selection.

Natural stands of cottonwood in the Mississippi Valley are made up of individuals that vary in growth rate, form, and apparent resistance to pests. The appearance or demonstrable characteristics of each individual make up its phenotype. Phenotypic variation in natural stands of cottonwood usually takes the familiar form of a bell-shaped curve for each characteristic measured.

Much of the variation between individuals within stands and especially between individuals from different stands results from environmental or site effects. Growth rate is especially influenced by site. A large degree of the variation between individuals, however, is due to inherent differences determined by genetic makeup, or genotype. A tree's genotype is fixed throughout its life and interacts with the environment to determine the tree's final form, or phenotype.

In cottonwood a single genotype can be extended, without alteration, through vegetative propagation. The original seedling is termed the ortet and the individual plants arising from its cuttings are known as ramets. A group of ramets originating from a single ortet is a clone. A clone, whether it consists of 10 or 10 million plants, thus represents a single genotype.

The task of the cottonwood improver is to select from a variable population phenotypes

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[2] Stationed at the Institute of Forest Genetics, Gulfport, Miss.

with superior genetic potential. Using the testing procedures outlined below, he can determine if selected phenotypes are in fact genetically superior. The genetically superior selections can then be propagated by cuttings and planted commercially.

SELECTION

The first step in genetic improvement is to select, either from natural stands or young plantations, phenotypes that appear superior. A natural stand used for selection should be on an extensive, fairly uniform site. A stand close to a large number of seed trees probably will offer a wider range of choice—hence a better chance of finding exceptional trees—than one that originated from a small number of seed trees. For the same reason, plantations should be used for selection only if they were established from seedlings or from cuttings taken from a large number of seedlings. No selections should be made when a superior site or lack of competition is the obvious cause of the good phenotype.

The trees chosen should be 2 to 3 years old; older ones are difficult to propagate vegetatively. At least 50 to 100 plants that are free of disease and insect damage, have no deforming forks or crooks, and are in the upper 1 percent of the stand in terms of height and diameter should be selected. As many 20-inch-long cuttings as possible should be made from each tree.

PROPAGATION

As the cuttings from the selected trees will be too few for a test, they should be propagated in a nursery until there is enough material in each clone (30 to 100 cuttings, depending upon the size of the test). Usually a year in the nursery will suffice; Maisenhelder describes methods for establishing a nursery.[3] Clones must be carefully identified; an easy way is to assign each clone to a single nursery row.

After testing begins, some trees from each clone should be held in the nursery by repeated annual planting or by cutting established trees back to the rootstocks. This will retain clones in the juvenile stage so that they can be easily propagated at any time desired, either for further testing or for commercial planting.

TESTING

The purpose of testing is to compare the performance of selected clones under uniform environmental conditions. This requires that all clones be planted in several replications on a given site.

Special care should be taken to make tests on areas that represent commercial planting sites. Performance of clones will be affected by both genotype and environment, and some clones which do best on a given site can be expected to continue their good performance only on that site or similar ones. Other clones may perform well on all sites tested; they will be of particular interest to the tree improver because of their wider utility. Methods of site quality determination described by Broadfoot[4] are useful in selecting sites.

The test layout described here assumes that 50 clones will be tested on three sites. It can be modified to incorporate additional numbers of clones or replications. The design is a randomized block with four replications on each site (more replications would be desirable). Each replication consists of a different randomization of the 50 clones. A single clone in each replication is represented by two ramets. One possible arrangement of the experiment on a single site is shown in figure 1. It is essential that soil type, depth, and drainage be uniform within each replication.

With planting techniques described by Maisenhelder,[5] the clonal test can be established as a separate enterprise or in conjunction with a commercial planting. In the latter case, selected clones may be planted alternately with standard cuttings. Trees grown from standard cuttings then serve as fillers which can be removed when an initial thinning is needed. Later thinnings can be made by removing one-half the ramets of selected clones. A standard spacing of 12 feet by 12 feet is recommended, and at least two rows of border trees should surround the test. All ramets should be identified as to clonal source (metal tags on heavy wire stakes are suitable) and their

[3] Maisenhelder, L. C. Cottonwood plantations for southern bottom lands. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 179, 24 pp., illus. 1960.

[4] Broadfoot, W. M. Field guide for evaluating cottonwood sites. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 178, 6 pp., illus. 1960.

[5] Op. cit.

Replication I

31	41	20	28	36	5	42	33	46	*24
31	41	20	28	36	5	42	33	46	24
19	2	27	21	48	18	44	4	23	45
19	2	27	21	48	18	44	4	23	45
47	9	29	38	16	14	50	32	17	30
47	9	29	38	16	14	50	32	17	30
7	40	1	37	49	25	26	43	10	12
7	40	1	37	49	25	26	43	10	12
8	35	13	3	22	6	11	34	39	15
8	35	13	3	22	6	11	34	39	15

Replication II

15	48	3	26	44	20	35	30	9	45
15	48	3	26	44	20	35	30	9	45
21	8	39	10	13	23	1	47	25	4
21	8	39	10	13	23	1	47	25	4
43	14	5	19	22	16	11	12	50	36
43	14	5	19	22	16	11	12	50	36
37	40	2	41	38	28	24	7	42	17
37	40	2	41	38	28	24	7	42	17
6	29	27	31	46	32	34	18	33	49
6	29	27	31	46	32	34	18	33	49

Replication III

16	42	14	9	37	29	15	3	10	49
16	42	14	9	37	29	15	3	10	49
32	50	35	7	41	33	38	44	27	22
32	50	35	7	41	33	38	44	27	22
43	18	28	1	30	8	26	13	25	23
43	18	28	1	30	8	26	13	25	23
21	47	24	31	17	36	4	12	45	40
21	47	24	31	17	36	4	12	45	40
34	19	46	11	6	39	48	2	5	20
34	19	46	11	6	39	48	2	5	20

Replication IV

35	44	1	31	5	9	14	21	24	8
35	44	1	31	5	9	14	21	24	8
22	13	2	41	43	15	23	18	32	42
22	13	2	41	43	15	23	18	32	42
45	48	25	28	38	27	6	20	26	10
45	48	25	28	38	27	6	20	26	10
36	7	16	39	12	29	3	40	19	34
36	7	16	39	12	29	3	40	19	34
47	30	17	11	50	37	4	33	46	49
47	30	17	11	50	37	4	33	46	49

FIGURE 1.—*Experimental layout for a four-replication test of 50 cottonwood clones. Each row-plot* consists of two ramets from a single clone.*

location should be accurately mapped. During the establishment period, the trees should be cultivated as described by Maisenhelder.

Measurements should begin during the first year. Rapid early height growth gives a tree an important advantage over weed competition, and some clones may be selected for this character after the first season. Furthermore, it is desirable to know whether a clone's early performance is indicative of its later development. Relative pest resistance may also be observable during the first season. After the first year, clones can be measured for diameter, height, form, and pest infestation as frequently as costs allow. Wood qualities (specific gravity, fiber length) can be determined from samples cut in thinning. Clonal comparisons should be based on the averages for all ramets in the test.

APPLICATION OF RESULTS

Clones can be selected for commercial use at any stage of testing, but it is best to wait for at least 5 to 10 years. Ideally, clones should be observed for one rotation before heavy investments are made in them. The pressure of needs for improved planting stock will in some cases dictate when selection will begin. When a decision is made to use tested material, at least the best 10 to 20 percent of the clones should be picked. In no case should a commercial planting be restricted to fewer than 10 clones. A selected clone that is superior in desirable characters may also be susceptible to some pest that was not present during testing. Hence, plantations should be mixtures of clones—never large blocks planted with one clone.

Establishment of the test outlined above will, inevitably, be more expensive than planting run-of-the-bar cuttings or random nursery stock. The value of the test will be largely governed by the care taken in establishing it and in making the measurements. The potential for improvement which the system offers should be well worth the effort expended, however. Once superior genotypes are identified the resulting gain is permanent, and the improved stock will be no more expensive to plant than run-of-the-bar cuttings.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE
SO-8

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

EPICORMIC BRANCHING IN NORTH LOUISIANA DELTA

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SOUTHERN FOREST EXPERIMENT STATION

In a nine-county area, epicormic branches were found on the second log of 72 percent of the saw-log size hardwoods. Branching was most frequent in stands with basal areas below 75 square feet per acre; for the most common species it was inversely related to the product of tree d.b.h. and stand basal area.

In a 1963 survey of a nine-county area in northeast Louisiana, epicormic branches were found on more than 70 percent of the saw-timber-size hardwoods sampled.

Epicormic branching often follows disturbances, such as thinning or top breakage, which stimulate the sprouting of dormant buds on the boles. The branches may add to the growth capacity of a tree, but they also create knots that reduce lumber value.

The effects of epicormic branching have been studied in localized stands, but the extent to which the hardwood resource over extensive areas is affected by this source of degrade is unknown. Therefore, in conjunction with a forest survey of the north Louisiana Delta, plots were taken at intersections of a 3-mile grid covering approximately 1.7 million acres of bottom-land forest—mostly second-growth stands of sweetgum, overcup oak, water hickory, water oaks, and elms.

The sample consisted of hardwood trees 11 inches d.b.h. and larger with a minimum scaling diameter of 8 inches at 32 feet. On each plot, such trees were selected with an angle gauge having a basal area factor of 37.5. Epicormic branches were counted on the second 16-foot log, and the log was then graded twice, with epicormic branching a defect and not a defect. Grading was by rules of the U. S. Forest Products Laboratory *(1)*,[1] except that logs were not degraded if they were undersize. Logs culled for reasons other than epicormic branching were excluded from the analysis.

The second log was used because of the greater frequency and persistence of epicormic branches in upper logs. Moreover, depending upon its severity, epicormic branching often limits merchantable length.

Of the 760 study logs of all species, 72 percent had epicormic branches (fig. 1). These 544 logs averaged 8.7 branches, a number often sufficient to cause degrade. Of the branch-free logs, approximately two-thirds occurred in stands where the basal area of trees 5 inches d.b.h. and larger exceeded 75 square feet.

[1] Italic numbers in parentheses refer to Literature Cited, p. 3.

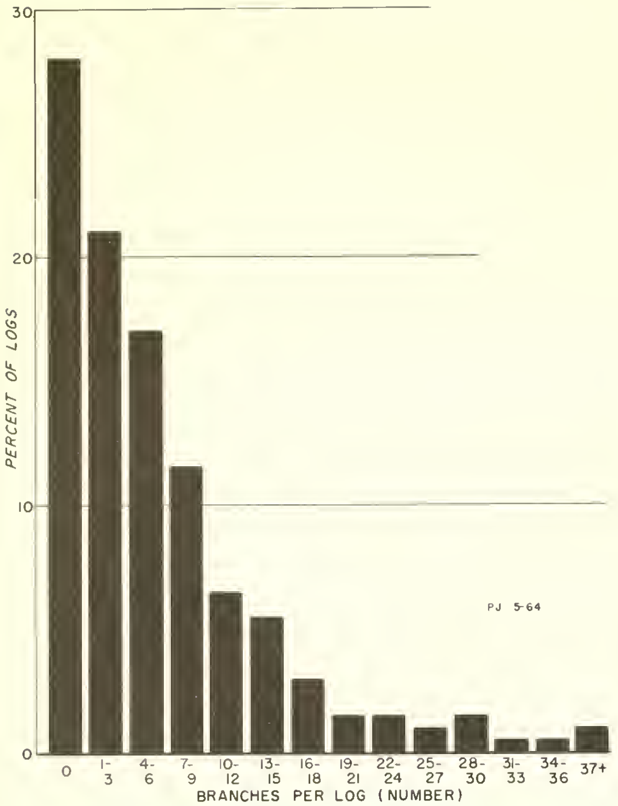

FIGURE 1.—*Distribution of 4,729 epicormic branches on 760 study logs.*

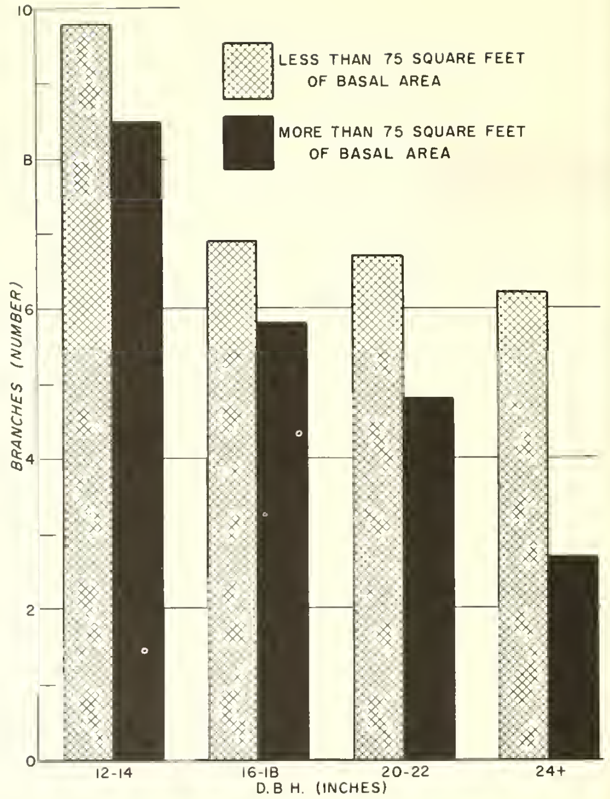

FIGURE 2.—*Average number of epicormic branches on the second log of 760 study trees, by d.b.h. and basal area per acre.*

The number of branches per log was significantly (0.05 level) greater in stands with less than 75 square feet of basal area than in well-stocked stands. An earlier study *(2)* reported that branching on sycamore was serious only at basal areas below 80 square feet.

Correlation between number of epicormic branches and d.b.h. was not significant. In stands of 75 square feet of basal area per acre and upwards, however, a definite trend was discernible—branching decreased as tree diameter increased (fig. 2). For example, in well-stocked stands, 12-inch trees averaged 5.5 more epicormic branches than 24-inch trees. Below 75 square feet of basal area, the difference between d.b.h. groupings was not so apparent.

The five most common species or species groups were selected for special analysis. These were water hickory *(Carya aquatica* (Michx. f.) Nutt.), sweetgum *(Liquidambar styraciflua* L.), overcup oak *(Quercus lyrata* Walt.), water oaks *(Quercus nuttallii* Palmer, *Q. nigra* L., *Q. phellos* L.), and elms *(Ulmus americana* L., *U. crassifolia* Nutt., *U. rubra* Muhl.). Regression analysis showed that the product of d.b.h. and basal area was inversely related to the number of epicormic branches for these species.

Covariance analysis with orthogonal polynomials indicated that the d.b.h.-basal area relationships were similar for all groups except water hickory. The latter was less heavily branched.

Log grades were greatly lowered by epicormic branching. Such branching caused degrade in almost 40 percent of the sample, with 23 percent of the logs lowered by two or more grades.

The effect on grade is shown in figure 3. With branching not a defect, the factory grade logs (grades 1, 2, 3) increased from 60 to 86 percent of the total number; cull logs and tie-and-timber grade logs (grade 4) decreased from 40 to 14 percent. In approximately one-third of the branched logs, grade was unaffected.

Because the history of the stands is unknown, the relationships developed in this

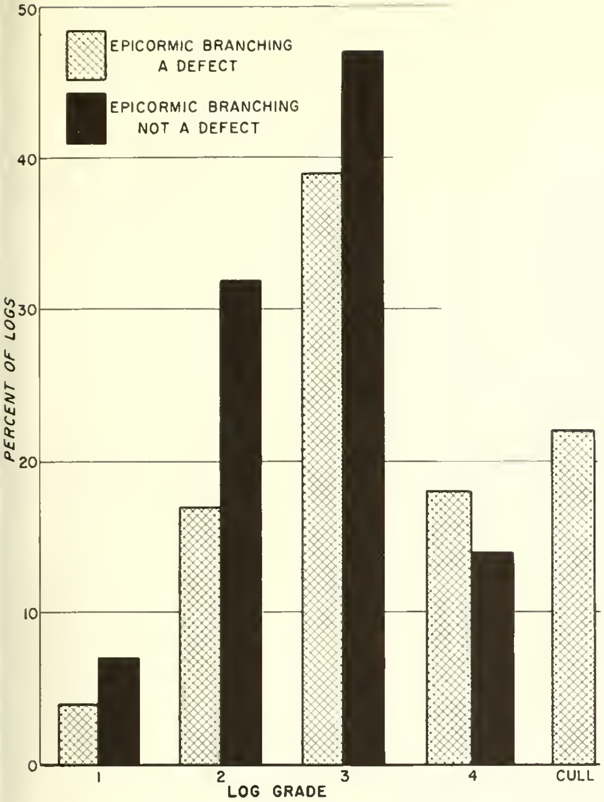

FIGURE 3.—*Effects of branching on grade distribution.*

study cannot reliably be used to predict how much branching will occur when hardwood stands are partially cut. But it seems evident from the results, and from earlier work in the Appalachians *(3)*, that plots established under controlled conditions would yield prediction equations of value to forest managers.

LITERATURE CITED

(1) U. S. Forest Service.
1961. Hardwood log grades for standard lumber and how to apply them. U. S. Forest Serv. Forest Prod. Lab. Rpt. D1737-A, 16 pp., illus.

(2) Huppach, C. D.
1961. Epicormic branching on sycamore. U. S. Forest Serv. Southeast. Forest Expt. Sta. Res. Note 166, 1 p.

(3) Jemison, G. M., and Schumacher, F. X.
1948. Epicormic branching in old-growth Appalachian hardwoods. Jour. Forestry 46: 252-255, illus.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-9

Forest Service, U. S. Dept. of Agriculture

-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

PULPWOOD PRICE TRENDS IN THE MIDSOUTH, 1937-1963

Joe F. Christopher

SOUTHERN FOREST EXPERIMENT STATION

In 1963, Midsouth mills paid an average price of $15.77 per cord for delivered pine bolts. Hardwood bolts sold for $13.10 per cord. The price for pine has increased nearly fivefold since 1937, when the rapid growth of the southern pulp industry began. Hardwood prices have increased some $3.00 per cord since 1947, the earliest year for which data are available.

Open-market values of green chips have remained stable from 1957 to the present (table 1). Average prices in 1963 declined slightly from the 1962 prices; output of chips increased about 12 percent.

Data in this note are based on reports from firms that pulp about three-fourths of the wood received by all mills in Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Tennessee, and Texas. Average prices for rough bolts trucked to rail sidings, woodyards, and millyards are given in table 2. Table 3 shows the proportion of roundwood delivered at the various pricing points during the past 7 years.

These prices somewhat understate wood costs to pulpmills. They do not, for example, include rail freight, costs of mechanized woodyards, and overhead. Nor do they reflect expenses incurred in establishing and maintaining an efficient wood procurement system.

TABLE 1.—*Average open-market prices per ton for green chips in the Midsouth, 1957-1963*

Year	Pine	Hardwood
	- - Dollars - -	
1957	6.19	4.31
1958	6.22	4.10
1959	6.21	4.97
1960	6.26	4.54
1961	6.30	4.98
1962	6.33	4.84
1963	6.26	4.71

TABLE 2.—*Average prices per cord for rough pulpwood bolts in the Midsouth, 1937-1963*

Year	Pine				Hardwood			
	Rail sidings	Wood-yards	Mill-yards	All wood	Rail sidings	Wood-yards	Mill-yards	All wood
	Dollars [1]							
1937	3.15	...	3.75	3.30	...	...	...	...
1938	3.31	...	4.29	3.63	...	...	...	...
1939	3.52	...	4.43	3.76	...	...	...	...
1940	3.81	...	4.67	3.99	...	...	...	...
1941	4.61	...	5.52	4.88	...	...	...	...
1942	5.96	...	6.78	6.10	...	...	...	...
1943	7.21	...	7.92	7.39	...	...	...	...
1944	8.40	...	9.06	8.55	...	...	...	...
1945	8.81	...	9.40	9.00	...	...	...	...
1946	9.84	...	10.89	10.03	...	...	...	...
1947	10.91	...	12.05	11.20	10.14	...	10.66	10.15
1948	11.65	...	12.64	11.91	9.94	...	10.84	10.05
1949	11.26	...	12.20	11.55	9.15	...	10.37	9.34
1950	11.87	...	13.10	12.16	10.41	...	11.56	10.66
1951	13.98	...	15.23	14.24	12.62	...	14.16	13.00
1952	14.03	...	15.41	14.30	12.40	...	14.17	12.91
1953	14.02	...	15.36	14.27	12.31	...	14.18	12.80
1954	14.08	...	15.23	14.31	12.39	...	14.17	12.86
1955	14.32	...	15.41	14.60	12.55	...	14.27	12.88
1956	15.39	...	16.40	15.65	13.23	...	15.04	13.49
1957	15.10	15.30	15.83	15.29	13.21	12.79	14.30	13.35
1958	15.15	15.11	16.17	15.32	12.82	12.57	13.97	13.10
1959	15.37	15.51	16.46	15.69	12.80	12.69	13.84	13.08
1960	15.57	15.85	16.91	16.07	12.57	12.83	13.93	13.12
1961	15.65	15.37	16.69	15.87	12.58	12.66	13.81	13.05
1962	15.66	15.20	16.60	15.79	12.74	13.03	13.74	13.18
1963	15.68	15.17	16.46	15.77	12.76	12.69	13.81	13.10

[1] Three dots indicate data are not available.

TABLE 3.—*Trends in delivery patterns for rough bolts in the Midsouth, 1957-1963*

Year	Pine				Hardwood			
	Rail sidings	Wood-yards	Mill-yards	All wood	Rail sidings	Wood-yards	Mill-yards	All wood
	Percent							
1957	52	31	17	100	54	24	22	100
1958	49	33	18	100	49	22	29	100
1959	33	43	24	100	37	33	30	100
1960	27	45	28	100	33	33	34	100
1961	31	38	31	100	32	32	36	100
1962	24	42	34	100	32	34	34	100
1963	21	41	38	100	27	38	35	100

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-10

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SOIL SUITABILITY FOR HARDWOODS IN THE MIDSOUTH

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SOUTHERN FOREST EXPERIMENT STATION

This note brings together information gathered by the Southern Hardwoods Laboratory as to the suitability of soils in the Midsouth for growing hardwood timber.

Most of the soils that support commercial hardwoods are found in the five soil areas mapped in figure 1. These groups, or land resource areas, differ importantly in parent material, age, texture, and drainage. Within areas, physiographic position, stratigraphy, and landforms influence local moisture conditions.

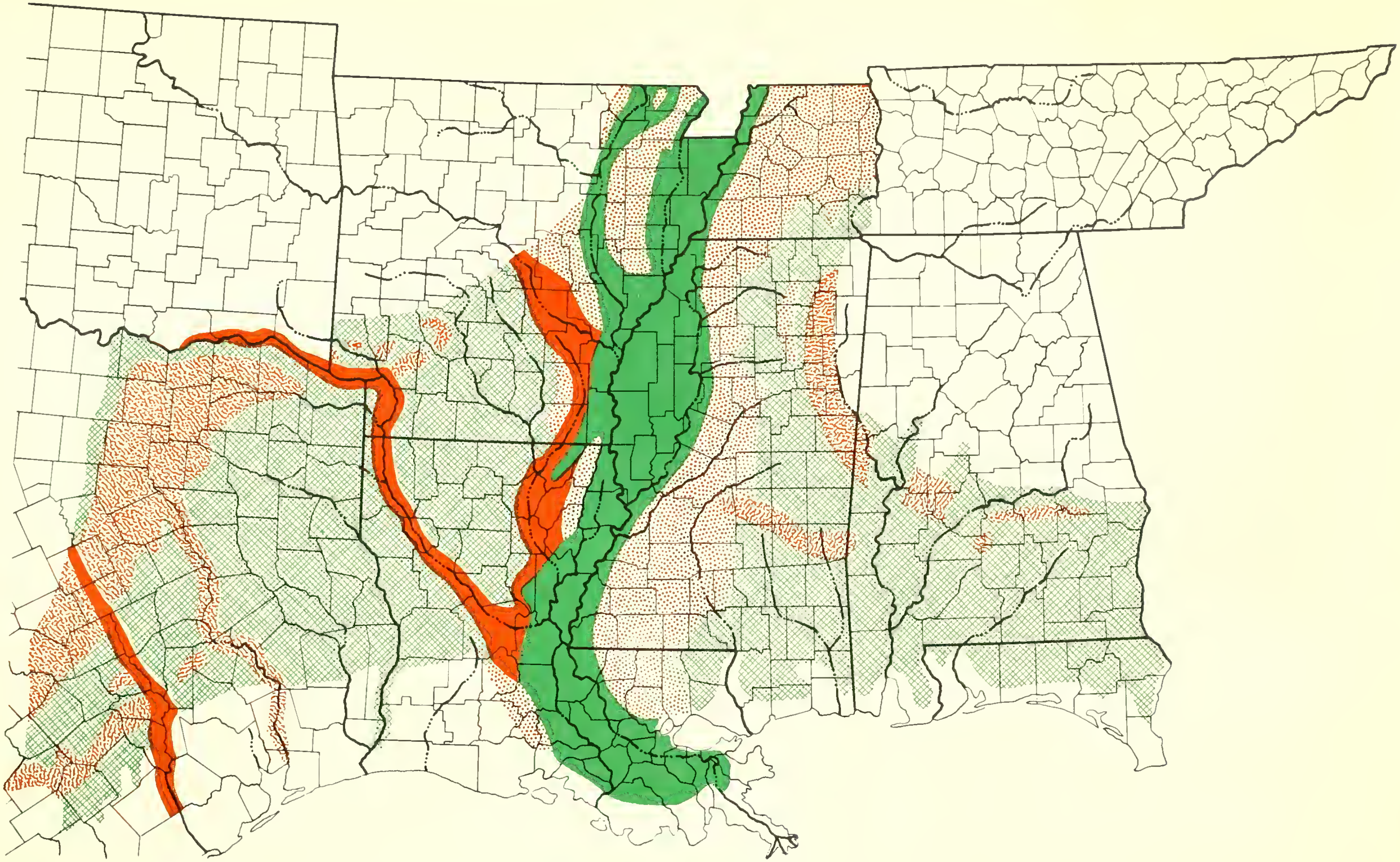
A table of suitability relationships for hardwoods is presented for each soil area. The tables indicate which species occur frequently and which occasionally, and which should be favored in management. Footnotes give information about species that are suited to special purposes, occur infrequently or only in special situations, or constitute forest weeds. Baldcypress and spruce pine are included in some tables because they are found on the same soils as hardwoods.

The relationships were derived mainly from data gathered on 515 plots throughout the States mapped in figure 1. The plots were established primarily for a study of the site factors that influence the growth of willow oak, cottonwood, cherrybark oak, water oak, and sweetgum *(1, 2, 3, 4, 5)*.[2] Hence they were located in mature, well-stocked, free-growing stands containing one or more of these five species. Data were taken, however, on all species present, and some supplementary information was secured for soils and species not adequately represented on the plots. Some soils listed in the tables do not occur in large bodies and are not widely distributed, while some are so important agronomically that very little of their acreage remains in forest. These circumstances, together with the sampling design imposed by the primary purpose of the study, resulted in an uneven distribution of plots among the soil areas. Of the total, 40 percent were in the Delta area, 20 percent in the Loess, 16 percent in the Coastal Plain, 13 percent in the Red, and 11 percent in the Blackland.

Since the tables were compiled from data and observations of natural stands, they may not apply where physical, chemical, and morphological conditions of the soil have been worsened, or where there are unusual soil variants such as sand ridges and exceptionally dry

[1] The author is stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Mississippi, by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] Italicized numbers in parentheses refer to Literature Cited, page 10.



Delta—included are some soils from Loess and Red areas.

Loess—included are some soils with Coastal Plain influence and some Delta soils.

Coastal Plain—mixed, in some places, with Blackland, Loess, and Red soils.

Blackland—some mixing or inclusions of Coastal Plain and Red soils.

FIGURE 1.—
General location of the five soil areas in the Midsouth where southern hardwoods are grown.

land tree seedlings. Soil Sci. Soc. Amer. Proc. 26: 401-404.

———— and Minckler, L. S.
1960. Hardwood reproduction in the river bottoms of southern Illinois. Forest Sci. 6: 67-77.

———— and Minckler, L. S.
1963. Bottomland hardwood forests of southern Illinois—regeneration and succession. Ecol. 44: 29-41, illus.

Huikari, O.
1954. Experiments on the effect of anaerobic media upon birch, pine, and spruce seedlings. Inst. Forest. Fenniae Commun. 42(5), 13 pp.

Hunt, F. M.
1951. Effects of flooded soil on growth of pine seedlings. Plant Physiol. 26: 363-368.

Jackson, W. T.
1955. The role of adventitious roots in recovery of shoots following flooding of the original root systems. Amer. Jour. Bot. 42: 816-819.

————
1956. Flooding injury studied by approach-graft and split root system techniques. Amer. Jour. Bot. 43: 496-502, illus.

Jarvis, P. G., and Jarvis, M. S.
1963. The water relations of tree seedlings. I. Growth and water use in relation to soil water potential. Physiologia Plant. 16: 215-235, illus.

Kramer, P. J.
1933. The intake of water through dead root systems and its relation to the problem of absorption by transpiring plants. Amer. Jour. Bot. 20: 481-492.

————
1940. Causes of decreased absorption of water by plants in poorly aerated media. Amer. Jour. Bot. 27: 216-220, illus.

————
1949. Plant and soil water relationships. 347 pp. New York: McGraw-Hill Book Co., Inc.

————
1951. Causes of injury to plants resulting from flooding of the soil. Plant Physiol. 26: 722-736, illus.

———— and Kozlowski, T. T.
1960. Physiology of trees. 642 pp., illus. New York: McGraw-Hill Book Co., Inc.

Kurz, Herman, and Demaree, Delzie.
1934. Cypress buttresses and knees in relation to water and air. Ecol. 15: 36-41, illus.

Kuster, A.
1948. Der Einfluss der Juraseen-Hochwasser auf die Strandwaldungen. Schweiz. Ztschr. f. Forstw. 99: 428-438.

Leyton, Leonard, and Rousseau, L. Z.
1958. Root growth of tree seedlings in relation to aeration. *In* The physiology of forest trees. Pp. 467-475, illus. New York: The Ronald Press Co.

Loustalot, A. J.
1945. Influence of soil moisture conditions on apparent photosynthesis and transpiration of pecan leaves. Jour. Agr. Res. 71: 519-532, illus.

McAlpine, R. G.
1959. Flooding kills yellow poplar. Forest Farmer 19(3): 9, 13-14, illus.

————
1961. Yellow-poplar seedlings intolerant to flooding. Jour. Forestry 59: 566-568, illus.

MacConnell, J. T.
1959. The oxygen factor in the development and function of the root nodules of alder. Ann. Bot. 23: 261-268, illus.

McDermott, R. E.
1954. Effects of saturated soil on seedling growth of some bottomland hardwood species. Ecol. 35: 36-41, illus.

McKnight, J. S.
1950. Forest management by Old Man River. South. Lumberman 181 (2273): 233-235, illus.

McReynolds, R. D.
1960. Mortality of newly germinated southern pine seedlings following inundation. U. S. Forest Serv. Tree Planters' Notes 43, pp. 23-25.

Mattoon, W. R.
1916. Water requirements and growth of young cypress. Soc. Amer. Foresters Proc. 11: 192-197, illus.

Olson, D. F., Jr.
1949. Relation of certain soil and site characteristics to understory composition in pond pine stands of the Southeastern Coastal Plain. 40 pp. M. F. thesis, Duke Univ., Durham, N. C.

Parker, Johnson.
1950. The effects of flooding on the transpiration and survival of some southeastern forest tree species. Plant Physiol. 25: 453-460, illus.

Penfound, W. T.
1949. Vegetation of Lake Chicot, Louisiana, in relation to wildlife resources. La. Acad. Sci. Proc. 12: 47-56, illus.

____
1952. Southern swamps and marshes. Bot. Rev. 18: 413-446, illus.

Phillips, J. J., and Markley, M. L.
1963. Site index of New Jersey sweetgum stands related to soil and water-table characteristics. U. S. Forest Serv. Res. Paper NE-6, 25 pp., illus. Northeast. Forest Expt. Sta., Upper Darby, Pa.

Poutsma, T., and Simpfendorfer, K. J.
1962. Soil moisture conditions and pine failure at Waarre, near Port Campbell, Victoria. Austral. Jour. Agr. Res. 13: 426-433, illus.

Pruitt, A. A.
1947. A study of the effects of soils, water table, and drainage on the height growth of slash and loblolly pine plantations on the Hofmann Forest. Jour. Forestry 45: 836.

Putnam, J. A., Furnival, G. M., and McKnight, J. S.
1960. Management and inventory of southern hardwoods. U. S. Dept. Agr., Agr. Handb. 181, 102 pp., illus.

Rathborne, J. C.
1951. Cypress reforestation. South. Lumberman 183(2297): 239-240.

Richard, Felix.
1959. Über den Einfluss des Wasser-und Luftgehaltes im Boden auf das Wachstum von Fichtenkeimlingen. Schweiz. Centralanst. f. Forstl. Versuchsw. Mitt. 35(1): 243-264, illus.

Satterlund, D. R., and Graham, S. A.
1957. Effect of drainage on tree growth in stagnant sphagnum bogs. Mich. Forestry 19, 2 pp.

Schlaudt, E. A.
1955. Drainage in forestry management in the South. U. S. Dept. Agr. Yearbook 1955: 564-568, illus.

Schramm, R. J., Jr.
1960. Anatomical and physiological development of roots in relation to aeration of the substrate. 204 pp. Ph. D. diss., Duke Univ., Durham, N. C. (Diss. Abs. 21: 2089. 1961.)

Shunk, I. V.
1939. Oxygen requirements for germination of seeds of Nyssa aquatica—tupelo gum. Sci. 90: 565-566.

Silker, T. H.
1948. Planting of water-tolerant trees along the margins of fluctuating-level reservoirs. Iowa State Col. Jour. Sci. 22: 431-447.

Smith, L. F.
1960. Early growth of slash pine on upland and wet sites. Jour. Forestry 58: 720, 725, illus.

Stoeckeler, J. H., and Sump, A. W.
1940. Successful direct seeding of northern conifers on shallow-water-table areas. Jour. Forestry 38: 572-577, illus.

Trousdell, K. B., and Hoover, M. D.
1955. A change in ground-water level after clearcutting of loblolly pine in the Coastal Plain. Jour. Forestry 53: 493-498, illus.

U. S. Army Corps of Engineers, New Orleans District.
1955. Timber protection in reservoirs. Civ. Works Invest. Proj. CW-515, 44 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-11

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SHELTER FOR TESTING DROUGHT-HARDINESS OF PLANTED SOUTHERN PINE SEEDLINGS

John J. Stransky and William B. Duke

SOUTHERN FOREST EXPERIMENT STATION[1]

A plastic-covered shelter simulates drought severe enough to cause seedling mortality. Air and soil temperatures, and relative humidity, are but slightly higher under the shelter than outside it.

Drought-endurance of pine seedlings is an important research problem in east Texas, but field plantings designed to test drought effects are often jeopardized by weather vagaries. In studies on the Stephen F. Austin Experimental Forest, near Nacogdoches, planting beneath a shelter made it possible to observe seedling behavior under simulated drought. This report describes the design of the shelter and its effect on soil moisture, air and soil temperatures, and relative humidity during two growing seasons.

DESIGN AND INSTRUMENTATION

The shelter was designed and built in 1960 to keep rain from planted pines without otherwise altering their environment. This was achieved with a transparent plastic cover stretched on 10- by 10-foot sashes that were supported by a redwood frame (fig. 1). The sashes were hinged on 1¼-inch (o.d.) aluminum pipes and could be raised at the free end to provide access. Drain channels on the rafters, between individual sashes, prevented water from dripping on the plots. The long axis of the shelter was east-west oriented.

During 1960, a plastic-lined trench under the north and south drip line kept surface water from flowing onto the plots. The liner had to be renewed several times, and during the next year the trench was replaced by an aluminum barrier, set 1 foot inside the drip line of the shelter. The barrier protruded 1½ inches above the ground and was set to a depth of 24 inches, to keep both surface and subterranean water from reaching the plots. Gutters collected and diverted runoff water from the roof.

Polyethylene film (0.002-inch thick) proved unsatisfactory for the cover, as it had to be

[1] The authors are on the staff of the Wildlife Habitat and Silviculture Laboratory, which is maintained at Nacogdoches, Texas, by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State College.

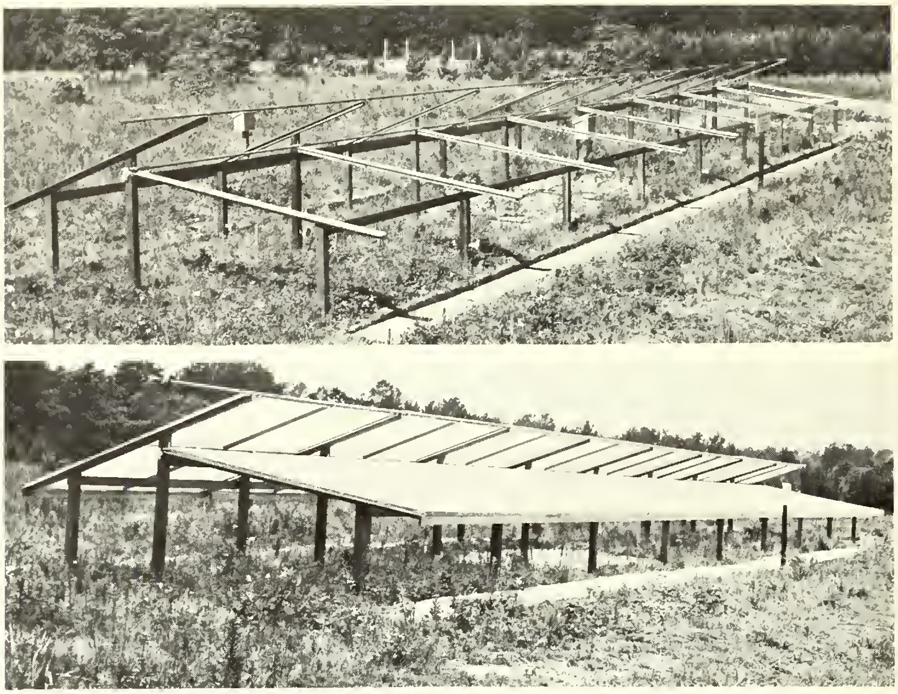


FIGURE 1.—
Above: *Frame of shelter.* Below: *Plastic-covered sashes in place. Gutters were added after the pictures were taken.*

replaced three times in the summer of 1960. The following year, Mylar W-1 (with weather-resistant treatment on one side) proved more durable. The manufacturer's advertising literature describes Mylar's light-transmitting qualities as essentially those of glass.

The total sheltered area was 80 by 16 feet. This provided six 10- by 10-foot test plots and two isolation plots of the same size on each end of the shelter's long axis (fig. 2). The shelter's cross-sectional dimensions are given in figure 3.

From three test plots the weed cover was removed along with the upper 2 to 3 inches of soil; on three other plots the weeds remained undisturbed. In 1960, loblolly pine *(Pinus taeda* L.) seedlings (1-0) were planted at 2-foot by 2-foot spacing. In 1961, the shelter was moved to a new location and the test repeated with loblolly, shortleaf *(P. echinata* Mill.) and slash pine *(P. elliottii* Engelm.) seedlings. Pines were planted in midwinter. The cover was applied in May or June and kept until fall.

In both years, gravimetric soil-moisture samples were taken to depths of 24 inches with a King tube at the time of planting and at 2-week intervals after the cover was applied. Samples were also taken along transects extending 2 feet into the unsheltered area.

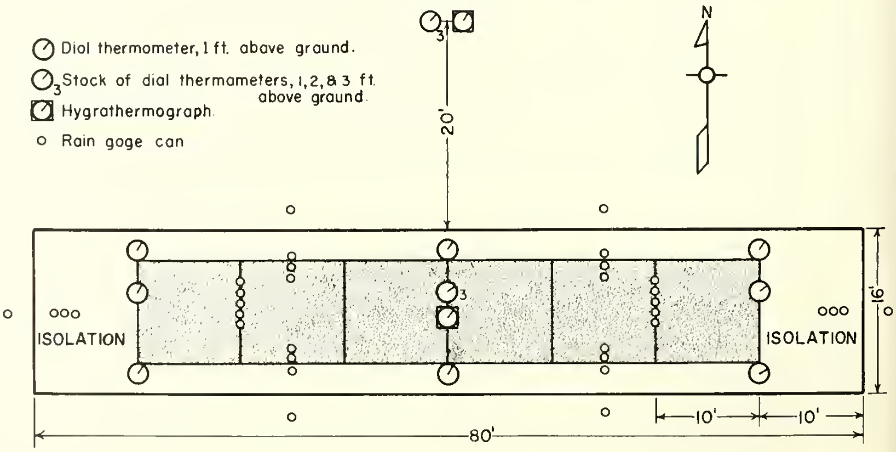


FIGURE 2.—
Sheltered area, test plots, and instrumentation.

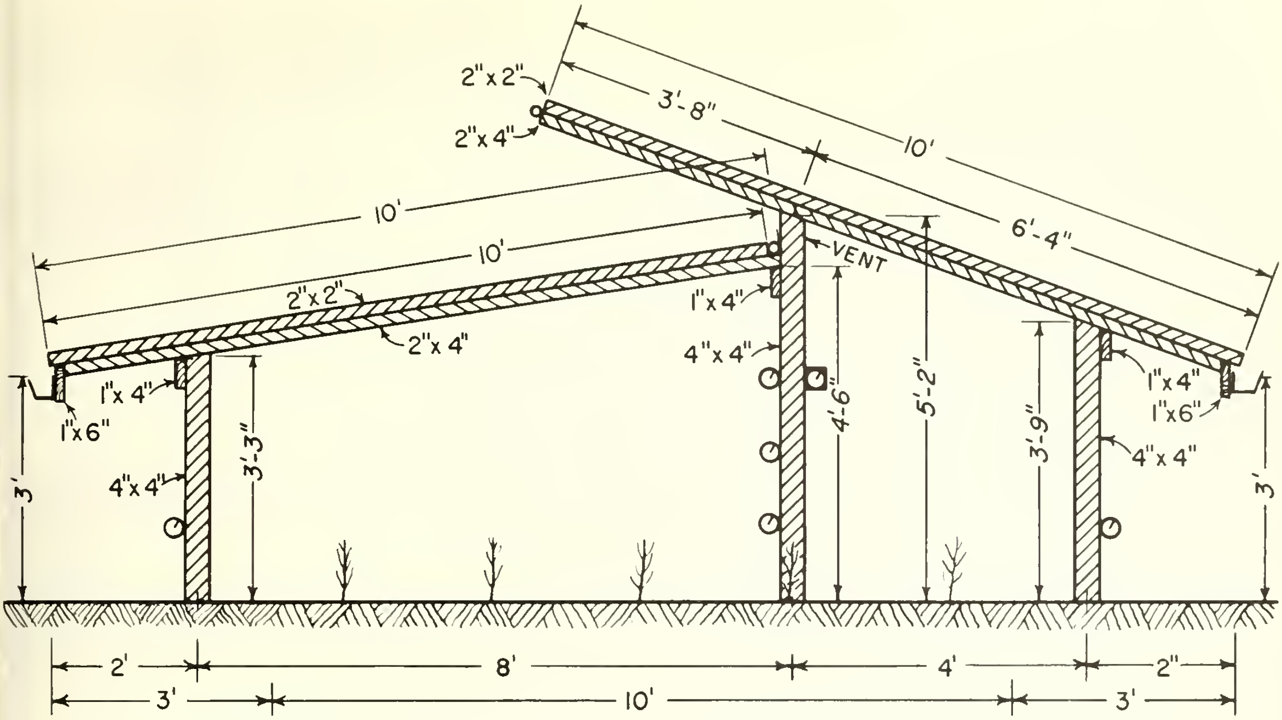


FIGURE 3.—*Cross-sectional dimensions of the shelter's frame.*

Air temperature was measured 1 foot above ground level with unshielded maximum-minimum thermometers at nine locations under the shelter and at one location 20 feet outside. Thermometers under the shelter were arranged to form transects of three units each, across the east and west ends and the middle of the shelter. Additional thermometers were used to measure temperatures at the 2- and 3-foot levels under the center of the shelter and 20 feet outside of it. Two hygrothermographs, one under and one outside the shelter, kept continuous records of temperature and relative humidity 3 feet above ground (fig. 2).

In the summer of 1960, daily maximum soil temperatures were measured at a depth of 1 inch for 2 weeks with pairs of mercury maximum thermometers installed in bare and weedy soil inside and outside the shelter.

During 1960, transects of rain gages (soil sample cans) were placed across all four edges of the shelter and also under the ventilating openings to ascertain whether winds might blow rain under the shelter (fig. 2).

SHELTER EFFECTS

During each test year, the shelter lowered soil moisture enough to cause seedling mortality, but it did not greatly change temperature and humidity in the seedlings' environment.

Soil moisture dropped below the estimated tension of 15 atmospheres (wilting percent) at all depths in weedy plots. Speed of depletion depended on the amount of herbaceous vegetation competing with the pines. Depletion rates were greatest in the upper layers, and decreased with increasing depth. On bare plots, moisture dropped below the wilting point only in the surface 6 inches.

For the two growing seasons, average daily maximum and minimum air temperatures at the 1-foot level were virtually uniform in all parts of the shelter. The maxima and minima under the long (east-west) axis of the shelter averaged slightly higher (104°F. maximum and 64°F. minimum) than under the south and north edges (102 and 63). Maxima of all nine thermometers inside averaged only a fraction higher (102.6) than on the outside (102.3). Minimum temperatures averaged 1.6° higher inside (63.3) than outside (61.7).

Average maximum temperatures under the shelter's center increased with increasing height, being 106 and 109 at the 2- and 3-foot levels. This was expected, because rising warm air was trapped to some extent by the roof. Average minimum temperatures at the same heights were 65 and 63.

The hygrothermographs generally recorded lower temperatures than unsheltered dial thermometers. For the 2 test years, daily maximum and minimum temperatures averaged higher under the shelter (91 maximum and 63 minimum) than outside of it (87 and 60). Relative humidity maxima and minima averaged 2 percentage points higher inside the shelter (97 percent maximum and 43 minimum) than outside (95 maximum and 41 minimum).

Temperatures and humidities under the cover materials used in 1960 and 1961 are compared in table 1. Generally, the summer of 1960 was warmer and had lower humidities than the 1961 season. These differences were noted under the shelter—an indication that the two cover materials did not differ greatly in their effects on the seedling environment.

TABLE 1.—*Yearly average of daily maximum and minimum temperatures and relative humidities under polyethylene and Mylar covers (3 feet above ground)*

Cover material	Year	Temperature				Humidity	
		Dial thermometers		Hygrothermograph			
		Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
		Degrees F.				*Percent*	
Polyethylene	1960	112	67	94	68	97	39
Mylar W-1	1961	105	59	86	59	97	47

Daily maximum soil temperatures averaged 108°F. inside the shelter and 104 outside.

Rain was registered under the shelter only once, when 0.01 inch was caught in a rain gage just inside the shelter's dripline but still 2½ feet outside the test plot. On three occasions, traces of rain were noticed under the open east and west ends of the shelter, more than 8 feet from the closest test plot. At no time was any rain noted under the ventilators.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-12

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

REFERENCES ON EFFECTS OF FLOODING ON FOREST TREES

J. J. Stransky and H. E. Daniel [1]

SOUTHERN FOREST EXPERIMENT STATION

Ahlgren, C. E., and Hansen, H. L.
1957. Some effects of temporary flooding on coniferous trees. Jour. Forestry 55: 647-650, illus.

Applequist, M. B.
1959. Longevity of submerged tupelogum and baldcypress seed. La. State Univ. Forestry Note 27, 2 pp.

____
1960. Soil-site studies of southern hardwoods. La. State Univ. Eighth Ann. Forestry Symposium Proc. 1959: 49-63, illus.

Averell, J. L., and McGrew, P. C.
1929. The reaction of swamp forests to drainage in northern Minnesota. Minn. Dept. Drainage and Waters, 66 pp., illus.

Bergman, H. F.
1920. The relation of aeration to the growth and activity of roots and its influence on the ecesis of plants in swamps. Ann. Bot. 34: 13-33.

____
1959. Oxygen deficiency as a cause of disease in plants. Bot. Rev. 25: 417-485.

Bonck, Juanda, and Penfound, W. T.
1944. Seasonal growth of twigs of trees in the batture lands of the New Orleans area. Ecol. 25: 473-475.

Briscoe, C. B.
1957. Diameter growth and effects of flooding on certain bottomland forest trees. 103 pp. Ph. D. diss., Duke Univ. School Forestry, Durham, N. C.

[1] The authors are on the staff of the Wildlife Habitat and Silviculture Laboratory, which is maintained at Nacogdoches, Texas, by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State College.

Drafts of this bibliography were reviewed and supplemented by Dr. John F. Hosner, Head of Virginia Polytechnic Institute's Forestry Department, Dr. Paul J. Kramer, Professor of Botany, Duke University, and Dr. Laurence C. Walker, Head of Stephen F. Austin College's Forestry Department. Miss Isabell Nelson, Messrs. F. T. Bonner, W. M. Broadfoot, H. H. Muntz, and R. L. Scheer of the Southern Forest Experiment Station's Timber Management Division have also added publications.

Broadfoot, W. M.
1958. A method of measuring water use by forests on slowly permeable soils. Jour. Forestry 56: 351.

———
1958. Study effects of impounded water on trees. Miss. Farm Res. 21(6): 1-2, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 595, 2 pp., illus.

———
1960. Soil-water shortages and a means of alleviating resulting influences on southern hardwoods. La. State Univ. Eighth Ann. Forestry Symposium Proc. 1959: 115-119.

Brown, C. A.
1943. Vegetation and lake level correlations at Catahoula Lake, Louisiana. Geog. Rev. 33: 435-445.

Childers, N. F., and White, D. G.
1942. Influence of submersion of the roots on transpiration, apparent photosynthesis, and respiration of young apple trees. Plant Physiol. 17: 603-618, illus.

Clements, F. E.
1921. Aeration and air-content. Carnegie Inst. Wash. Pub. 315, 183 pp.

Conway, V. M.
1940. Aeration and plant growth in wet soils. Bot. Rev. 6: 149-163.

Curlin, J. W., and McDermid, R. W.
1961. Reclamation of timberlands damaged by oilfield waste. Jour. Forestry 59: 171-174, illus.

Demaree, Delzie.
1932. Submerging experiments with *Taxodium*. Ecol. 13: 258-262.

Dickson, R. E.
1962. The effects of four water regimes upon the growth of four bottomland tree species. 79 pp. M. S. thesis, South. Ill. Univ., Carbondale, Ill.

Eggler, W. A., and Moore, W. G.
1961. The vegetation of Lake Chicot, Louisiana, after eighteen years impoundment. Southwest. Nat. 6(3-4): 175-183.

Godman, R. M.
1959. Are water table levels an important factor in the establishment and growth of yellow birch? Papers Mich. Acad. Sci., Arts and Letters 44: 183-190.

Grano, C. X.
1961. Germination of stratified latex-coated loblolly pine seed after submergence. Jour. Forestry 59: 452.

Green, W. E.
1947. Effect of water impoundment on tree mortality and growth. Jour. Forestry 45: 118-120.

Hall, T. F., Penfound, W. T., and Hess, A. D.
1946. Water level relationships of plants in the Tennessee Valley with particular reference to malaria control. Jour. Tenn. Acad. Sci. 21: 18-59.

——— and Smith, G. E.
1955. Effects of flooding on woody plants, West Sandy Dewatering Project, Kentucky Reservoir. Jour. Forestry 53: 281-285, illus.

Hosner, J. F.
1957. Effects of water upon the seed germination of bottomland trees. Forest Sci. 3: 67-70.

———
1958. The effects of complete inundation upon seedlings of six bottomland tree species. Ecol. 39: 371-373.

———
1959. Survival, root, and shoot growth of six bottomland tree species following flooding. Jour. Forestry 57: 927-928, illus.

———
1960. Relative tolerance to complete inundation of fourteen bottomland tree species. Forest Sci. 6: 246-251, illus.

——— and Boyce, S. G.
1962. Tolerance to water saturated soil of various bottomland hardwoods. Forest Sci. 8: 180-186, illus.

——— and Leaf, A. L.
1962. The effect of soil saturation upon the dry weight, ash content, and nutrient absorption of various bottom-

phases. Species-site relationships in plantations may also differ from those indicated in the tables.

DELTA

The Delta area lies in the flood plains of the Mississippi River. The soils originated in alluvial material washed down from northern lands between the Appalachian and Rocky Mountains. They are fertile, and, under proper management, some of the best producers of high-quality hardwood timber (table 1).

Variations in the soils of recent natural levees usually can be traced to differences in

TABLE 1.—*Soil suitability for southern hardwoods in the Delta area*

Important commercial species [1]	Recent natural-levee soils		Old natural-levee soils			Slackwater soils		Depressional soils	
	Crevasse, Robinsonville	Commerce, Mhoon	Beulah, Bosket	Dubbs, Dundee	Forestdale	Bowdre, Tunica	Sharkey, Alligator	Ark	Dowling, Souva
Ash, green	●	■	—	○	□	○	■	■	■
Baldcypress	—	●	—	—	○	—	■	●	■
Cottonwood, eastern	■	■	●	●	●	■	■	●	○
Elms, slippery & American	□	□	○	□	□	□	□	○	—
Hackberry and sugarberry	■	■	○	○	□	□	□	□	○
Hickory, water	—	—	—	○	□	○	□	○	□
Honeylocust	○	○	—	○	□	○	□	○	○
Maple, red	—	—	—	○	□	■	■	●	—
Maple, silver	●	■	—	—	—	—	—	—	—
Oak, cherrybark	○	○	■	■	■	●	●	●	—
Oak, Nuttall	—	○	—	●	■	●	■	●	●
Oak, overcup	—	○	—	○	■	○	■	○	■
Oak, Shumard	—	—	●	■	○	●	○	—	—
Oak, swamp chestnut	—	—	○	■	■	●	○	○	—
Oak, water	○	●	■	■	■	■	■	●	—
Oak, willow	—	—	■	■	■	■	■	●	○
Pecan	■	■	○	●	○	●	○	—	—
Persimmon, common	○	○	○	○	□	●	■	●	●
Sassafras	○	—	■	■	○	○	○	—	—
Sweetgum	●	■	■	■	■	■	■	●	○
Sycamore, American	■	■	■	■	●	●	●	○	—
Tupelo, black	—	—	□	■	○	○	○	—	—
Tupelo, water	—	—	—	—	—	—	—	●	●
Willow, black	○	■	—	—	○	—	○	■	■

[1] In this and succeeding tables, common names are according to E. L. Little, Jr., **Check list of native and naturalized trees of the United States (including Alaska).** U. S. Dept. Agr., Agr. Handb. 41, 472 pp. 1953.

POST AND SPECIALTY SPECIES: Black locust, catalpa, and flowering dogwood on moderately to well-drained acid soils; Osage-orange on neutral to alkaline soils; mulberry on all soils.

LIMITED COMMERCIALLY OR IN OCCURRENCE: Boxelder on neutral to alkaline soils; bur oak, American holly, winged elm on acid soils; post oak, river birch, hickories (exc. water), and white oak on well-drained acid soils; swamp cottonwood and laurel oak on poorly drained acid soils; black walnut on well-drained soils; chinaberry, cedar elm, buckeye, and Kentucky coffeetree on all soils.

WEED SPECIES: American hornbeam and eastern hophornbeam on acid soils; planertree on wet soils; hawthorn, swamp-privet, redbud, and roughleaf dogwood on all soils.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
□ Occurs frequently; manage, but do not favor.
○ Occurs occasionally; manage, but do not favor.

drainage and in texture. The alluvial sediments have been in place for such a short time that only the first stages of development have taken place. As materials left by the river contain lime, and as extensive leaching has not yet occurred, the soils are usually neutral to alkaline. They are generally light in color, because organic matter has not had time to build up. Crevasse and Robinsonville are moderately to well drained, while Commerce and Mhoon are somewhat poorly to poorly drained. The principal timber species found on these young soils are cottonwood, green ash, American elm, hackberry and sugarberry, pecan, sycamore, sweetgum, and black willow (table 1).

The old natural-levee soils are all acid. Beulah and Bosket are well drained, Dubbs and Dundee have moderate drainage, and Forestdale is poorly drained. In addition to the species common on the young soils, these old soils support oaks and hickories as well as sassafras.

The slack-water soils are nearly level or gently sloping, occupy broad areas, and usually are some distance from both the present and former channels of the Mississippi. Their clay content is high, and they are locally called buckshot and sometimes gumbo. They have developed under conditions of slow drainage. Differences among them result primarily from differences in the thickness of the layer of fine-textured sediments that overlies the sandier strata underneath. Alligator and Sharkey soils are poorly drained, while Bowdre and Tunica are moderately well drained. A wide variety of hardwoods occurs naturally on the slack-water soils.

Depressional soils occur in old, partly filled river channels throughout the Mississippi River flood plain. These channels provide means for the slow return of floodwaters to the bayous and main rivers. They are the lowest-lying soils of the region and are subject to flooding by local runoff even though they may be protected by levees. They were formed chiefly of alluvium washed from adjacent areas of other soils. All have weak profile development and are mottled or gray. Ark soils have better internal drainage than Dowling and Souva. The most important soil is Dowling, but species are limited to those tolerant of poor drainage and aeration.

LOESS

The band of soils lying immediately east and west of the Delta is loess, or wind-deposited.

The upland soils in this group vary in depth. Their texture is uniform, usually silt loam to silty clay loam. Only the noneroded condition is listed in table 2, as sites with less than 6 inches of topsoil are considered more suitable for pine than hardwoods. Calloway, Henry, and Bude have pans. Falkner, Tickfaw, and Hurricane also are poorly drained, being underlaid with stiff clays. Pine should be favored along with sweetgum, cherrybark oak, Shumard oak, and white oak on these soils, as they are very dry in summer.

Terrace soils in the Loess area show considerable profile development. Olivier, Calhoun, Carroll, Hatchie, and Almo are poorly drained and have strong pans that seriously limit root development and height growth of hardwoods.

A number of river flood plains in the Loess area border the Delta on the east. From north to south, the principal ones are the Obion, Forked Deer, Hatchie, Wolf, Coldwater, Tallahatchie, Yocona, Yalobusha, Yazoo, Big Black, Pearl, Homochitto, and Amite. Soils in this group may be found also in the flood plains of rivers and streams in and near Crowley's Ridge and Macon Ridge in Arkansas, and adjacent to and near small loess ridges in Louisiana west of the Mississippi River.

In general, the same wide variety of species is found in the terraces of this soil area as on the bottoms. The middle and lower slopes of the uplands and the acid bottoms are particularly productive of many important commercial species.

TABLE 2.—*Soil suitability for southern hardwoods in Loess area*

Important commercial species	Uplands: Memphis-Loring, Natchez — Ridge and upper slope	Uplands: Memphis-Loring, Natchez — Middle and lower slope [1]	Uplands: Lexington, Atwood, Brandon — Ridge, upper, and middle slope	Uplands: Lexington, Atwood, Brandon — Lower slope	Uplands: Grenada, Providence, Franklinton, Dulac, Lax, Tippah	Uplands: Calloway, Henry, Falkner, Bude, Tickfaw, Hurricane	Terraces: Lintonia, Richland, Dexter, Freeland	Terraces: Olivier, Calhoun, Carroll, Hatchie, Almo	Acid bot[tom]: Vicksburg, Collins
Ash, green & white	○	■	—	○	○	□	○	□	□
Baldcypress	—	—	—	—	—	—	—	—	○
Basswood, American	○	■	—	○	●	○	●	○	●
Beech, American	○	□	—	□	○	○	□	○	□
Cherry, black	○	■	○	●	○	○	●	○	●
Cottonwood, eastern	—	●		○	—	—	○	○	■
Elms, slippery & American	○	□	○	□	□	○	□	□	□
Hackberry and sugarberry	—	○	—	○	○	○	○	○	●
Hickories (exc. water)	□	□	□	□	□	○	□	○	□
Honeylocust	—	○	—	○	—	○	—	○	○
Magnolia, southern	○	■	○	○	○	○	●	○	●
Maple, red	○	□	○	□	□	□	□	□	□
Oak, cherrybark	■	■	●	■	■	■	■	●	■
Oak, Nuttall	—	—	—	—	—	—	●	●	●
Oak, overcup	—	—	—	—	—	—	—	○	○
Oak, Shumard	■	■	■	■	■	●	■	●	■
Oak, southern red	□	■	□	■	□	○	●	○	●
Oak, swamp chestnut	○	●	—	○	●	○	●	●	●
Oak, water	□	■	□	■	●	■	●	■	■
Oak, white	■	■	■	■	■	■	●	●	●
Oak, willow	○	●	○	●	○	○	○	○	●
Persimmon, common	□	●	□	○	□	○	□	○	●
Pines	●	○	■	○	○	●	○	●	○
Sassafras	□	●	○	○	○	○	●	○	●
Sweetgum	□	■	□	■	■	■	■	■	■
Sycamore, American	○	●		●	●	○	●	○	■
Tupelo, black	□	■	□	■	□	□	●	○	●
Yellow-poplar	□	■	□	■	□	○	■	○	■

[1] Includes all slopes greater than 17 percent.

POST AND SPECIALTY SPECIES: Black locust, flowering dogwood, and catalpa on well-drained acid soils; eastern redcedar

SPECIES LIMITED COMMERCIALLY OR IN OCCURRENCE: Cucumbertree and black walnut on well-drained soils; chi oak, black oak, sugar maple, northern red oak, and royal paulownia on well-drained upland soils; laurel oak and p bottoms; water tupelo, swamp cottonwood, and swamp tupelo on wet, acid bottoms; boxelder on all bottoms; river b American holly on all acid soils; post oak on uplands and terraces; water hickory and black willow on all poorly cedar elm, winged elm, and buckeye on all soils; spruce pine on acid lower slopes, terraces, and bottoms.

WEED SPECIES: Eastern hophornbeam, and American hornbeam on acid terraces and bottoms; blackjack oak and smooth su terraces; swamp-privet and common buttonbush on wet, poorly drained bottoms; hawthorn on all soils.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
□ Occurs frequently; manage, but d
○ Occurs occasionally; manage, but

...ns	Neutral to alkaline bottoms	
...laya, ...verly	Morganfield, Adler	Wakeland, Birds, Dekoven

...d mulberry on all soils.

...pin oak, scarlet oak, chestnut ...oak on wet, acid terraces and ... on well-drained acid bottoms; ...ined soils; pecan, chinaberry,

...: on well-drained uplands and

...ot favor.

...not favor.

COASTAL PLAIN

Many soils supporting hardwoods in the Midsouth are on terraces and bottoms within the Coastal Plain. In general, they are sandy, acid, and lacking in natural fertility, but some have adequate moisture and drainage for many of the important species.

Table 3 lists the principal Coastal Plain soils and the hardwoods that occur naturally on them. Soils developed on upland positions are omitted, because most are too poor and dry for commercial hardwoods, except perhaps on lower slopes. Pines (excluding spruce pine) are included because they are better adapted to poorly drained panlike soils than are hardwoods. Of the terrace soils the best drained are Cahaba, Kalmia, and Amite, and the poorest drained are Stough, Wahee, Myatt, and Leaf. The best drained bottom-land soils are Ochlockonee, Iuka, and Bruno, and the poorest drained are Bibb, Chastain, and Johnston. Stough, Wahee, Myatt, and Leaf have subsoils that act like pans with respect to water relations.

Rivers whose alluvium is derived primarily from Coastal Plain soils include the Chattahoochee bordering a part of Florida and Alabama; Escambia in Florida; Black Warrior, Cahaba, Alabama, Tombigbee, and Mobile in Alabama; Leaf, Chickasawhay, Pascagoula, and Pearl in Mississippi; Calcasieu and Sabine in Louisiana; Saline and Ouachita in Arkansas; Neches and Angelina in Texas; and numerous smaller streams throughout the area.

BLACKLAND

The Blackland soils occur chiefly in Alabama, Mississippi, and eastern Texas, with smaller areas in Louisiana and Arkansas. They are found within the much larger Coastal Plain land area, but differ in their prairie-like nature and characteristic color.

In general, Blackland soils are derived from marly clays and soft limestone. Some have weathered slightly acid, but most are neutral to alkaline. Texture is principally fine or clay-size. The alluvial soils are sufficiently fertile to support excellent growth of some hardwood species, provided that moisture and drainage are adequate. The upland soils are not considered suitable for hardwood timber.

The principal soils that support good stands are listed in table 4. The terrace soils, Kipling and Geiger, are poorly to somewhat poorly drained clays, medium acid to neutral. Of the bottom-land soils, Marietta and Verona are young alluvium, somewhat poorly to poorly drained, coarse to medium in texture, and neutral to calcareous. Of the fine-textured acid soils, Kaufman

TABLE 3.—*Soil suitability for hardwoods in the Coastal Plain area*

Important commercial species	Terraces			Bottoms from Coastal Plain materials					
	Cahaba, Kalmia, Amite	Flint, Prentiss, Tilden, Izagora	Stough, Wahee, Myatt, Leaf	Ochlockonee, Iuka, Bruno	Mantachie, Urbo	Bibb	Chastain: Coarse surface	Chastain: Fine surface	Johnston
Ash, green & white	—	○	○	○	□	■	○	●	●
Baldcypress	—	—	—	—	○	■	○	●	●
Beech, American	—	—	—	○	□	○	○	○	—
Birch, river	—	—	—	□	○	—	—	—	—
Cherry, black	●	○	○	■	○	—	—	—	—
Cottonwood, eastern	—	—	○	●	●	●	●	●	—
Elms, slippery & American	○	○	○	□	□	□	○	—	—
Hackberry and sugarberry	—	○	○	●	●	○	○	○	—
Hickories (exc. water)	□	□	○	□	□	○	○	○	—
Magnolia, southern	○	○	—	■	■	○	○	—	—
Maple, red	○	○	□	■	■	■	■	●	□
Oak, cherrybark	●	■	■	■	■	■	■	■	—
Oak, laurel	—	—	○	○	●	■	■	■	—
Oak, Nuttall	—	—	—	—	●	■	●	■	—
Oak, overcup	—	—	—	—	○	□	○	□	—
Oak, Shumard	●	●	●	●	●	●	●	○	—
Oak, southern red	■	■	○	●	●	○	—	—	—
Oak, swamp chestnut	—	●	○	●	■	■	●	○	—
Oak, water	□	■	□	■	■	■	□	□	—
Oak, white	■	■	□	■	■	●	●	○	—
Oak, willow	○	○	□	●	■	●	●	□	—
Persimmon, common	○	○	○	○	●	●	●	●	—
Pines (exc. spruce)	□	□	■	○	○	○	○	○	—
Pine, spruce	—	—	—	●	●	●	●	○	—
Sweetgum	■	■	■	■	■	■	■	■	○
Sycamore, American	—	—	—	■	■	●	●	●	—
Tupelo, black	■	■	□	■	■	□	□	□	—
Tupelo, water	—	—	—	—	—	●	●	●	■
Walnut, black	●	○	○	●	●	○	○	—	—
Yellow-poplar	■	■	□	■	■	■	●	—	●

POST AND SPECIALTY SPECIES: Black locust and flowering dogwood on moist, well-drained soils; mulberry on all soils.

SPECIES LIMITED COMMERCIALLY OR IN OCCURRENCE: Basswood, pecan, post oak, and silver maple on well-drained soils; shingle oak, sweetbay, and swamp tupelo on poorly drained soils; boxelder, winged elm, honeylocust, black willow, sassafras, American holly, buckeye, chinaberry, and common sweetleaf on all soils.

WEED SPECIES: Blackjack oak and smooth sumac on well-drained soils; planertree, roughleaf dogwood, poison-sumac, and buttonbush on poorly drained soils; eastern hophornbeam, American hornbeam, devils-walkingstick, hawthorn, and flatwoods plum on all soils.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
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is moderately well drained, Houlka is somewhat poorly drained, and Una is poorly drained. Of the fine-textured alkaline group, Catalpa, which is brown, and West Point (sometimes called Trinity), which is black, have the best internal drainage. Tuscumbia has the poorest.

The larger river flood plains in the Blackland area with some of these soils are Tombigbee, Alabama, Noxubee, and Trinity.

TABLE 4.—*Soil suitability for hardwoods in the Blackland area*

Important commercial species	Terrace soils:[1] Kipling, Geiger	Bottom soils					
		Recent coarse and medium-textured: Marietta, Verona	Fine-textured acid			Fine-textured calcareous	
			Kaufman	Houlka	Una	Catalpa, West Point	Leeper, Tuscumbia
Ash, green & white	□	■	○	■	■	■	■
Cottonwood, eastern	●	■	●	●	○	■	■
Elms, slippery & American	○	□	○	□	○	□	□
Hackberry and sugarberry	○	■	●	■	□	■	■
Hickories (exc. water)	○	○	□	□	○	—	—
Maple, red	○	□	○	■	□	—	○
Maple, silver	○	○	—	—	—	○	○
Oak, cherrybark	●	●	■	■	■	—	—
Oak, Durand	●	●	■	■	—	●	●
Oak, Nuttall	—	—	●	■	■	○	○
Oak, overcup	—	—	○	○	□	—	○
Oak, post	□	—	—	—	—	—	—
Oak, Shumard	●	●	■	■	○	—	—
Oak, swamp chestnut	○	●	●	■	○	○	—
Oak, water	□	■	●	■	□	○	○
Oak, white	●	—	●	●	○	—	—
Oak, willow	○	■	●	■	□	○	—
Persimmon, common	○	○	○	□	○	—	—
Sweetgum	●	●	■	■	■	●	●
Sycamore, American	○	●	●	●	●	●	●
Tupelo, black	○	○	●	●	○	○	○
Yellow-poplar	—	●	●	●	○	—	—

[1] Noneroded phases only.

POST AND SPECIALTY SPECIES: Black locust and catalpa on all well-drained, moist soils; eastern redcedar on all dry soils; Osage-orange on all neutral to alkaline soils; mulberry on all soils.

SPECIES LIMITED COMMERCIALLY OR IN OCCURRENCE: Boxelder, winged elm, honeylocust, and pecan on all soils; American beech, southern magnolia, spruce pine, American holly, shingle oak, sassafras, and chinaberry on all acid soils; black walnut and black cherry on all well-drained, moist soils; laurel oak and sweetbay on acid, poorly drained soils; black willow and baldcypress on all moist, poorly drained soils.

WEED SPECIES: Hawthorn and privet on all soils; American hornbeam, eastern hophornbeam, roughleaf dogwood, and flatwoods plum on all acid soils; smooth sumac on all moist, well-drained soils; redbud and Hercules-club on terraces and acid soils.

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● Occurs occasionally; favor.
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RED

Reddish-brown soils occupy the flood plains of the Arkansas and Red Rivers and include acid to alkaline sands, silts, and clays. They are formed of alluvium, mainly from the western plains. The more alkaline soils occur in the Red River flood plain and the more acid soils in the Arkansas River flood plain.

Their wide range in properties produces an equivalent range in quality and growth of many important commercial hardwoods. Suitability relationships are shown in table 5.

Of the terrace soils, McKamie, Hortman, and Muskogee are moderately to well drained acid soils, Morse and Asa are similar in drainage but neutral to alkaline, and Gore, Acadia, and Wrightsville are poorly to somewhat poorly drained and acid.

Of the acid bottom-land soils, Pulaski, Gallion, Lonoke, and Mer Rouge are better drained than Hebert, Portland, and Perry. Of the

TABLE 5.—*Soil suitability for hardwoods in the Red area*

Important commercial species	Terraces			Bottoms			
	McKamie, Hortman, Muskogee	Morse, Asa	Gore, Acadia, Wrightsville	Pulaski, Gallion, Lonoke, Mer Rouge	Yahola, Norwood	Hebert, Portland, Perry	Miller, Buxin, Roebuck, Pledger
Ash, green & white	□	○	□	□	■	■	■
Cottonwood, eastern	—	—	—	●	■	●	●
Elms, slippery & American	□	□	○	□	□	□	□
Hackberry and sugarberry	□	□	○	□	■	□	□
Hickories (exc. water)	□	—	□	□	—	○	○
Honeylocust	—	□	—	○	○	○	□
Oak, cherrybark	■	○	●	■	—	■	—
Oak, Nuttall	●	○	●	●	○	■	○
Oak, overcup	—	—	○	○	○	□	○
Oak, swamp chestnut	□	—	○	■	—	■	○
Oak, water	■	○	●	■	○	■	○
Oak, white	■	—	●	●	—	○	—
Oak, willow	□	○	●	●	—	■	○
Pecan	○	■	—	■	■	○	■
Pines	□	—	□	—	—	—	—
Sweetgum	■	■	■	■	■	■	●
Sycamore, American	●	●	—	■	■	●	●
Tupelo, black	○	—	□	○	—	—	—

POST AND SPECIALTY SPECIES: baldcypress on all poorly drained soils; eastern redcedar on all moderately to well-drained soils; Osage-orange on neutral to alkaline soils; mulberry and persimmon on all soils.

SPECIES LIMITED COMMERCIALLY OR IN OCCURRENCE: post oak on well-drained acid soils; swamp tupelo on poorly drained acid soils; blackjack oak, American holly, winged elm, sassafras, and Shumard oak on acid soils; boxelder on neutral to alkaline soils; American smoketree on poorly drained neutral to alkaline soils; black willow, pumpkin ash, water hickory, and pin oak on all poorly drained soils; cedar elm, chinaberry, and red maple on all soils.

WEED SPECIES: American hornbeam and eastern hophornbeam on acid soils; hawthorn, swamp-privet, redbud, and roughleaf dogwood on all soils; devils-walkingstick on terraces.

■ Occurs frequently; favor in management.
● Occurs occasionally; favor.
□ Occurs frequently; manage, but do not favor.
○ Occurs occasionally; manage, but do not favor.

others, which are neutral to alkaline to calcareous, Yahola and Norwood are better drained than Miller, Buxin, Roebuck, and Pledger.

LITERATURE CITED

(1) Beaufait, W. R.
1956. Influence of soil and topography on willow oak sites. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 148, 12 pp., illus.

(2) Broadfoot, W. M.
1960. Field guide for evaluating cottonwood sites. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 178, 6 pp., illus.

(3) ———
1961. Guide for evaluating cherrybark oak sites. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 190, 9 pp., illus.

(4) ———
1963. Guide for evaluating water oak sites. U. S. Forest Serv. Res. Paper SO-1, 8 pp., illus. South. Forest Expt. Sta., New Orleans, La.

(5) ——— and Krinard, R. M.
1959. Guide for evaluating sweetgum sites. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 176, 8 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-13

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

REFRIGERATOR-CAR STORAGE OF LOBLOLLY PINE SEEDLINGS HIGHLY SUCCESSFUL

Hamlin L. Williston [1]
SOUTHERN FOREST EXPERIMENT STATION

Cold storage of pine seedlings has become an accepted practice in the South. For the past 3 years the Yazoo-Little Tallahatchie Flood Prevention Project in north Mississippi has been using railroad refrigerator cars, parked on sidings, to store loblolly pine seedlings. This is a report of a 1963 study of survival and growth of stock that was outplanted after being held for 1, 5, and 9 weeks in refrigerator cars and in a cold-storage room.

METHODS

Fifteen kraft-polyethylene bags of loblolly seedlings (1,000 per bag) were received from the Ashe Nursery, Brooklyn, Mississippi, on January 9. Three bags were placed immediately in each of four refrigerator cars and three were put in a cold-storage room with the regular run of Project seedlings. The cars were on sidings at Oxford, Coffeeville, Oakland, and Batesville, Mississippi.

A thermocouple was installed in the center of one bag of seedlings at each of the five storage locations. Holes made in the bags by the wires were sealed with masking tape. Temp-

Figure 1.—*Railroad refrigerator cars are convenient for storing bagged pine seedlings to extend planting seasons beyond nursery lifting dates.*

[1] The author is in charge of the project on management of erosive watersheds. This project is maintained at Oxford, Mississippi, in cooperation with the University of Mississippi.

eratures were read three times a week with a potentiometer. Two additional thermocouples were placed in the top and bottom of one of the bags and read for 6 weeks to determine the variation within the bag. Wall thermometers in each storage unit were read whenever the thermocouples were. Recording hydrothermographs were placed in one car and in the cold storage room for a continuous record of temperature and humidity.

On January 18 one bag of seedlings was removed from each of the five storage places. Two hundred Grade I or II seedlings were selected from each bag and outplanted 50 to a plot in randomly selected plots. Similar outplantings were made on February 15 and March 15.

In late March, after rains had settled the soil, heights of the outplanted seedlings were measured and mortality and animal damage noted. First-year survival and heights were recorded in October.

RESULTS

Storage temperatures.—Air temperatures in the cars ranged from 26 to 68° F., with an average low of 28° and an average high of 56° during the 9 weeks. For 67 percent of the time they were lower than 40°. Temperatures in the bags were in the forties 68 percent of the time; the highest recorded was 68° on a day in March when the outdoor air was about 85°. In the middle of the bags of seedlings temperatures averaged 2° higher than just inside the bags and 6° higher than the air temperature in the cars.

In the cold-storage room average temperatures were several degrees higher than in the cars, ranging from 30 to 55° in the air and from 35 to 60° in the bags. Temperatures in the bags were lower than 50° for 55 percent of the time. Air temperatures in the room were below 40° only 31 percent of the time. It had been expected that the cold-storage room would provide colder and more even temperatures than the cars, but the refrigeration unit was too small.

In figure 2 car and bag temperatures are compared for a 9-week period. Bag temperatures were generally higher than the maximum car temperatures, probably because of heat generated by the seedlings. The fluctuations in minimum and maximum car temperatures

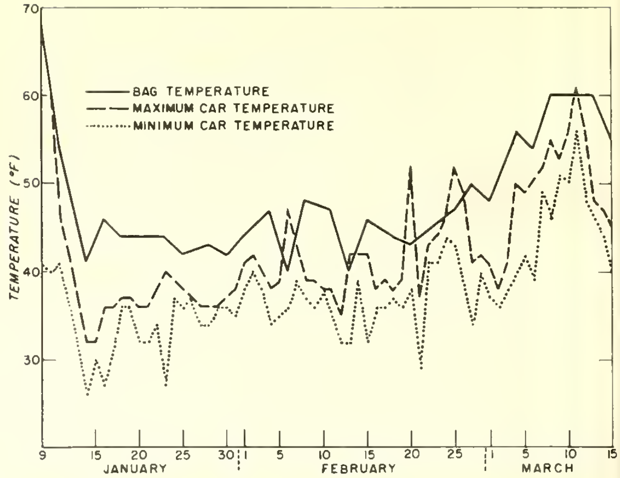

Figure 2.—*Daily minimum and maximum air temperatures and periodic bag temperatures in a refrigerator car at Oxford, Mississippi.*

are largely attributable to the influence of the outdoor air when the car doors were open during loading and unloading.

Humidity in the cars ranged from 20 to 100 percent and averaged about 69 percent. In the cold-storage room it ranged from 40 to 100 percent and averaged about 77.

Bag temperatures in °F. (B) in the cars were significantly related (0.01 level) to car temperatures (C). The simple linear regression equation was: $B = 16.37 + 0.7847\ C$.

As car temperature rose the spread between car and bag temperatures decreased. For example:

Car	*Bag*
30°	40°
40°	48°
50°	56°
60°	63°

Seedling survival and growth.—For the January and February plantings, seedlings stored in cars survived somewhat better than those from the cold-storage room, but the differences were not statistically significant. For the March planting, survival was the same for both storage methods (table 1). Height growth was not significantly affected by storage method. Car-to-car variation in seedling performance was small.

Time of planting had a very significant effect (0.01 level) on both survival and height

Table 1.—*Seedling survival and height at end of first growing season*

Planting date	Storage duration	Seedling survival		Seedling height	
		Cars	Cold-storage room	Cars	Cold-storage room
	Weeks	– *Percent* –		– – – *Feet* – – –	
January 18	1	79	78	0.87	1.00
February 15	5	96	82	1.16	1.23
March 15	9	99	99	1.52	1.43

growth. Survival in October averaged 79 percent for the January planting, 93 percent for the February planting, and 99 percent for the March planting. Immediately after they were planted, seedlings averaged about 0.5 foot in height. By fall those planted in January averaged 0.90 foot, those planted in February 1.18 feet, and those planted in March 1.50 feet.

Seventeen percent of the seedlings were browsed by mules, cows, deer, and rabbits, but only 15 percent of the browsed trees died. Seedlings planted in January suffered the heaviest mortality, perhaps from the combined effect of 9 days of subfreezing weather in late January and the browsing. Summer mortality averaged only 2 percent despite an August-September drought.

Other studies in other years have shown similar increases in survival and height growth with late planting. Presumably storage does not make the seedlings more viable; it simply permits planting when hazards are lower and conditions for immediate root growth better. Seedlings can be lifted during cold weather when they are dormant and well hardened and stored until the weather is most favorable for planting.

STORAGE FACTS

Three years of experience and the results of this study have proven that storage of pine seedlings in refrigerator cars is economical and convenient. The Yazoo-Little Tallahatchie Project used 4 cars in 1962, 9 in 1963, and 16 in 1964.

In 1963, the Project stored 25,445,000 seedlings. The nine cars, which were used for an average of 96 days each, were obtained from the Illinois Central Railroad at a special rate, as they were in need of repairs for over-the-road service. Each car had 1,972 cubic feet of space and held a maximum of 750,000 seedlings. An average of 2,433 pounds of ice was used per car-week at a cost of $0.012 per pound. (In 1962, when the winter was much warmer, 5,000 pounds of ice were used per car-week.) Racks for holding the seedlings were built of lumber at a cost of $166 per car.

Storage cost per thousand seedlings in 1963 was about $0.22. This value was a function not only of the number of seedlings stored but also of the duration of storage. Nearly 7 million seedlings were stored in one car at a cost of $0.105 per thousand.

The refrigerator car's mobility is its greatest asset. Provided that ice does not have to be trucked too far, a car is convenient in many communities where commercial cold-storage rooms are lacking, and in many towns may provide cheaper storage than commercial rooms. It gives excellent protection against freezing temperatures and good protection against high temperatures, and it can usually be spotted in a convenient place.

Some cautions are in order. Salting the ice is necessary when the outside temperature gets much above 50°. Uniformity of bags or bales is essential in order to utilize the space to greatest advantage. To the extent feasible, cars should be loaded so that the seedlings longest in storage can be planted first.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-14

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

ROT CULL IN BLACK WILLOW

E. Richard Toole [1]

SOUTHERN FOREST EXPERIMENT STATION

In stands on the batture of the lower Mississippi River, the proportion of volume rendered cull by rot increased with stand age but was less than 1 percent after 30 years, by which time most pure stands were breaking up.

Black willow (*Salix nigra* Marsh.) is an important hardwood along the lower Mississippi River, being cut extensively for pulpwood and other products. As growth is fast and the trees are intolerant, considerable top dieback and mortality occur at an early age, often in the second decade. In addition, rot fungi gain entrance through insect holes, top breaks, branch stubs, and butt wounds. The study reported here measured the proportion of volume destroyed by rot in natural stands of various ages, and identified the important rot fungi.

METHODS

Forty-four plot centers were located at random in pure, well-stocked, unthinned willow stands along the Mississippi River in Arkansas and Mississippi. At each center, all live trees that qualified when viewed through a wedge prism with a factor of 10, and that were at least 5 inches d.b.h., were measured, felled, and bucked into 4-foot pulpwood bolts. Minimum bolt diameter was 4 inches, inside bark. The total sample of 694 trees represented stands ranging from 7 to 34 years in age and from 122 to 184 square feet per acre in basal area. Unthinned willow stands characteristically break up at relatively early ages, and in this study no fully stocked pure stands over 34 years of age were found. No attempt was made to estimate volume in trees that were dead when the stands were sampled.

RESULTS

Cull volume increased significantly (0.01 level) with stand age (fig. 1), but the volumes of cull were small. In the 34-year-old stands, the average amount was 41 cubic feet per acre (table 1)—about 1 percent of the stand volume, and therefore not of practical importance. Essentially no rot occurred in trees less than 12 years of age.

Most of the cull volume resulted from infections that had originated at branch stubs. Broken tops were the next most important infection court, followed by butt wounds and insect

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Mississippi, by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

Table 1.—*Basal area and volumes (inside bark, to a 4-inch top) of sample stands*

Age (years)	Plots	Average basal area per acre	Gross volume per acre	Cull volume per acre	Proportion of cull volume by infection court			
					Insect holes	Top breaks	Branch stubs	Butt wounds
	Number	*Sq. ft.*	*Cu. ft.*	*Cu. ft.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
7	5	122	1,135	0.0	...	...	...	...
12	9	160	3,065	.65	62	28	10	0
20	10	184	4,945	4.38	0	11	68	21
28	10	144	4,167	35.44	5	29	45	21
34	10	161	4,714	40.78	12	21	66	1

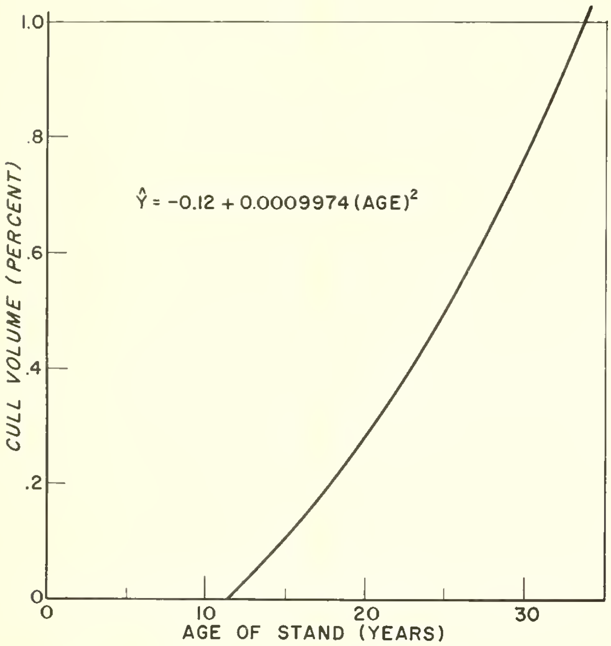

Figure 1.—*Cull volume in willow stands along the Mississippi River.*

holes. The stands were on moist sites where fire is rare, hence butt wounds ranked low as infection courts. On other hardwood sites fire wounds are the chief point of entry for rot fungi. Pulpwood utilization enhances the importance of rot from branch stubs and top breaks, because bolts are cut from portions of the crown that would be ignored in logging for other products.

The bolts, which were chiefly sapwood, yielded isolates of 19 rot fungi. Those identified were *Daedalea confragosa* (Bolt.) Fr., *Lentinus tigrinus* (Bull.) Fr., *Pleurotus corticatus* Fr., *P. ostreatus* (Jacq.) Fr., *Polyporus supinus* (Swartz) Fr., *P. versicolor* (L.) Fr., and *Schizophyllum commune* Fr. Many of these are important sap rotters on other hardwood species. Most of them formed sporophores on some of the sampled trees.

The scarcity of cull on the sample plots suggests that the breakup of willow stands is due to causes other than the action of rot fungi.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-15

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LOUISIANA'S TIMBER HARVEST, 1963

Charles C. Van Sickle

SOUTHERN FOREST EXPERIMENT STATION

In 1963, timber products from Louisiana forests totaled 381 million cubic feet. This harvest supplied roundwood to more than 220 primary wood-using plants within the State, and to about 60 in surrounding States. A canvass of these plants, together with a survey of nonindustrial wood use, provided the data summarized in table 1.

Saw logs made up nearly half of the 1963 output. Most of the saw-log harvest was softwood, almost all pine but including some cypress and redcedar. Oak and gum made up three-fourths of the hardwood. Louisiana mills processed 86 percent of the saw logs. The balance, 144 million board feet, was delivered to Arkansas, Mississippi, and Texas. Some 31 million board feet were brought into Louisiana from neighboring States. More than 90 percent of all the logs sawn in the State were cut by 84 mills, each of which produced at least 3 million board feet of lumber in 1963. Of these establishments, 28 cut more than 10 million apiece.

Pulpwood bolt production rose to an alltime high of 2 million cords, or 39 percent of the roundwood. In addition, 270 thousand cord equivalents of chips were derived from residues that came largely from sawmills. At the year's end, 10 wood pulpmills were operating in Louisiana; their combined daily pulping capacity was 6 thousand tons. Five mills outside the State were using wood grown in Louisiana.

All veneer logs made in Louisiana were hardwood. More than three-fourths of the 1963 volume was soft-textured. Sweetgum, blackgum, and tupelo were by far the leading species. Sweetgum alone contributed 40 percent of the total volume. Oak accounted for most of the firm-textured wood. Although 11 veneer plants were active in 1963, a third of the veneer log output was shipped to adjacent States for manufacture.

Poles and piling accounted for 3 percent of the 1963 harvest. Virtually all of the volume was southern pine. Most of this material was shipped to local wood-preserving plants for treatment. All of the 26 plants are of the pressure type, and also treat large quantities of lumber, crossties, and fence posts.

Round fuelwood output dropped to 376 thousand cords. A decade ago, the annual cut was 761 thousand cords. The number of homes burning wood for heating and cooking is expected to decline further as rising trends in per capita income and urbanization continue.

All other products cut in 1963 supplied 2 percent of the total roundwood output in Louisiana. Their volume, 7.7 million cubic feet, was mostly in fence posts and dimension stock.

Tables 2 through 6 of this report constitute a directory of Louisiana's primary wood-using plants. Plant locations are mapped in figure 1. Small, generally portable, sawmills are omitted because of their transitory nature; these mills numbered about 80 in 1963. While an effort was made to locate all active plants, a few may have been accidentally missed. Omission of a firm, therefore, is no reflection upon its activities, nor does inclusion constitute a recommendation.

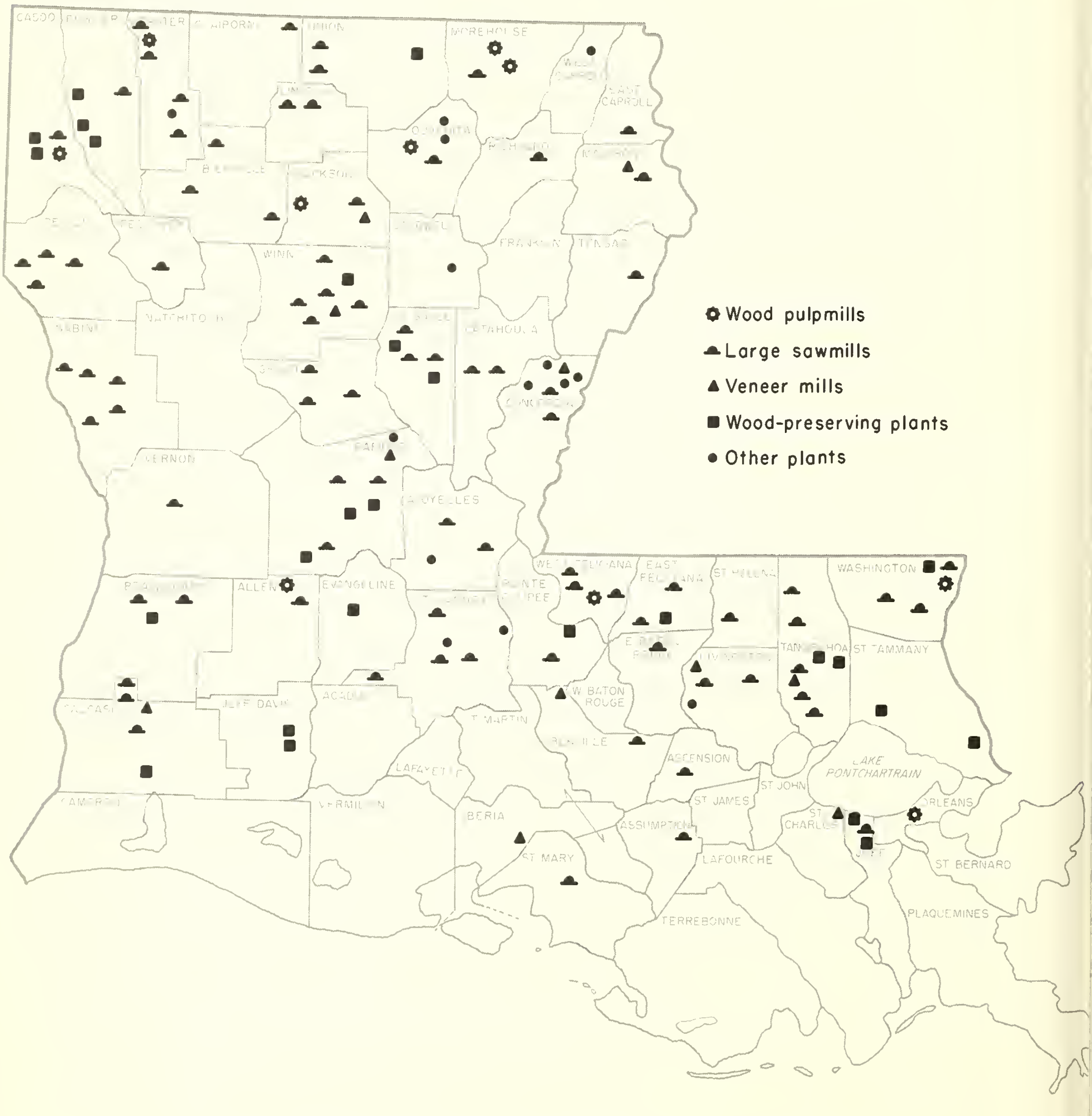

Figure 1.—*Location of primary wood-using plants in Louisiana, 1963.*

Table 1.—*Output of roundwood by product*

Product	Standard units				Roundwood volume		
	Unit	All species	Softwood	Hardwood	All species	Softwood	Hardwood
					– – – – *M cubic feet* – – – –		
Saw logs	M bd. ft. [1]	1,065,888	673,572	392,316	176,202	110,803	65,399
Veneer logs	M bd. ft. [1]	48,069		48,069	8,066		8,066
Pulpwood	Std. cords [2]	[3] 1,968,521	1,502,990	465,531	149,543	113,325	36,218
Piling	M linear ft.	4,891	4,891		3,941	3,941	
Poles	M pieces	473	473		7,419	7,419	
Posts	M pieces	4,625	4,111	514	2,275	1,946	329
Fuelwood	Std. cords [2]	[4] 375,936	21,159	354,777	28,195	1,587	26,608
Misc. products [5]	M cubic ft.	[6] 5,424	20	5,404	5,424	20	5,404
All products					381,065	239,041	142,024

[1] International ¼-inch rule.
[2] Rough wood basis.
[3] Not including 20.4 million cubic feet of wood from mill residues used for pulp.
[4] Not including 26.2 million cubic feet of wood from mill residues used for domestic and industrial fuel.
[5] Includes cooperage logs and bolts, handle stock, furniture stock, chemical wood, and other miscellaneous products.
[6] Not including 1.1 million cubic feet of mill residues used for miscellaneous products.

Table 2.—*Wood pulpmills*

Parish	Firm	Location	Type [1]
Allen	Calcasieu Paper Co., Inc.	Elizabeth	S
Caddo	Bird and Son, Inc.	Shreveport	S-C
Jackson	Continental Can Co., Inc.	Hodge	S,S-C
Morehouse	International Paper Co. (Bastrop Mill)	Bastrop	S-C
	International Paper Co. (Louisiana Mill)	Bastrop	S,G
Orleans	The Flintkote Co.	New Orleans	G
Ouachita	Olin Mathieson Chemical Corp.	West Monroe	S
Washington	Crown Zellerbach Corp.	Bogalusa	S,S-C
Webster	International Paper Co.	Springhill	S
West Feliciana	St. Francisville Paper Co.	St. Francisville	G

[1] S indicates sulfate process.
S-C indicates semichemical process.
G indicates groundwood and other mechanical processes.

Table 3.—*Large sawmills* [1]

Parish	Firm	Plant	
		Location	Address [2]
Allen	Hillyer-Deutsch-Edwards, Inc. [3]	Oakdale	
Ascension	Donaldsonville Band Lumber Co.	Donaldsonville	
Assumption	DeJean Hardwood Lumber Co.	Napoleonville	
Avoyelles	Elder Lumber Co., Inc.	Marksville	
	Riverland Hardwood Co., Inc.	Simmesport	
Beauregard	International Paper Co. [3]	De Ridder	
	C. N. Lockwood	De Ridder	
Bienville	Hunt Lumber Co., Inc. [3]	Danville	Ruston
	Martin Timber Co. [3]	Castor	
	Woodard-Walker Lumber Co. [3]	Taylor	
Bossier	Willis Lumber Co. [3]	Princeton	
Caddo	J. W. Jeffries Lumber Co.	Shreveport	
Calcasieu	Carter Lumber Co.	De Quincy	
	Emmick Lumber Co.	De Quincy	
	Johnson Lumber Co. [3]	Sulphur	
Catahoula	Easterling Lumber Co.	Jonesville	
	Mississippi Valley Hardwood Co., Inc.	Jonesville	
Claiborne	Anthony Kervin Lumber Co., Inc.	Junction City	
Concordia	Ferriday Hardwood Lumber Co.	Ferriday	
	Rogers Brothers Lumber Co.	Ferriday	
De Soto	McCoy Brothers Lumber Co. [3]	Stanley	Logansport
	Matthews Lumber Co. [3]	Mansfield	
	Matthews Lumber Co.	Mansfield	
	James A. Pace Lumber Co. [3]	Logansport	
East Baton Rouge	Zachary Hardwood Lumber Co.	Zachary	
East Carroll	E. Sondheimer Co.	Sondheimer	
East Feliciana	J. B. Brunt Lumber Co.	Clinton	
	Central Creosoting Co.	Slaughter	
Grant	Colfax Lumber Co., Inc. [3]	Colfax	
	Carroll W. Maxwell Lumber Co., Inc. [3]	Pollock	
	Verda Lumber Co.	New Verda	
Iberville	Johnson Hardwood Lumber Co., Inc.	Plaquemine	
Jackson	W. L. Browder Lumber Co.	Chatham	
Jefferson	W. A. Ransom Lumber Co. [3]	Harahan	
La Salle	Carraway and McDougald Lumber Co. [3]	Jena	
	Tullos Lumber Co. [3]	Jena	
	The Urania Lumber Co., Ltd. [3]	Urania	
Lincoln	M. L. Hood	Dubach	
	G. L. Trammell and Sons	Dubach	
Livingston	E. E. Fowler Lumber Co.	Denham Springs	
	Starns-McConnell Lumber Corp.	Holden	
Madison	Chicago Mill and Lumber Co.	Tallulah	

Table 3.—*Large sawmills*[1] (Continued)

Parish	Firm	Plant	
		Location	Address[2]
Morehouse	Simpson Lumber Co., Inc.	Bastrop	
Ouachita	Walter Kellogg Lumber Co., Inc.	Monroe	
Pointe Coupee	Esper Marionneau Lumber Co.	Livonia	
Rapides	Crowell Lumber Industries	Longleaf	
	L. D. Kellogg, Lumber Co., Inc.	Alexandria	
	Roy O. Martin Lumber Co., Inc.[3]	Alexandria	
Red River	Almond Brothers Lumber Co.	Coushatta	
Richland	George B. Franklin and Son	Holly Ridge	
Sabine	Hunt Lumber Co., Inc.[3]	Zwolle	
	Louisiana Longleaf Lumber Co.[3]	Fisher	
	Mathews Lumber Co., Inc.	Many	
	Sabine Lumber Co.[3]	Zwolle	
	Wright's Sawmill, Inc.	Many	
St. Helena	Terrebonne Lumber and Supply Co., Inc.[3]	Pine Grove	
St. Landry	Gantt Nicholson Lumber Co.	Opelousas	
	May Brothers Inc.	Eunice	
	Turner Lumber Co.	Lemoyne	Le Moyen
St. Mary	May Brothers Inc.	Garden City	
Tangipahoa	Clemons Brothers Lumber Co.[3]	Amite	
	Conway Guiteau Lumber Co.[3]	Fluker	
	Louisiana Cypress Lumber Co.[3]	Ponchatoula	
	Ponchatoula Lumber Co., Inc.[3]	Ponchatoula	
	Reimers-Schneider Lumber Co., Inc.[3]	Natalbany	
Tensas	W. E. Parks Lumber Co.	Newellton	
Union	Bernice Hardwood Co., Inc.	Bernice	
	C. A. Reed Lumber Co., Inc.[3]	Bernice	
Vernon	Anderson Enterprises	Leesville	
Washington	T. P. Fornea	Varnado	
	Pearl River Lumber Co.	Bogalusa	
	Richardson Forest Products Inc.[3]	Franklinton	
Webster	Johnson Lumber Co.[3]	Cotton Valley	
	Pace Brothers Lumber Co., Inc.[3]	Minden	
	Springhill Lumber Co.[3]	Springhill	
	Woodard-Walker Sawmill Co.[3]	Heflin	
West Feliciana	King Lumber Industries	St. Francisville	
	Riverland Hardwood Co., Inc.	Tunica	
	Tunica Hardwood Co., Inc.	Tunica	
Winn	Brewton and Taylor Lumber Co.[3]	Winnfield	
	L. L. Brewton Lumber Co.[3]	Winnfield	
	Hunt Lumber Co., Inc.[3]	Dodson	Hunt
	Olin Mathieson Chemical Corp.[3]	Winnfield	
	Tremont Lumber Co.[3]	Joyce	

[1] Output of 3 million board feet or more.
[2] Specified only if different from plant location.
[3] Produces chips for sale to pulpmills.

Table 4.—*Wood preserving plants*

Parish	Firm	Location	Type [1]
Beauregard	International Paper Co., Wood Preserving Division	De Ridder	P
Bossier	Benton Creosoting Co.	Benton	P
	Joslyn Manufacturing and Supply Co.	Bossier City	P
	T. J. Moss Tie Co.	Bossier City	P
Caddo	Olin Mathieson Chemical Corp.	Shreveport	P
	Standard Wood Preservers of Shreveport, Inc.	Shreveport	P
Calcasieu	Reeves Lumber Co.	Lake Charles	P
East Feliciana	Central Creosoting Co.	Slaughter	P
Evangeline	Reddell Creosote Co., Inc.	Reddell	P
Jefferson	Celcure Wood Preserving Corp. of Louisiana	Kenner	P
	Joslyn Manufacturing and Supply Co.	Harahan	P
Jefferson Davis	Evr-Wood Treating Co.	Jennings	P
	Renner Creosoting Co.	Jennings	P
La Salle	LaSalle Creosoting Co., Inc.	Jena	P
	The Urania Lumber Co., Ltd.	Urania	P
Pointe Coupee	Laurent Wood Treating Service	New Roads	P,N
Rapides	Colfax Creosote Co., Division of R. O. Martin Lumber Co.	Pineville	P
	Koppers Co., Inc., Wood Preserving Division	Alexandria	P
	Glenmora Creosote Co.	Glenmora	P
St. Tammany	American Creosote Works, Inc.	Slidell	P
	Madisonville Creosote Works	Madisonville	P
Tangipahoa	Oliver Treated Products Co.	Hammond	P
	R and K Creosoting Co.	Natalbany	P
Union	Linville Creosoting Co.	Linville	P
Washington	Angie Wood Preserving Co.	Angie	P,N
Winn	American Creosote Works, Inc.	Winnfield	P

[1] P indicates pressure testing.
N indicates nonpressure treating.

Table 5.—*Veneer plants*

Parish	Firm	Location	Type [1]
Calcasieu	General Box Co. [2]	Lunita	C
Concordia	Wilson and Co., Inc.	Clayton	C
Iberia	Grimes and Freeman	Jeanerette	O
Iberville	Southwood Veneer Co. [2]	Maringouin	C
Jackson	Louisiana Veneer Co. [2]	Chatham	O
Livingston	McIntyre Veneers, Inc.	Denham Springs	O
Madison	Chicago Mill and Lumber Co.	Tallulah	C
Rapides	American Box Co. [2]	Pineville	C
St. Charles	Delta Match Corp. of Louisiana	Kenner	O
Tangipahoa	American Box Co.	Hammond	C
Winn	Winnfield Veneer Co. [2]	Winnfield	O

[1] C indicates plants producing chiefly container veneer.
O indicates plants producing chiefly commercial and other veneers.
[2] Produces chips for sale to pulpmills.

Table 6.—*Miscellaneous plants*

Parish	Firm	Location
Avoyelles	Louisiana Hoop Co., Inc.	Bunkie
Caldwell	Winters Hardwood Products	Columbia
Concordia	Leon E. Ellis	Wildsville
	L. L. McDowell	Ferriday
	Rogers Brothers Lumber Co.	Ferriday
	Winters Hardwood Products	Wildsville [1]
Livingston	W. B. Brown and Sons, Inc.	Denham Springs
Ouachita	Walter C. Crowell Co.	Monroe
	Louisville Cooperage Co. [2]	Monroe
Rapides	Standard Lumber Co.	Tioga
St. Landry	Martin Furniture Works	Washington
	True Wood Products, Inc.	Melville
Webster	Leakey's Mill	Minden
West Carroll	Bennett Lumber Co.	Oak Grove

[1] Address Columbia, La.
[2] Produces tight cooperage; all others produce dimension stock.

SOUTHERN FOREST EXPERIMENT STATION

1964

U.S. FOREST SERVICE RESEARCH NOTE

SO-16

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

ESTIMATING FOLIAGE ON LOBLOLLY PINE

Thomas L. Rogerson [1]

SOUTHERN FOREST EXPERIMENT STATION

The weight of foliage on loblolly pine trees in a 25-year-old north Mississippi plantation was found to be closely related to tree diameters, while fascicle length and weight were independent of tree size. Thus foliage parameters such as needle numbers, volumes, or surface areas, often needed for hydrologic and other purposes, may be approximated from relatively inexpensive stand measurements. Since the study area included a considerable range in site quality, the relationships should be rather widely applicable in similar fully stocked stands.

METHODS

Fascicles were stripped from 28 trees in the 25-acre plantation during April 1963, after winter leaf fall was complete, and before new needles had developed. They were air-dried for 2 months and then weighed. Ovendry weights were determined from subsamples dried at 105° C. for 24 hours.

Sample trees ranged from 5.4 to 10.9 inches in diameter and averaged 8.08 inches—very close to the stand average. Total heights ranged from 37 to 66 feet; lengths of live crowns, from 15 to 30 feet; and areas of crowns projected vertically, from 50 to 373 square feet. Basal area as measured on 10 one-tenth-acre plots was 131.2 ± 20.6 square feet per acre at the 5-percent probability level. Site index ranged from 69 to 97 over the area sampled.

Relationship of Foliage Weight to Tree Characteristics

Equations were developed to relate foliage weight per tree to every possible combination of the seven independent tree variables:

X_1 = Diameter at breast height (d.b.h.)
X_2 = Projected crown area
X_3 = Length of live crown
X_4 = Total height
X_5 = Basal area
X_6 = Basal area × projected crown area
X_7 = Projected crown area × length of live crown

Table 1 is a summary of selected equations.

Single-variable equations utilizing diameter and basal area accounted for more variation

[1] The author is assigned to the Coastal Plain Hydrology Project, maintained by the Southern Forest Experiment Station at Oxford, Mississippi, in cooperation with the University of Mississippi.

Table 1.—*Summary of selected equations for predicting foliage weight (Y) in kilograms*

Variables		Equations	Percent of variation accounted for
D.b.h., X_1	(1)	$Y = 1.46342X_1 - 7.16756$	78.7
Basal area, X_5	(2)	$Y = 16.10160X_5 - 1.26096$	78.8
Projected crown area, X_2	(3)	$Y = 0.02688X_2 + 0.74603$	74.7
Length of live crown, X_3	(4)	$Y = 0.34565X_3 - 3.31464$	24.1
Total height, X_4	(5)	$Y = 0.20612X_4 - 6.71368$	32.4
Basal area × projected crown area, X_6	(6)	$Y = 0.03898X_6 + 2.24574$	76.6
Projected crown area × length of living crown, X_7	(7)	$Y = 0.00091X_7 + 1.47624$	68.7
X_1, X_2	(8)	$Y = 0.89876X_1 + 0.01298X_2 - 4.49355$	84.4
X_2, X_5	(9)	$Y = 0.01273X_2 + 9.92227X_5 - 0.84208$	83.9
X_1, X_2, X_3, X_4, X_5, X_6, and X_7	(10)	$Y = 0.76181X_1 + 0.02715X_2 - 0.07712X_3 - 0.02310X_4 + 5.36089X_5 - 0.01947X_6 - 0.00012X_7 - 2.73002$	86.1
Log d.b.h., X_8	(11)	$\text{Log } Y = 2.67156X_8 - 1.79586$	81.0

than the other one-variable equations. Projected crown area made a small but statistically significant contribution when included after diameter or basal area in the better two-variable equations. Adding a third variable to either of these equations did not provide significant improvement.

The minor refinement associated with the inclusion of crown area after diameter or basal area, together with the difficulty of measuring this variable, encouraged the acceptance of a single-variable equation relating foliage weight to some function of diameter. A logarithmic transformation suggested by previous investigations,[2,3] seems to describe the relationship adequately. The equation finally accepted (No. 11 in table 1) is graphed in figure 1. The weight of foliage on a tree at the geometric mean diameter (7.95 inches) was 4.074 kilograms or 8.98 pounds. The gray band around the regression in figure 1 indicates the confidence limits for mean foliage weight with a one-in-three chance of error. Within the wide band are the probable limits of error for predicting the weight of foliage on a single tree at the same odds.

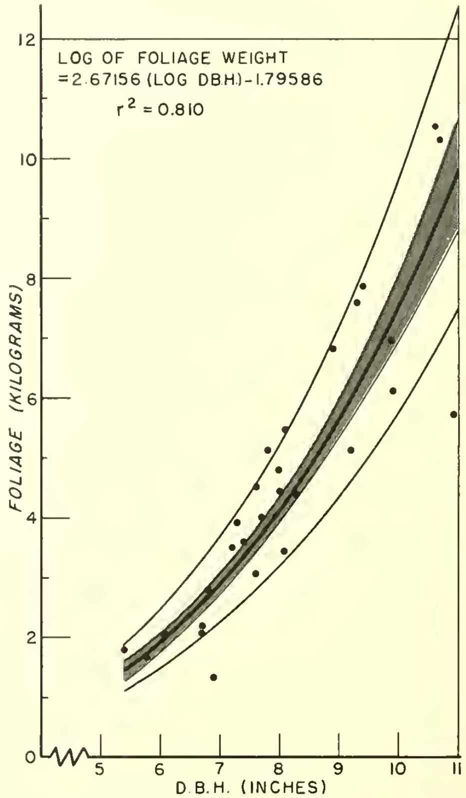

Figure 1.—*Regression of ovendry foliage weight on tree diameter with 67-percent confidence bands for mean foliage weight of population (gray band) and of individual observations (wide band).*

[2] Kittredge, Joseph. Forest influences. 394 pp., illus. New York: McGraw-Hill. 1948.

[3] Cable, Dwight R. Estimating surface area of ponderosa pine in central Arizona. Forest Sci. 4: 45-49, illus. 1958.

ESTIMATE OF FASCICLES

The average length of fascicles and their ovendry weight were independent of tree diameter. Correlation coefficients squared (r^2) were 0.003 and 0.018, respectively. Because of this independence, the fascicle is best described by the mean length and weight of all fascicles sampled. The average length was 5.88 ± 0.06 inches (95-percent level); the average ovendry weight was 0.11709 ± 0.00423 gram (95-percent level).

Dividing estimated foliage weights by average weight per fascicle provides estimates of numbers of fascicles, which can be multiplied by three to obtain needle numbers. With a good model of needle geometry, needle length and number can be used to estimate total foliage volume and surface. Since these calculations involve errors of estimate in addition to the variance about the regression (fig. 1), estimates for single trees would be subject to appreciable errors. For many purposes, however, estimates on an area basis are useful, and could be computed with considerably more precision by applying these relationships to stand tables.

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-17

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

TREE DIAMETER GROWTH IN ALABAMA

George M. Judson

SOUTHERN FOREST EXPERIMENT STATION

How fast do Alabama's trees grow? Measurements taken on 2,872 trees resurveyed in Alabama during 1962-63 provide answers to this question.

The sample trees were on plots established in 1951-53 on a systematic grid covering the State. Species and diameters were sampled in proportion to occurrence. Growth was computed for all growing-stock trees that were at least 5.0 inches in diameter breast high at the first measurement. D.b.h. was taken outside bark in both inventories. Thus diameter growth, wood and bark, was gaged directly, and the problems of making estimates from increment borings were avoided.

Diameter increase of each tree was divided by the interval between measurements to arrive at periodic annual diameter growth. Because the growth interval varied among trees, the statistics are reported on an annual basis. Nevertheless, the interval was about 10 years. Hence, decadal growth can be approximated by multiplying the annual rates by 10. This note summarizes growth rates by species, tree diameter class, site, and geographic area.

Pines.—Data for the major southern pines, loblolly, shortleaf, longleaf, and slash, and for the minor species (Virginia and spruce pines combined) are given in table 1. The table indicates average growth capabilities over the range of sites each species occupies in the State.

Table 1.—*Annual diameter growth of pine species*

Species group	Sample trees	Mean growth	Standard deviation
	Number	*Inch*	*Inch*
Shortleaf	415	0.18	0.11
Longleaf	246	.22	.11
Slash	65	.24	.11
Loblolly	445	.26	.15
Minor species	39	.25	.17

A Duncan's 5-percent multiple range test showed that shortleaf was the slowest grower. Loblolly had the fastest growth, but its margin was not great enough to separate it from slash and the minor pines. The results of the test appear below; the means for any species not enclosed by the same bracket are significantly different:

Shortleaf
Longleaf
Slash
Minor species
Loblolly

Hardwood species.—Among the hardwoods, yellow-poplar was the fastest-growing species, and the red oaks were next (table 2).

Upland trees grew significantly (0.01 level) slower than bottom-land trees. The contrast was most pronounced in the oaks and the group of other hard species. Sweetgum and the group of other soft species were least affected by site.

Duncan's test was applied to the differences between species means in both upland and bottom-land sites:

For uplands—

Tupelos
Other hard hardwoods
Hickories
Other soft hardwoods
White oak group
Sweetgum
Red oak group
Yellow-poplar

For bottom lands—

Tupelos
Other soft hardwoods
Hickories
Other hard hardwoods
Sweetgum
White oak group
Red oak group
Yellow-poplar

As the bracketing shows, yellow-poplar and the red oaks were superior on both sites. On the uplands, the tupelos, represented by blackgum, were distinctly slower than the other species. On the bottom lands, where the group included additional species, growth was similar to that of the other soft hardwoods and the hickories.

Pine versus hardwood.—Neither for pines nor for hardwoods did growth vary much by diameter class (table 3). The difference between the Statewide means of 0.22 inch for pine and 0.13 inch for hardwood was significant (0.01 level). The lack of a definite trend in growth by diameter reflects the moderate stocking common over the State.

The diversity of hardwood species represented, and the wide range of sites they occupy, causes them to vary more in growth rate than do the pines. The coefficient of variation

Table 2.—*Annual diameter growth of hardwoods by physiographic site*

Species group	All sites		Uplands			Bottom lands		
	Sample trees	Mean growth	Sample trees	Mean growth	Standard deviation	Sample trees	Mean growth	Standard deviation
	Number	*Inch*	*Number*	*Inch*	*Inch*	*Number*	*Inch*	*Inch*
Red oaks	311	0.18	264	0.17	0.10	47	0.25	0.16
White oaks	292	.13	271	.12	.07	21	.19	.10
Hickories	249	.10	238	.10	.07	11	.14	.06
Other hard hardwoods	183	.13	102	.10	.08	81	.16	.10
Yellow-poplar	47	.24	33	.22	.15	14	.29	.17
Sweetgum	198	.15	157	.14	.10	41	.16	.15
Tupelos (inc. blackgum)	249	.08	151	.07	.06	98	.10	.08
Other soft hardwoods	133	.12	94	.12	.08	39	.13	.10

Table 3.—*Annual diameter growth by d.b.h. class*

D. b. h. class (inches)	Pine			Hardwood		
	Sample trees	Mean growth	Standard deviation	Sample trees	Mean growth	Standard deviation
	Number	*Inch*	*Inch*	*Number*	*Inch*	*Inch*
6	522	0.22	0.13	733	0.13	0.10
8	352	.23	.13	416	.13	.11
10	179	.24	.12	255	.13	.10
12	88	.22	.12	122	.14	.10
14	40	.24	.14	66	.14	.10
16	11	.26	.19	40	.13	.09
18	10	.21	.09	18	.16	.10
20+	8	.18	.09	12	.15	.13
All diameters	1,210	.22	.13	1,662	.13	.10

is 76 percent for hardwoods and 58 percent for pine.

Survey regions.—Growth of pines and hardwoods within the six regions recognized by the Forest Survey (fig. 1) was subjected to Duncan's test:

For pine:

Survey region	6	5	1	4	2	3
Annual diameter growth	.16	.19	.23	.23	.24	.25

For hardwood:

Survey region	1	5	2	6	4	3
Annual diameter growth	.12	.12	.13	.13	.14	.15

Pine growth is slowest in the more mountainous northern units, where shortleaf is heavily represented. Loblolly predominates in the southeast, where pine diameter growth reaches 0.25 inch.

The narrow range of hardwood growth by units results from the combining of many species and sites in arriving at unit means.

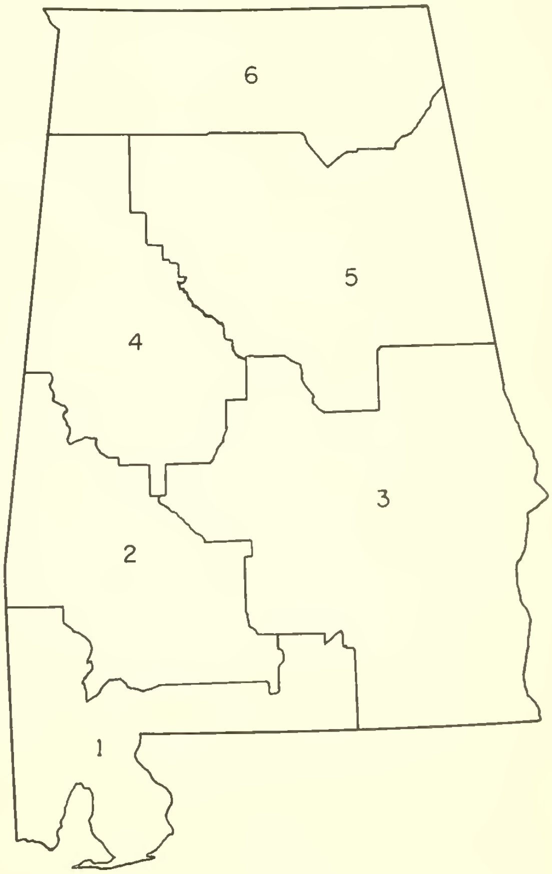

Figure 1.—*Forest Survey regions in Alabama.*

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-18

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA 70113

TOWN ANTS CONTROLLED WITH MIREX BAITS

Hamp W. Echols

SOUTHERN FOREST EXPERIMENT STATION

In exploratory tests in central Louisiana,[1] colonies of town ants, *Atta texana* (Buckley), have been destroyed with an experimental bait containing mirex, a chemical used for controlling the imported fire ant. The bait was formulated as small pellets and placed on the surface of the ground. It is safe to handle, requiring only the use of rubber gloves. The chemical compound is dodecachlorooctahydro-1, 3, 4-metheno-2H-cyclobuta [cd] pentalene.

The town ant, sometimes called the Texas leaf-cutting ant, is a serious pest of pine seedlings in central Louisiana and east Texas. The insects damage trees by cutting off needles, bark, and buds, which they carry to underground gardens for the culture of a fungus that they use for food. Complete control of the ants for 4 or 5 years is essential to success in planting or seeding forest trees. Fumigation with methyl bromide or carbon disulfide is at present the only known control, but it is not fully effective at all seasons and the volatile materials require very careful handling.

Fourteen colonies, ranging in size from 1 to more than 500 surface mounds, were treated with the bait in an initial test during the fall of 1963. The pellets were placed around feeder holes, which surround the central nest and connect it with foraging trails. For small nests without outlying feeder holes, the bait was placed directly on the mounds. Dosages were heavy: 14 grams of bait per entrance, with 10 to 100 feeder holes baited, depending on nest size.

Worker ants immediately carried all the pellets into the nest (fig. 1). Normal foraging ceased in 5 to 10 days, and all colonies were dead within 30 days.

Similar results were observed in February 1964, when 18 colonies were treated. They ranged in size from 50 to 100 mounds. Bait was applied at the rate of 2.8 grams per visible mound, and was distributed around 10 or more entrance holes. For example, a colony having 100 mounds in the central portion of the nest received 280 grams.

In each test, the foraging ants exhibited toxic symptoms in 3 to 5 days. Their mandibles were spread apart, they reared backwards, and shortly before they became immobilized they drew their abdomens up under the thorax.

[1] The research was done with the cooperation of Allied Chemical Corporation.

FIGURE 1.—*Foraging ants carried pelleted bait to their underground chambers.*

Twelve nests were partially excavated after all surface activity had stopped. All ants in them were dead, and the fungus gardens were in an advanced stage of deterioration and covered with foreign fungi. Follow-up examinations for a 6-month period disclosed no new activity.

Laboratory tests were made to learn how a colony utilizes the bait. Small, one-mound nests were excavated and placed in clear plastic containers that were connected to additional containers holding bait and accessible to foraging workers. Though the workers seldom moved the pellets into the fungus garden, the colonies were affected in the same way as those in the field: workers were dying within 3 days and the colonies were destroyed in 6 days.

It has usually been thought that the fungus gardens are the ants' sole source of food, but laboratory studies with dyed bait showed that the workers were feeding outside the gardens. Microscopic examinations revealed dye throughout the digestive tract and concentrations of it in the post-pharyngeal glands, which are associated with the digestive system (fig. 2). Similar concentrations of dye occurred in the nonforaging workers, indicating that there was a direct food transfer between individuals.

The bait promises to reduce costs, give consistent control, and extend the season in which colonies can be treated. Additional studies are in progress to determine minimum dosage and the feasibility of simple broadcast application.

Mirex bait developed specifically for use on town ants is not yet available commercially. It may be marketed during 1965, after current studies are complete and hazard to wildlife has been evaluated.

FIGURE 2.—*Head of a town ant that has eaten mirex bait; dye from the bait has accumulated in the post-pharyngeal glands, which are located above the antennae.*

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-19

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SEED ORIGIN AFFECTS LONGLEAF PINE IN LOUISIANA PLANTATION

Eugene Shoulders

SOUTHERN FOREST EXPERIMENT STATION

Seed source significantly affected both survival and height of longleaf pine *(Pinus palustris* Mill.) in a 5-year-old plantation in central Louisiana. Survival was correlated with mean annual temperature, and height with January-through-April rainfall at the source.

The plantation, situated on a cutover longleaf site in Rapides Parish, comprises longleaf series 4 and 6 of the Southwide Pine Seed Source Study *(4)*[1] planted adjacent to each other. Ten sources are included that cover most of the range of longleaf pine: two from Alabama, two from Louisiana, and one each from Virginia, South Carolina, Georgia, Florida, Mississippi, and Texas. Series 4 follows an east-west transect of the species' range; series 6, a north-south transect. Local (Rapides Parish, Louisiana) and Georgia sources are common to both series.

Preliminary analyses revealed that fifth-year survival and height in each series were significantly affected by seed origin; but neither survival nor growth was prominently related to climatic, geologic, or geographic characteristics of the sources. Therefore, the two series were combined in joint analyses, with means and variances adjusted by the technique of Gomes and Guimarães *(2)*. Duncan's multiple range test *(1)* was used to isolate means that differed significantly.

[1] Italic numbers in parentheses refer to Literature Cited, page 3.

SURVIVAL

Adjusted fifth-year survival ranged from 81 percent for seed from Perry County, Alabama, to 29 percent for the Hillsborough County, Florida, source (table 1). Seedlings from Perry County survived significantly better (0.05 level) than those from Baldwin County, Alabama; Polk County, Texas; Washington Parish, Louisiana; and Hillsborough County, Florida. Those representing the Florida source survived significantly less well than trees from 7 of the 10 sources, and were equal in survival only to southeast Louisiana and Texas sources. Trees from Rapides Parish survived as well as any others, and significantly better than those from south Alabama, Texas, southeast Louisiana, and Florida. Other significant differences are indicated in the last column of table 1.

Multiple regression analysis revealed a curvilinear relationship between survival, mean

Table 1.—*Fifth-year survival of longleaf pine, adjusted for differences between series*

Seed source	Series	Mean annual temperature	Fifth-year survival	Significance [1]
		°F.	*Percent*	
Perry County, Ala.	4	64	81	
Rapides Parish, La.	4 and 6	67	74	
Harrison County, Miss.	6	67	72	
Florence County, S. C.	6	64	72	
Treutlen County, Ga.	4 and 6	67	64	
Nansemond County, Va.	6	60	63	
Baldwin County, Ala.	4	67	59	
Polk County, Tex.	4	67	48	
Washington Parish, La.	4	67	43	
Hillsborough County, Fla.	6	72	29	

[1] Any two means not enclosed in the same bracket are significantly different at 0.05 level.

annual temperature of the source, and mean annual temperature squared. These variables accounted for 58 percent (R = 0.759) of the variation in fifth-year survival (fig. 1). The results confirm, at least for this plantation, the hypothesis *(4)* that temperature at the source influences planting survival. The curvilinear relationship seems logical, as the mean annual temperature of central Louisiana is intermediate among those represented in the plantation.

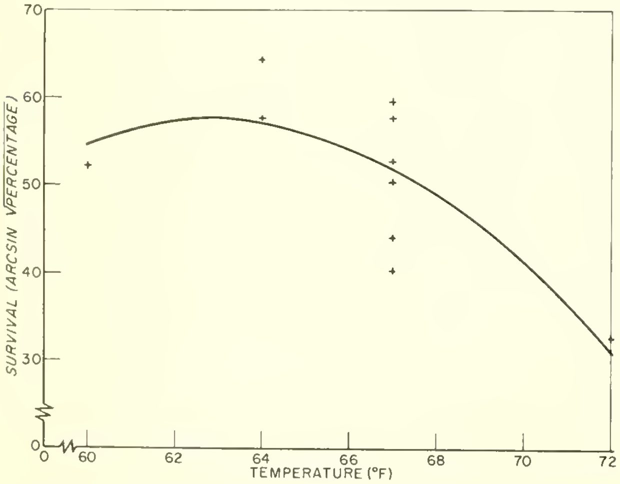

FIGURE 1.—*Fifth-year survival of longleaf seedlings in relation to mean annual temperature of their seed sources.*

HEIGHT GROWTH

Seedlings of the Baldwin County, Alabama, source excelled in height growth during the first 5 years. Their adjusted heights averaged 4.91 feet (table 2). Trees from three other sources—Texas, Mississippi, and Perry County, Alabama—also were significantly taller than those of local origin. Conversely, local source trees, with an average height of 2.44 feet, were taller than representatives of Washington Parish, Louisiana, and Hillsborough County, Florida. The latter averaged only 0.62 foot tall, and grew less in the 5-year period than trees from 8 of the 10 sources. The brackets in table 2 show other heights that differed significantly.

Heights were correlated with January-through-April rainfall at the source. A regression that included both rainfall and rainfall squared as independent variables explained 75 percent (R = 0.864) of the variation among individual source means (fig. 2). This correlation between height and early season rainfall supports Squillace and Kraus' *(3)* hypothesis that rapidly growing trees will predominate in areas where rainfall is optimum for growth, and that a race of superior growers should develop in these regions.

Table 2.—*Fifth-year heights of longleaf pine adjusted for differences between series*

Seed source	Series	Rainfall, January through April	Fifth-year height	Significance [1]
		Inches	*Feet*	
Baldwin County, Ala.	4	19	4.91	
Polk County, Tex.	4	17	3.75	
Perry County, Ala.	4	20	3.73	
Harrison County, Miss.	6	20	3.56	
Florence County, S. C.	6	13	2.58	
Rapides Parish, La.	4 and 6	22	2.44	
Treutlen County, Ga.	4 and 6	15	2.31	
Nansemond County, Va.	6	14	2.19	
Washington Parish, La.	4	22	1.35	
Hillsborough County, Fla.	6	11	.62	

[1] Any two means not enclosed in the same bracket are significantly different at 0.05 level.

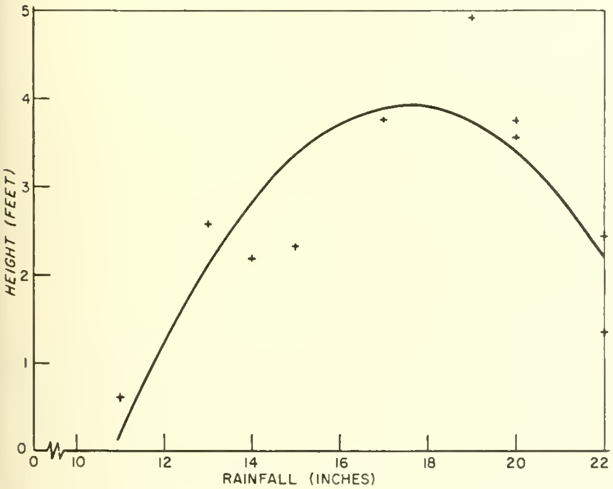

FIGURE 2.—*Relationship between fifth-year heights of longleaf seedlings and January-through-April rainfall of their seed sources.*

CONCLUSIONS

Obviously, fifth-year results of one local test are insufficient to verify the growth hypothesis. They do suggest, however, that similar appraisals of other seed source plantations be made to determine if some function of rainfall will facilitate delineation of seed collection zones. The correlation of survival with mean annual temperature should also be investigated further to learn if temperature at the source limits survival sufficiently to warrant consideration when establishing collection boundaries.

LITERATURE CITED

1. Duncan, D. B.
   1955. Multiple range and multiple *F* tests. Biometrics 11: 1-42, illus.
2. Gomes, F. P., and Guimarães, R. F.
   1958. Joint analysis of experiments in complete randomised blocks with some common treatments. Biometrics 14: 521-526.
3. Squillace, A. E., and Kraus, J. F.
   1959. Early results of a seed source study of slash pine in Georgia and Florida. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 21-34, illus.
4. Wakeley, P. C.
   1952. Working plan for cooperative study of geographic sources of southern pine seed. U. S. Forest Serv. South. Forest Expt. Sta., for the Comn. on South. Forest Tree Impr., 35 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-20

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SECTIONAL POLE FOR MEASURING TREE HEIGHTS

R. H. Brendemuehl and James B. Baker

SOUTHERN FOREST EXPERIMENT STATION

A sectional aluminum pole designed by the Silviculture Laboratory at Marianna, Florida, has proved useful for measuring tree heights. It is more convenient than a sectional bamboo pole[1] or a telescoping fiberglas pole. A tree 5 to 30 feet in height can be measured to the nearest tenth of a foot in 30 seconds. The pole is constructed of low-cost, readily available materials, is easy to maintain, and is light in weight yet durable. All heights greater than 5 feet are read directly at eye level.

Materials and construction details are indicated in figure 1. Permanent graduations can be made on the tubing by cutting it very lightly with a pipe cutter. Numbers about ½-inch high are marked with a center punch and hammer. A length of ⅞-inch O.D. steel pipe should be placed inside the tubing to keep it from bending while numbers are being marked. Black paint placed in the graduations further improves their legibility.

To measure a tree, the 6-foot base pole, with attached canvas bag containing the upper sections, is placed upright at the base of the tree. Next, section 1 (fig. 1)—with the 5-foot graduation at its upper end—is raised parallel to the bole of the tree, but is not attached to the base pole. Section 2, with the 10-foot graduation at the upper end, is then fitted into the lower end of section 1 and the two sections raised upward along the bole. Other sections are added as needed. The second member of the two-man crew, the tallyman, signals when the pole is even with the top of the tree. Now the sections that have been extended up the bole are aligned with the base pole. The tree height is then read directly from the extended pole (in feet) and the 5.0- to 5.9-foot section

[1] Liming, Franklin G. A sectional pole for measuring tree heights. Jour. Forestry 44: 512-514, illus. 1946.

of the base pole (tenths of feet). The "Parts in Reading Position" portion of figure 1 shows the base and extended poles properly aligned for measuring a tree 18.6 feet tall. Trees up to 35 feet tall have been measured with this equipment.

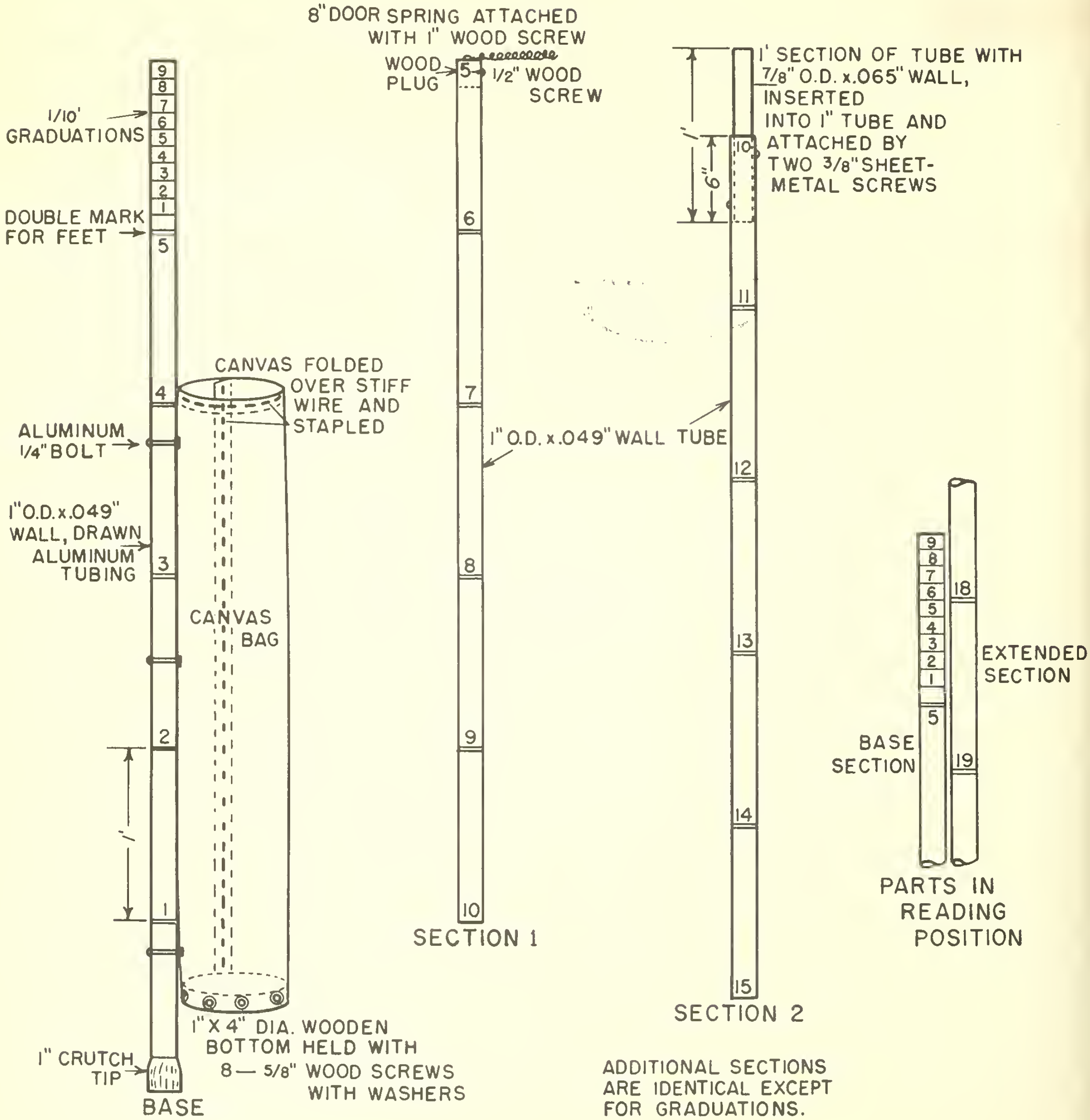

FIGURE 1.—*Details of sectional measuring pole. All rough edges should be smoothed to prevent injury to hands and to insure good fit.*

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-21

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FOREST-FIRE DANGER AS RELATED TO AIRMASS IN THE OUACHITA MOUNTAINS[1]

Myron W. Gwinner[2]

SOUTHERN FOREST EXPERIMENT STATION

In warm, moist Gulf airmasses, temperature and relative humidity on an exposed ridgetop were similar to those in a nearby valley. In cooler Canadian and Pacific airmasses, afternoon measurements at the two locations were about the same, but during the night the ridgetop averaged 8° F. warmer and 27 percentage points drier than the valley.

The Ouachita Mountains of west-central Arkansas and southeastern Oklahoma are an area of long, east-west ridges separated by wide to narrow valleys. Local differences in elevation range from a few hundred to about 2,000 feet. Main slopes are 30 to 50 percent. Until the 1930's this region had one of the worst forest fire histories in the United States. Though fire incidence and area burned now are usually low, occasional outbreaks during dry fall or spring weather show what fire can do. For example, in record-dry October 1963, 80 fires burned more than 20,700 acres of land under protection of the U. S. Forest Service.

The Ouachita National Forest measures fire danger at a relatively few valley-bottom stations and gets forecasts from the U. S. Weather Bureau office at Fort Smith, Arkansas. Fire-control personnel have long suspected that the measurements and predictions do not represent burning conditions accurately over the full range of topography. To learn how the fire weather observations and forecasts apply to upper slopes, ridgetops, and different aspects, the National Forest and the Forest Fire Research Project of the Southern Forest Experiment Station established a study in October 1962.

METHODS

Four experimental weather stations recorded fire danger factors in an area near the east end of the Ouachita Mountains, about 50 miles west of Little Rock. Three stations were on Fourche Mountain—one on the ridgetop near Cove Mountain Fire Tower and one each on the north and south slopes at elevations about 140 feet below that of the tower. The tower is at 1,200 feet on a straight narrow ridge. Secondary ridges, several hundred feet lower, lie about a mile north and south of the main

[1] Based on a paper presented to the Sixth National Conference on Agricultural Meteorology, sponsored by the American Meteorological Society. Lincoln, Nebraska, October 8-10, 1964.

[2] The author is on the staff of the Forest Fire Research Project, Alexandria, Louisiana.

ridge. The fourth weather station was at Jessieville Guard Station, in a major valley 16 miles south-southeast of the tower, elevation 730 feet.

Temperature and relative humidity data from weekly hygrothermograph charts were tabulated for each station at bihourly intervals, on even hours. Wind speeds, measured by Weather Bureau-type anemometers, were averaged for 1-hour periods preceding even hours. Prevailing wind direction 80 feet above the ridgetop was determined for the same 1-hour periods.

Weights of fuel moisture indicator sticks were available one to three times daily at each station. Regular observation times were 10 a. m., 2 p. m., and 4 p. m. Other duties of the observers sometimes caused omissions, mostly during periods of low fire danger.

Precipitation was recorded with a tipping-bucket rain gage at the tower, and was measured daily at Jessieville.

For a preliminary analysis, data from the period February through May 1963 were grouped according to airmass types. Major types were continental polar (cP) air that originated over Canada and the Arctic, maritime polar (mP) air from over the North Pacific Ocean, and maritime tropical (mT) air from over the Gulf of Mexico.

Days were eliminated from consideration if airmass type changed or was in transition, or if precipitation, excessive cloudiness, or fog occurred. Because only 9 continental polar days remained, the analysis was made with data for 9 days from each airmass type, the days being randomly chosen for the other two types.

Bihourly mean temperatures and mean relative humidities were calculated for each station for each airmass. For each station, differences between the means for airmasses were subjected to the "t" test. To determine station (or within-airmass) significance, means of differences between the ridgetop and each of the other stations were tested.

RESULTS

This report presents data from the ridgetop and valley stations only. Differences between slope stations and the ridgetop were generally too small to be conclusive.

Temperature.—All temperature differences between airmasses (table 1) were highly significant. Mean temperature of the cP air was 32° F., of the mP air 58°, and of the mT 73°.

The valley was 2 to 3° warmer than the ridgetop during the afternoon and 4 to 12° cooler at night (fig. 1). All afternoon differences and all night differences greater than 5° were significant (i. e., at the 0.05 level). Both day and night differences were slightly greater in the mP air than in the other two types.

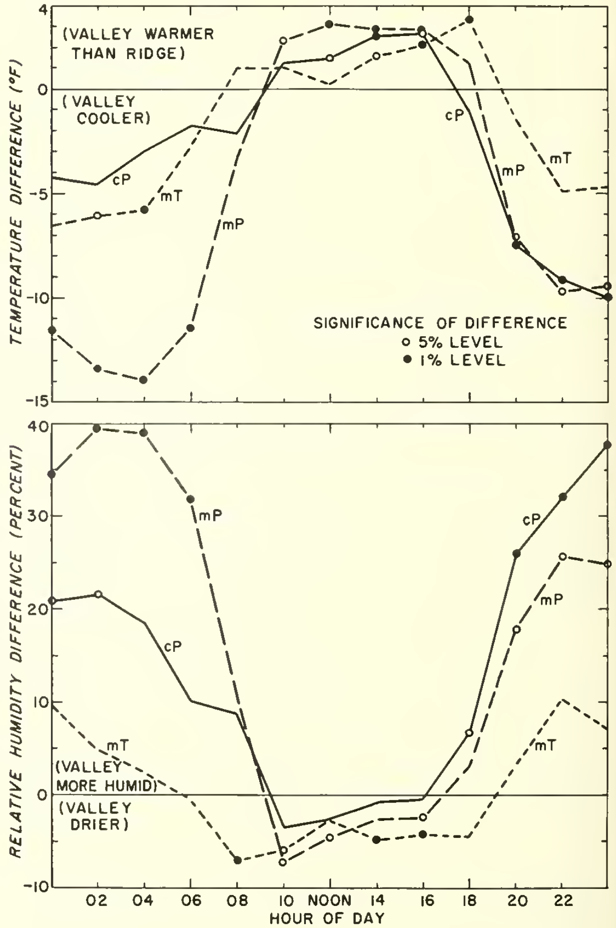

Figure 1.—*Difference of valley from ridgetop temperature and relative humidity in three airmass types.*

Relative humidity.—Relative humidities in the two polar airmass types were similar. But during the daytime (10 a.m. to 4 p.m.) polar air humidity averaged 33 percent and tropical air 49 percent (table 1). All daytime humidity differences between polar and tropical air were highly significant (i. e., at the 0.01 level) both on the ridgetop and in the valley.

Table 1.—*Mean values of day, night, and 24-hour temperature and relative humidity*

Element and airmass	Day, 10 a.m. to 4 p.m.		Night, 8 p.m. to 6 a.m.		24 hours	
	Ridge	Valley	Ridge	Valley	Ridge	Valley
			TEMPERATURE			
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Continental polar	39.8	41.7	28.4	22.9	32.8	30.4
Maritime polar	68.0	70.8	55.7	44.6	60.6	55.9
Maritime tropical	80.3	81.5	68.8	64.4	73.3	71.9
			RELATIVE HUMIDITY			
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Continental polar	33.5	31.7	47.1	70.1	42.0	54.1
Maritime polar	34.7	30.5	45.7	76.2	41.3	56.4
Maritime tropical	51.0	46.6	75.3	80.0	65.7	65.7

Nighttime (8 p.m. to 6 a.m.) relative humidity was 10 to 40 percentage points higher in the valley than on the ridgetop in the polar airmass types, and 5 to 10 percentage points higher in the tropical air (fig. 1). Only the polar-air differences were significant.

Daytime relative humidity in the valley was 1 to 4 percentage points lower than on the ridgetop in the cP air, and 3 to 7 points lower in the mP and mT air. Most of the mP and mT differences were significant; none of the cP differences were.

Wind.—Wind at the fire tower blew from all directions in the two polar airmass types, but it was nearly always from the south and southwest in tropical air (fig. 2). Southerly winds usually were stronger than those from other directions.

Winds on the ridgetop blew steadily day and night, averaging 8 to 10 m.p.h., while valley winds calmed on most nights. Valley winds averaged 1 m.p.h. at night and 6 m.p.h. during the day.

Relation of nighttime differences to valley wind speed.—Further investigation of nighttime ridgetop-valley differences of temperature and relative humidity showed that magnitude of the difference was related to valley wind speed (table 2). When valley winds were calm, the usual cool, moist valley condition prevailed. As wind speed increased, differences decreased, and at about 3 m.p.h. temperature and humidity were the same at both locations. All nighttime observations when valley wind was 4 m.p.h. or greater showed the valley warmer and drier than the ridgetop.

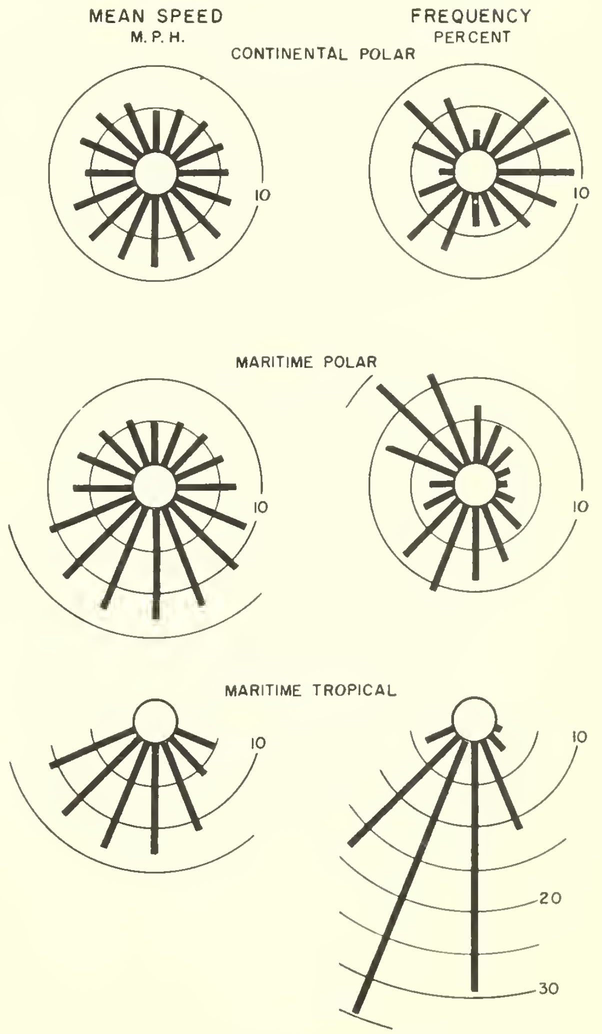

Figure 2.—*Frequency of wind and mean speed from different directions for three airmass types. Wind speed is from the ridgetop station; frequencies are expressed as percentages of all observations.*

Table 2.—*Relation to valley wind speed of nighttime ridgetop-valley differences of temperature and relative humidity*

Airmass	Temperature difference when valley winds were—		Relative humidity difference when valley winds were—	
	Calm	4 m.p.h. or more	Calm	4 m.p.h. or more
	°F.	*°F.*	*Pct.*	*Pct.*
Continental polar	−9.2	4.0	36.4	−11.0
Maritime polar	−16.3	3.3	45.8	−10.2
Maritime tropical	−9.8	1.9	14.6	−7.8
	(valley cooler)	(valley warmer)	(valley more humid)	(valley drier)

Fuel moisture content.—Afternoon (2 p.m. and 4 p.m.) fuel moisture averaged lowest, about 5½ percent, in the mP air at both stations (fig. 3). It was 6 to 6½ percent in the cP air, and about 7 percent in the mT air. Wide variation and scarcity of observations kept most differences from being significant, but mP fuel moisture was significantly lower than mT at both stations and significantly lower than cP in the valley. Afternoon differences between the ridgetop and valley were not significant.

The morning (10 a.m.) fuel moisture measurement provided another indication of the

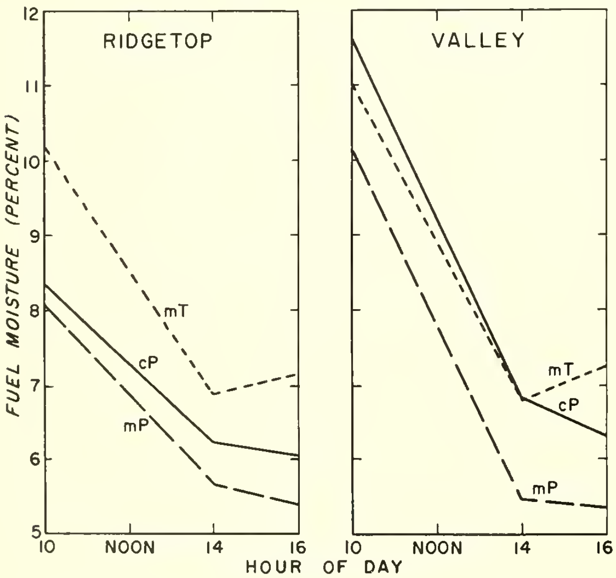

Figure 3.—*Comparison of fuel moisture content among three airmass types at ridgetop and valley stations.*

drier nighttime conditions on the ridgetop in polar air. In polar air, morning fuel moisture averaged 2½ percentage points lower on the ridgetop than in the valley, while in tropical air the ridgetop fuel averaged less than 1 percentage point drier than valley fuel. The differences were significant in both polar airmass types.

CONCLUSIONS

The conclusion most important for fire control is that, in polar air, 24-hour burning conditions are definitely more severe on ridgetops than in valley bottoms even though afternoon fire danger ratings differ little between the two locations. In tropical air, differences in burning conditions due to topographic situation are small at all hours, except for differences in wind speed.

Polar air predominates during the periods of greatest fire occurrence and highest danger in late fall and early spring. Therefore, fire danger measured at the usual valley-bottom locations may result in serious under-estimates of general burning conditions just when accurate estimates are most needed. Cool, moist air at night over valley fire danger stations can completely hide high-danger conditions at higher elevations.

Wind amplifies the topographic difference in severity. It blows throughout the night at higher elevations, but usually calms in the valleys. When valley winds do blow at night, valley and ridgetop have similar temperature and humidity conditions.

The relatively higher temperatures of maritime polar air make it potentially more dangerous from a fuel moisture viewpoint than continental polar air.

Fundamentally the most important conclusion is that the inherent differences between airmass types make them a meaningful and significant basis for stratifying certain types of climatological data. Recognition of this fact can be helpful both to fire-weather forecasters and fire-control personnel.

SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

1965

SO-22

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

DIAMETER GROWTH AND PHENOLOGY OF TREES ON SITES WITH HIGH WATER TABLES

D. C. McClurkin

SOUTHERN FOREST EXPERIMENT STATION

On a site where the water table always was within the root zone, thinning had little effect on diameter growth of white ash or sweetgum but increased the growth of baldcypress. Thinning did not extend duration of growth into the fall, nor was growth related to seasonal fluctuations in the water table. In ash and sweetgum, growth initiation seemed related to soil temperature; in baldcypress, to day length.

Previous studies with pines *(1, 4, 8, 9, 10)*[1] had indicated that tree diameter growth is related to soil moisture depletion on upland sites that are well above any water table. The current study examined seasonal growth of hardwoods and cypress on a bottom-land site where free water was present in the rooting zone during much of the growing season.

THE STUDY AREA

Two plots were laid out in pure stands of each of three species: baldcypress *(Taxodium distichum* (L.) Rich.), white ash *(Fraxinus americana* L.), and sweetgum *(Liquidambar styraciflua* L.). One plot of each species had been thinned in 1958, prior to study installation, and the other left unthinned. Ash plots were 1 acre in size, baldcypress 1/2 acre, and sweetgum 1/10 acre.

The site was a minor botton on the Tallahatchie Experimental Forest near Oxford, Mississippi. The soil is moderately deep, permeable loam to silty clay with fairly good internal drainage. The bottom is fed by numerous temporary springs and is bounded on one side by a small permanent stream. Plot elevations above the stream bed for the thinned and unthinned treatments respectively were: sweetgum—6.3 and 5.5 feet; ash—6.0 and 8.7 feet; baldcypress—6.9 and 6.4 feet. During heavy winter and spring rains, the bottom is subject to brief overflow. The gum plots were on land farmed as recently as the early 1940's, and furrows are still visible in places.

PROCEDURE

Ten dominant or codominant trees in each plot were instrumented with dendrometer stations *(3, 11)*. In the center of each plot, a ground-water well made of 3-inch galvanized

[1] Italic numbers in parentheses refer to Literature Cited, p. 4.

downspout pipe was sunk to a depth of about 6 feet. On the thinned sweetgum plot—the one at the highest elevation—a stack of six fiber glass units *(2)* was installed at intervals from the surface to 42 inches.

Observations on moisture, growth, temperature, and phenology were made from March through September each year from 1959 through 1962. Readings were taken twice weekly but never on the day following a rain. Dendrometers were read with a dial gage, the fiber glass units with a Colman moisture meter, and the ground-water wells with a dip stick.

Diameter growth rates tend to change with age. Hence, to facilitate comparisons, growth increments were converted into cross-sectional wood accrued per stem per year.

Initial stand conditions are given in table 1. Two increment cores were taken from each tree to determine average diameter growth for the 5 years prior to thinning. The cores indicated that, in baldcypress and sweetgum, trees on the thinned and unthinned plots had been growing at equal rates. In ash, the older and larger trees on the thinned plot had been growing faster than the trees on the unthinned plot (table 2).

Table 1.—*Initial stand conditions, 1958*

Species and treatment	Age [1]	D.b.h. [2]	Basal area per acre [3]	
			Before thinning	After thinning
	Years	*Inches*	*– Sq. ft. –*	
Sweetgum				
Thinned	16	6.0	96	80
Unthinned	16	5.6	92	
White ash				
Thinned	40	13.3	93	62
Unthinned	35	9.3	100	
Baldcypress				
Thinned	85	14.7	258	199
Unthinned	85	15.9	265	

[1] Age and d.b.h. values are the averages of the 10 dendrometer trees per plot.

[2] D.b.h. of the baldcypress was measured at 6 feet.

[3] Basal area computations include all trees 4 inches in d.b.h. and larger.

RESULTS

Growth in 1959-62 on all plots except the unthinned ash was considerably faster than in 1954-58, when several severe droughts had occurred (table 2). Baldcypress responded the most to thinning, ash the least.

Comparisons between thinned and unthinned plots were clouded by site differences, probably those related to heights of the water table. Thus the increase on the thinned sweetgum, though appreciable, was less than on the unthinned.

Diameter growth curves on the two sweetgum plots were almost identical each year until early July, at which time the thinned gum began to lag (fig. 1). The water table on the thinned plot was almost exactly 1 foot lower than on the unthinned plot throughout the measurement period; the difference corresponded roughly to the difference in plot elevations. When the growth curves began to diverge, there still were 5 to 12 inches of available water in the top 4 feet of soil.

For each species, thinned and unthinned trees began growth at the same time in the spring. On no plot did thinning appear to extend growth into the late summer or early autumn.

Table 2.—*Average cross-sectional growth per tree per year*

Year	Baldcypress		White ash		Sweetgum	
	Thinned	Unthinned	Thinned	Unthinned	Thinned	Unthinned
	Square inches					
1954-1958 (av. annual)	3.45	3.45	4.03	2.25	3.26	3.27
1959	5.59	3.26	4.62	2.20	4.11	4.62
1960	5.43	4.80	3.83	2.07	4.30	4.71
1961	5.28	4.87	4.96	2.26	4.68	5.28
1962	4.36	3.89	3.74	2.14	4.33	4.77
Av., 1959-1962	5.16	4.20	4.29	2.17	4.36	4.83

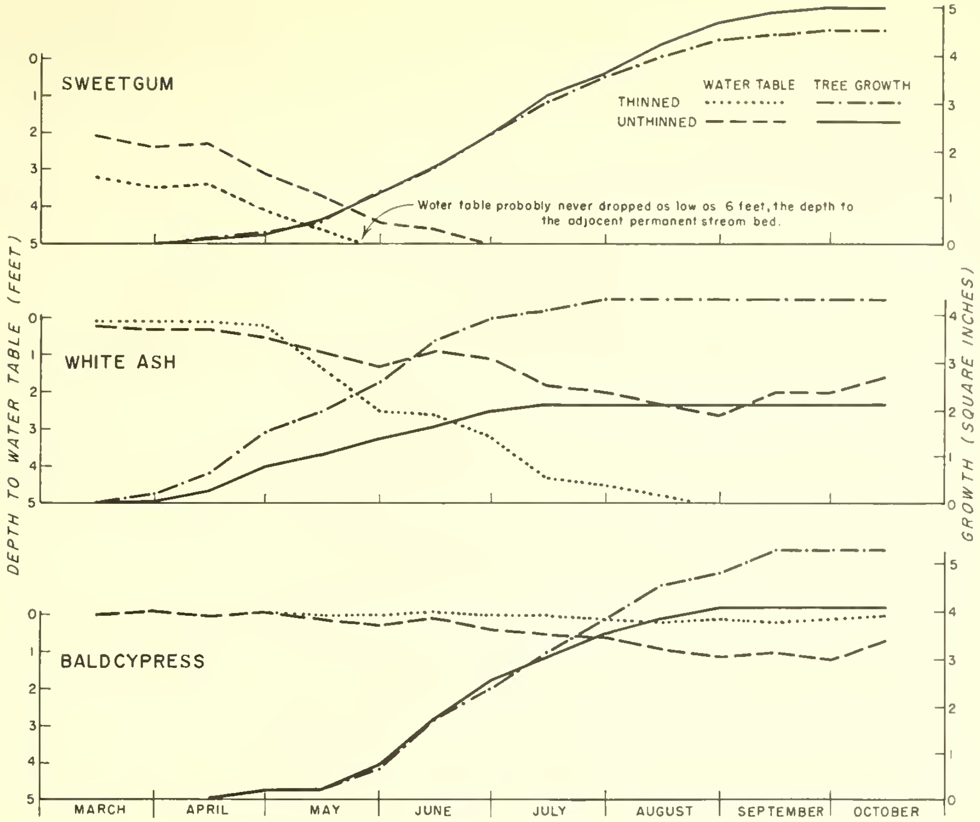

Figure 1.—*Mean basal area growth per tree and water-table fluctuations. Values are averaged for the 4-year period.*

Ash trees consistently began diameter growth several weeks in advance of sweetgum and baldcypress and several weeks before leafing out. They typically were leafed out by the first week in May. Ash also concluded growth weeks or even months ahead of the others. Possibly the prolonged high summer temperature and photoperiodic responses cause early cessation of growth even though soil moisture is still abundant *(5)*.

Sweetgum trees began diameter growth near the time of full leaf, usually in late April. Baldcypress were in full leaf several weeks before growth began, a characteristic that has been reported previously *(7)*; the trees typically began leafing out near April 1, and were in full leaf before May.

If soil temperature helped regulate the onset of growth *(6, 8)*, it varied with species. Ash began growing when soil in the 6- to 12-inch layer neared 50° F., while sweetgum began about the time soil reached 60°. Baldcypress performance appeared unrelated to temperature, since growth began after the soil had been in or near the 60's for several weeks. In this species, day length may be the critical factor, for growth began about the same calendar date each year.

Growth in baldcypress and ash trees began each year with water standing on the surface or within an inch or two of it, and continued steadily throughout the season without regard to fluctuations of the water table.

The performance of the ash plots does not appear to be related to water. Though the unthinned plot was the wetter, trees grew only about half as fast on it as on the thinned plot. Nor does it seem likely that water was a deterrent: both ash plots were totally saturated during the first few weeks of the season, during which time the thinned ash made rapid growth.

No relationships were observed for any species between proximity of water table to the surface and duration of growth. Differences in diameter or volume accrued per year were related to velocity rather than duration of growth.

LITERATURE CITED

1. Boggess, W. R.
   1957. Weekly diameter growth of shortleaf pine and white oak as related to soil moisture. Soc. Amer. Foresters Proc. 1956: 83-89, illus.
2. Coleman, E. A., and Hendrix, T. M.
   1949. The fiberglas electrical soil-moisture instrument. Soil Sci. 67: 425-438, illus.
3. Daubenmire, R. F.
   1945. An improved type of precision dendrometer. Ecol. 26: 97-98, illus.
4. Dils, R. E., and Day, M. W.
   1952. The effect of precipitation and temperature upon the radial growth of red pine. Amer. Midland Nat. 48: 730-734, illus.
5. Eggler, W. A.
   1955. Radial growth in nine species of trees in southern Louisiana. Ecol. 36: 130-136, illus.
6. Friesner, R. C.
   1942. Dendrometer studies of five species of broadleaf trees in Indiana. Butler Univ. Bot. Studies 5: 160-172.
7. Jackson, L. W. R.
   1952. Radial growth of forest trees in the Georgia Piedmont. Ecol. 33: 336-341, illus.
8. MacDougal, D. T.
   1938. Tree growth. 240 pp., illus. Leiden, Holland: Chronica Botanica Co.
9. McClurkin, D. C.
   1958. Soil moisture content and shortleaf pine radial growth in north Mississippi. Forest Sci. 4: 232-238, illus.
10. ————
   1961. Soil moisture trends following thinning in shortleaf pine. Soil Sci. Soc. Amer. Proc. 25: 135-138, illus.
11. Reineke, L. H.
   1932. A precision dendrometer. Jour. Forestry 30: 692-699, illus.

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-23

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SEASONAL TWIG GROWTH OF SOUTHERN BROWSE PLANTS

Lowell K. Halls and Rene Alcaniz [1]

SOUTHERN FOREST EXPERIMENT STATION

After rapid growth in spring, twig elongation practically ceased for 12 of 16 browse species. A few species responded to increased moisture and grew through the summer, and two continued on into fall. Most vines died back somewhat in late summer and fall.

Five species fruited in the summer, others in the fall.

The purpose of the study reported here was to learn the rate and season of twig elongation for 16 species of browse plants that are major sources of deer forage in southern forests. Similar information has been collected for the more common trees of eastern forests *(2, 3, 5, 6,* and *7)* [2] and for some browse plants in the West *(1, 4,* and *9)*, but little or none is available for the shrubs, vines, and the understory trees of southern forests.

PROCEDURES

Three ungrazed, medium-sized plants of each species were located in a well-stocked shortleaf-loblolly pine-hardwood stand on the Stephen F. Austin Experimental Forest, near Nacogdoches, Texas. In February 1963, one terminal and one lateral branch of each plant were marked at the base of the bud with a small band of yellow paint. Twig elongation was measured from the outer edge of this band. Measurements were made semiweekly from the time growth began until the end of June, and monthly thereafter until January. Length of all twigs that formed above the paint mark was included in the measurements. Observations also included the beginning dates of flowering and fruiting and the average length of time that flowers and fruit persisted.

The same procedures were followed in 1964 except that measurements were taken only on twigs that grew from the terminal branches. Laterals were excluded because the 1963 data showed their growth patterns to be similar to those of terminals.

Weather data were recorded at a station less than a half mile from the study site.

Rainfall averaged well below normal (table 1). During the 2 years there were 17 periods of 10 days or more when under 0.1 inch of rain

[1] The authors are on the staff of the Wildlife Habitat and Silviculture Laboratory, which is maintained at Nacogdoches, Texas, by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State College.

[2] Italic numbers in parentheses refer to Literature Cited, page 5.

was recorded. The longest droughts were in March and from late August to November of 1963, and in May and from late June to mid-August of 1964.

Average temperatures were below normal during both winters and above normal during both summers.

Table 1.—*Weather data at Stephen F. Austin Experimental Forest, 1963-1964*

RAINFALL

Month	1963	1964	65-year average [1]
	Inches	*Inches*	*Inches*
January	1.76	3.27	3.81
February	2.67	2.02	3.72
March	1.41	4.07	4.10
April	4.41	8.18	4.94
May	1.70	.89	5.22
June	5.35	4.16	3.42
July	4.72	.50	3.98
August	3.59	3.44	2.39
September	1.38	3.21	2.74
October	.00	1.86	2.90
November	5.15	3.71	4.13
December	3.63	3.30	4.88
Total	35.77	38.61	46.23
FREEZING DATES AND FROST-FREE SEASON			
Last freeze in spring	Mar. 27	Mar. 26	Mar. 22
First freeze in fall	Nov. 4	Oct. 20	Nov. 13
Frost-free season (days)	222	208	236

[1] From records at Nacogdoches, approximately 12 miles from study area.

RESULTS

A spring flush was characteristic of all species. Thereafter differences developed and growth patterns fell into three groups.

American beautyberry, blackgum, fringetree, parsley hawthorn, rusty blackhaw, and sassafras formed one general pattern that was very similar in both years (fig. 1) and resembles that common to many trees *(8)*. After the rapid flush in early spring, stems ceased to elongate and terminal buds formed. Except on American beautyberry, twig elongation had essentially ceased by June 1, even when rain was ample. Only rarely was there a recurrence of stem growth or formation of new twigs from lateral or terminal buds during the remainder of the season. In a few instances insects destroyed the tips, causing negligible decreases in twig length. For these species it appears that temperature and soil moisture in early spring have the strongest effect on the yields of forage and that the quantity available later in the year is relatively unaffected by low rainfall and high temperature during summer and fall.

Twigs of yaupon and flowering dogwood (fig. 2) elongated rapidly during spring, and thereafter made some growth whenever moisture was adequate. Thus, forage yields continued to increase until late summer or early fall, the quantity depending somewhat on the amount of rain.

Dogwood continued to grow through August in both years and through October in 1964, when fall rains kept moisture levels high. Most growth after May was by formation of new twigs rather than by elongation of those that had developed earlier.

Yaupon elongated rapidly in April and was relatively quiescent through June in both years. From June 17 through August 15, 1963, rainfall was 13.5 inches and yaupon developed new twigs from recently formed buds. Essentially the same pattern evolved in 1964 but about 1 month later, presumably because July was dry and August and September had ample rain. This response indicates that yaupon may form new twigs throughout the frost-free season when soil moisture is adequate.

The eight vines (fig. 3) formed the third set of growth patterns. Following the period of rapid growth and relative quiescence the new twigs often wilted and died back to a well-formed lateral bud (usually the last) which then became the new terminal. The reasons for dieback were not always obvious but drought, insects, and disease appeared to be contributing causes. Occasionally twig dieback and formation of new twigs occurred concurrently on different plants of the same species. Most vines made essentially all their growth in early spring during both years, but the percent of maximum twig length that remained in late summer and fall varied considerably among species and between years. For example, in 1963 most vines suffered little dieback, but in 1964 a large proportion of growth was lost on all except saw greenbrier.

Yellow jessamine grew through July in 1963, when soil moisture was reasonably good, but practically ceased in May of 1964, when rainfall was much below normal. Later in the summer of 1964 dieback occurred on two of

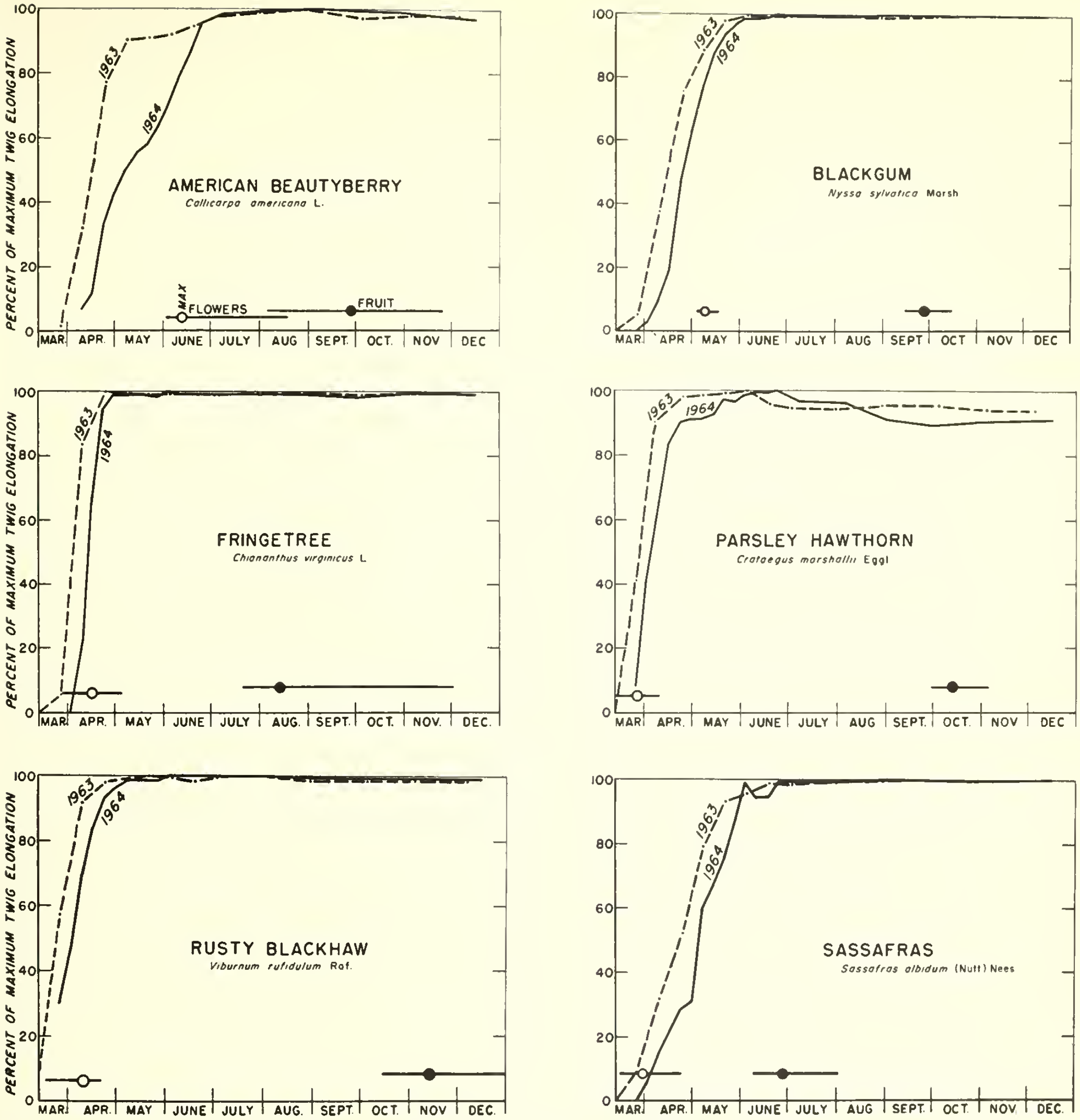

Figure 1.—*For several important species twig length remained essentially unchanged after the early flush had ended. Here, and in the following figures, horizontal lines show average period when flowers and fruit were on the plants, and circles indicate height of the season.*

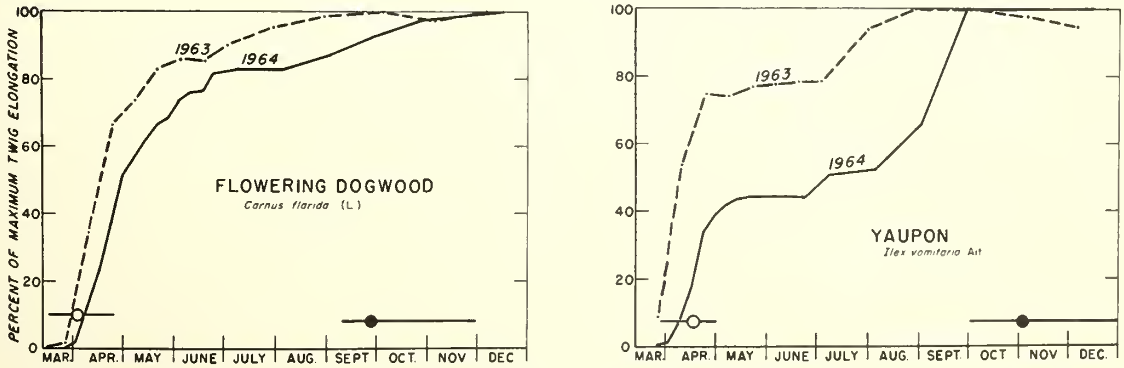

Figure 2.—*Twigs of dogwood and yaupon elongated rapidly in early spring but did not attain maximum length until early fall.*

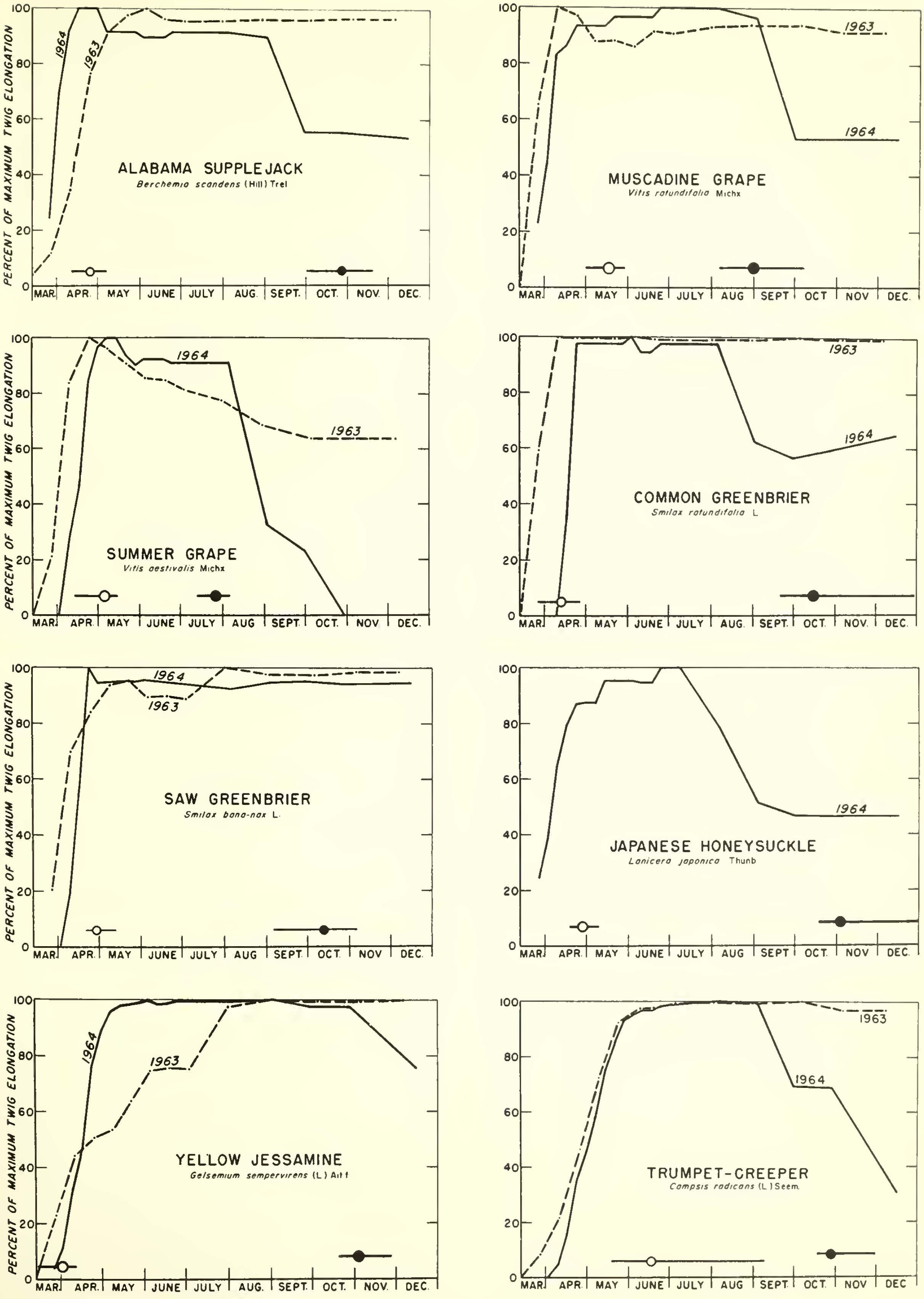

Figure 3.—*Vines grew rapidly in spring but frequently died back in summer and fall.*

the plants; the third plant showed no dieback but put out a few new leaves and grew during October, following rains. Observations in the nearby woods revealed that other plants of this species responded similarly.

In 1963 measurements of Japanese honeysuckle were discontinued early in July because all twigs died. In 1964 they all suffered severe dieback through September. Summer grape had considerable dieback in 1963, and in 1964 all the measured twigs died.

In all the vines studied, the dieback represented a considerable loss of palatable forage.

Fruits from woody plants also are important sources of game food. The fruiting time of species in this study further illustrates the periodicity of food supply. Most species set seed in the fall, when acorns usually are ample. Five species—muscadine and summer grapes, fringetree, sassafras, and American beautyberry—fruited during the summer. Thus, their importance is enhanced by their fruiting at a time when nutritious game food might otherwise be scarce.

LITERATURE CITED

1. Bedell, T. E., and Heady, H. F.
1959. Rate of twig elongation of chamise. Jour. Range Mangt. 12: 116-121, illus.

2. Bonck, Juanda, and Penfound, W. T.
1944. Seasonal growth of twigs of trees in the batture lands of the New Orleans area. Ecol. 25: 473-475.

3. Cook, D. B.
1941. The period of growth in some northeastern trees. Jour. Forestry 39: 956-959, illus.

4. Costello, D. F., and Price, Raymond.
1939. Weather and plant-development data as determinants of grazing periods on mountain range. U. S. Dept. Agr. Tech. Bul. 686, 31 pp., illus.

5. Farnsworth, C. E.
1955. Observation of stem elongation in certain trees in the western Adirondacks. Ecol. 36: 285-292, illus.

6. Jacobs, R. D.
1965. Seasonal height growth patterns of sugar maple, yellow birch, and red maple seedlings in upper Michigan. U. S. Forest Serv. Res. Note LS-57, 4 pp. Lake States Forest Expt. Sta., St. Paul, Minn.

7. Kozlowski, T. T., and Ward, R. C.
1961. Shoot elongation characteristics of forest trees. Forest Sci. 7: 357-368, illus.

8. Romberger, J. A.
1963. Meristems, growth, and development in woody plants. U. S. Dept. Agr. Tech. Bul. 1293, 214 pp., illus.

9. Watkins, V. M., and de Forest, H.
1941. Growth in some chaparral shrubs of California. Ecol. 22: 79-83.

SOUTHERN FOREST EXPERIMENT STATION

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1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-24

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

TIPS FOR MANAGING DROUGHT-STRICKEN COTTONWOODS ALONG THE LOWER MISSISSIPPI RIVER

R. L. Johnson and R. M. Krinard [1]

SOUTHERN FOREST EXPERIMENT STATION

Cottonwood trees with more than two-thirds of their crowns affected by dieback are unlikely to survive, and therefore should be marked for early cutting. Trees with less than one-third dieback are likely to recover. Those in intermediate dieback classes should be cut if their crowns are small or if a main leader or major branch is dead.

The period 1952 through 1956 was extremely dry in the lower Mississippi River Valley. At Stoneville, Mississippi, annual rainfall during these 5 years ranged from 3 to 14 inches below the previous 25-year average. As reported by Broadfoot,[2] the shortage of moisture caused considerable mortality and dieback in cottonwood stands. The greatest losses were on deep, excessively drained sands and on soils with stratified beds of silty clay loams, silt loams, and sandy loams over clay.[3]

The drought was broken during 1957. In August of that year, 200 cottonwoods were selected for study in a 20-year-old stand on the batture northwest of Vicksburg, Mississippi. The majority were between 10 and 16 inches in diameter. Each tree was measured at d.b.h. and tallied into one of three crown-size groups and one of 10 dieback classes.

Crown-size groups were: *large*—crown broad, usually full, umbrella-shaped, and comprising approximately one-fourth of total tree height; *small*—crown generally less than 15 feet across and sparse, usually comprising one-half to two-thirds of total tree height; and *medium*—crown wider than for *small* and usually not as sparse, generally comprising one-fourth to one-half of total tree height.

Dieback classes were based on the percent of total crown area affected, as determined by ocular estimates. In addition, observations

[1] The authors are stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] Broadfoot, W. M. Soil-water shortages and a means of alleviating resulting influences on southern hardwoods. In Southern Forest Soils. La. State Univ. Eighth Ann. Forestry Symposium Proc. 1959: 115-119. 1960.

[3] Broadfoot, W. M., and Toole, E. R. What's causing the mortality in southern hardwoods? Jour. Soil and Water Conserv. 13: 276-277, illus. 1958.

were taken on whether dieback was mainly in the periphery of the crown or in a main limb or leader.

A prism with a basal area factor of 9.7 was used to determine the degree of competition around each tree. Soils were Robinsonville silt loam and Mhoon silty clay.

Trees were observed each August from 1958 through 1963 and, when necessary, reclassified into another dieback class. Rainfall was average or above during 5 of the 7 measurement years.

RESULTS

By the third year of normal rainfall, all trees were dead that were going to die, and the others were steadily improving their crown condition (fig. 1). The factor most closely related to mortality was initial degree of dieback (table 1). Trees with more than two-thirds of their crowns affected generally died, whereas those with less than one-third dieback generally lived. In the middle ranges of dieback, mortality varied with crown size; that is, trees with large crowns were better able to recover than those with small crowns.

Table 1.—*Mortality by dieback classes*

Degree of dieback (percent)	Mortality
	Percent
0-19	2
20-39	13
40-59	33
60-99	85

Overall dieback classes, only 5 percent of the trees with large crowns died, while 9 percent with medium crowns and 38 percent with small crowns succumbed (fig. 2). None of the large-crowned trees had more than 50 percent initial dieback.

Although most of the survivors had extended their crown area and appeared relatively free of dieback 7 years after the drought, they had not necessarily recovered fully. The tree in figure 3, for example, appeared to have nearly a full crown in 1961. But the earlier photographs show that the main leader broke off in 1959, disguising the effects of dieback but also leaving an entrance for rot-inducing fungi.

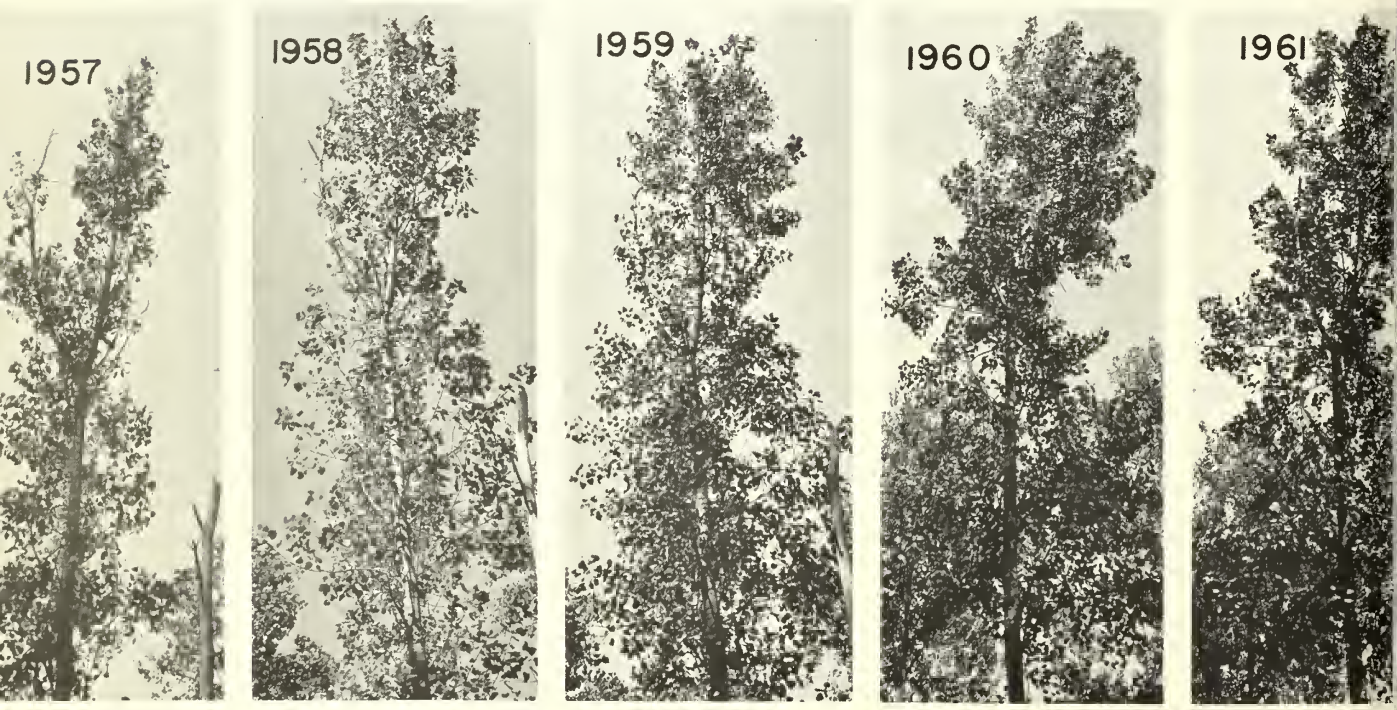
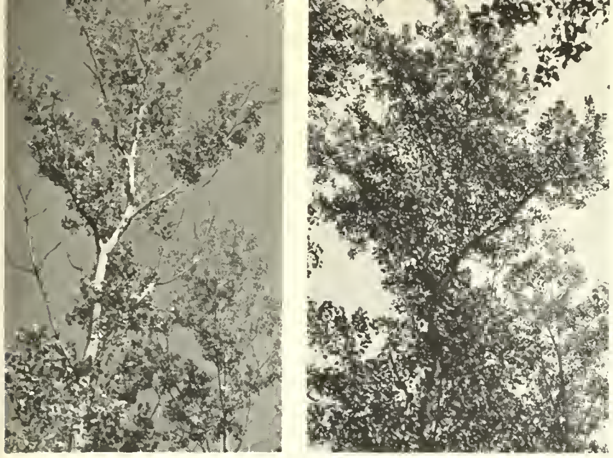
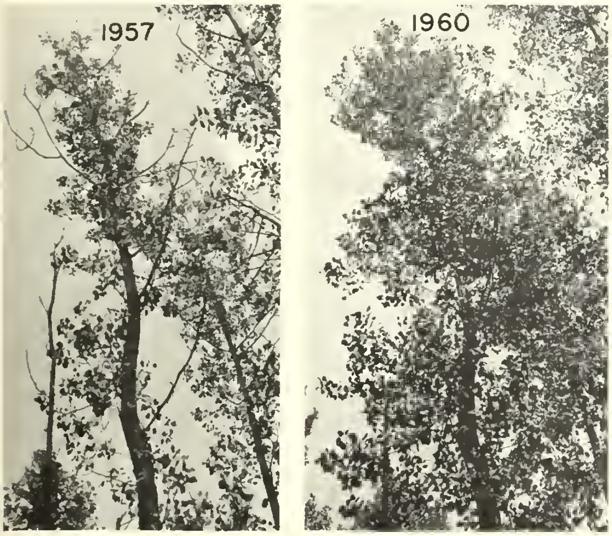


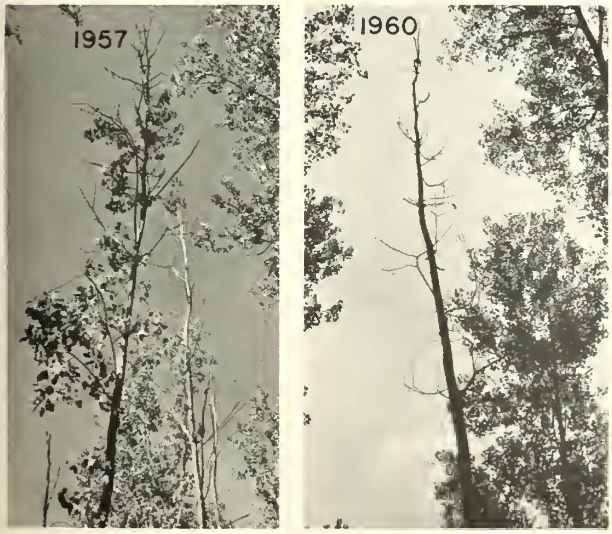
Figure 1.—*This tree completely recovered from crown dieback of 20 to 30 percent.*



Large crown, 10-20 percent dieback.



Medium crown, 30-40 percent dieback.



Small crown, 70-80 percent dieback

Figure 2.—*Crown size and amount of initial dieback largely determine whether a tree will die or recover.*

Figure 3.—*Dieback in the main leader or large limbs is often followed by breakage. Though regrowth may mask the damage, rot fungi usually enter and spread downward into the most valuable parts of the bole.*

RECOMMENDATIONS

When marking in drought-stricken cottonwood stands of the lower Mississippi River Valley, foresters should remove trees with two-thirds or more of the crown affected by dieback and may leave trees with less than one-third of the crown affected.

Whether to remove trees with one-third to two-thirds of the crown affected by dieback will depend largely on the trees' crown size. Large-crowned cottonwoods may be left even if one-half of the crown is dead. Trees with medium to small tops should frequently be marked when only one-third of the crown is gone. Often these trees are lower in vigor and smaller in d.b.h. than their neighbors and would be removed anyway in a normal thinning or improvement cutting. Competition may be an important factor in determining the future of drought-damaged trees, but in the experimental stand basal area did not prove to be a good predictor of whether a tree would live or die.

Regardless of their crown size, trees should be cut if a substantial portion of the main leader or a major crown limb is dead. Even though they may live and develop for several years, their potential as crop trees is reduced by the breakage and rot that ultimately follow this type of dieback.

SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

1965

SO-25

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

ROOTING CUTTINGS OF BROWSE PLANTS

Lowell K. Halls and Rene Alcaniz
SOUTHERN FOREST EXPERIMENT STATION[1]

Under greenhouse conditions, stem cuttings from American beautyberry, flowering dogwood, black willow, and common greenbrier rooted consistently enough to warrant recommendation for vegetative propagation. Rooting of 11 other species was erratic or poor, varying considerably between seasons and years. Two species did not root at all.

For 3 consecutive years beginning in 1962, stem cuttings were taken in May, September, and January from plants of 17 species that are commonly browsed by deer in pine-hardwood forests of the South. All cuttings were collected at the Stephen F. Austin Experimental Forest and tested for rooting ability in a greenhouse.

The May cuttings were, in general, collected when twigs were actively growing and after leaves had fully expanded. The September cuttings were taken after growth had ceased and the wood was partially matured. January cuttings were from dormant twigs formed the previous year.

Cuttings were approximately 6 inches long. Those from shrubs and trees were restricted to the distal extremity. Vine stems were usually sectioned, so that several cuttings were taken from one stem. All leaves except one or two terminals were removed before stems were stuck into the propagation bed. Each species was represented by cuttings taken from several plants (a different set of plants at each collection period), with no distinction between terminals and laterals.

To stimulate root initiation, the proximal end of each cut stem was dipped into a commercial preparation of indolebutyric acid and then set upright to a depth of 2 inches in a 3:1 mixture (by volume) of sand and peat. Forty-eight sand-peat flats were grouped into four blocks. Within each block, 60 cuttings of each species were arranged in rows of 15 each, with stems approximately 2 inches apart in rows. Rows within blocks were randomly located.

The greenhouse was covered with saran cloth that produced 30 percent actual shade. Insofar as possible, the air was kept at 80° F., but on hot summer days the temperature occasionally rose to 100° for 1 or 2 hours. Infrequently, during the coldest winter nights it dropped to 55°.

Watering was by an overhead intermittent mist that was regulated to spray for an average of 12 seconds at 2½-minute intervals. The spray time was lengthened slightly in summer and shortened in winter.

After 13 weeks the cuttings were removed and examined for presence, number, and maximum length of live roots.

[1] The authors are on the staff of the Wildlife Habitat and Silviculture Laboratory, which is maintained at Nacogdoches, Texas, by the Southern Forest Experiment Station in cooperation with Stephen F. Austin State College.

The planting mixture was reworked before it was used for a new batch of cuttings.

RESULTS

American beautyberry, black willow, common greenbrier, and flowering dogwood were consistent rooters. Though better in some trials than in others, cuttings of these species rooted from 51 to 75 percent of the time (table 1).

September was definitely the best month for making American beautyberry cuttings, as 96 percent success was achieved. May and September, when rooting percentages ranged from 58 to 67, were usually better than January for collecting common greenbrier and flowering dogwood, but results were not always consistent between years. Black willow tended to root best from January cuttings, averaging 74 percent.

Seven species were classed as erratic rooters (table 1). Rooting percentages in the individual trials ranged from 0 to 75; the averages varied from 7 for red mulberry and white ash to 23 for winged elm and 32 for saw greenbrier. With the exception of rusty blackhaw and saw greenbrier, which rooted best from September cuttings, the results were inconsistent between years and seasons.

Cuttings from the four poor rooters usually failed to form any roots. Infrequently a small percentage of fringetree, blackgum, and cat greenbrier grew roots but on no more than 9 percent of the cuttings. Pawpaw rooted only once in 9 trials—in cuttings taken in May 1963—when 29 percent rooted. For these four species the cuttings made in May appeared somewhat better than those made in September; the January cuttings were all failures.

Sassafras *(Sassafras albidum* (Nutt.)Nees) and laurel greenbrier *(Smilax laurifolia* L.) cuttings failed to produce roots at any time.

Why some species rooted better at one season or year than at another is not known. Weather conditions prior to taking the cuttings do not offer a reliable explanation. Environment within the greenhouse was held constant within reasonable limits and therefore does not account for variability in rooting among years. Perhaps the differences are attributable to physiological condition and growth stage of cuttings and to position of cuttings on parent plant (lateral or terminal branch), factors which were not measured or controlled.

With the exception of saw greenbrier, red mulberry, and white ash, the May cuttings had longer and frequently more numerous roots than those collected in September and January—hence presumably a better chance of surviving if outplanted. Conditions in the field, however, are apt to be harsh at the time of year May cuttings would be transplanted. This disadvantage would be less serious if rooted cuttings could be kept in the greenhouse or nursery to await planting the following spring.

Table 1.—*Root formation from stem cuttings of southern deer browse plants*

Species	Average proportion rooting
	Percent
CONSISTENT ROOTERS	
American beautyberry, *Callicarpa americana* L.	75
Black willow, *Salix nigra* Marsh.	65
Common greenbrier, *Smilax rotundifolia* L.	55
Flowering dogwood, *Cornus florida* L.	51
ERRATIC ROOTERS	
Saw greenbrier, *Smilax bona-nox* L.	32
Winged elm, *Ulmus alata* Michx.	23
Yaupon, *Ilex vomitoria* Ait.	14
Sweetbay, *Magnolia virginiana* L.	11
Rusty blackhaw, *Viburnum rufidulum* Raf.	10
Red mulberry, *Morus rubra* L.	7
White ash, *Fraxinus americana* L.	7
POOR ROOTERS	
Pawpaw, *Asimina triloba* (L.) Dunal	3
Fringetree, *Chionanthus virginicus* L.	3
Cat greenbrier, *Smilax glauca* Walt.	1
Blackgum, *Nyssa sylvatica* Marsh.	1

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-26

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FOREST FLOOR IN LOBLOLLY PINE PLANTATIONS AS RELATED TO STAND CHARACTERISTICS

Hamlin L. Williston [1]

SOUTHERN FOREST EXPERIMENT STATION

At ages 8 to 16 years, erosion-control plantings in north Mississippi had floors whose ovendry weights averaged 7.3 tons per acre. $W = 1.38 + 0.246\ (age) + 0.0218\ (basal\ area)$.

Because it produces a mantle of soil-stabilizing litter, loblolly pine is widely planted on eroding sites in the South. This paper reports a study in which the forest floor under established plantations was measured and analyzed in relation to several stand characteristics. The study was made in north Mississippi, where large acreages of erosion-control plantings have been made by the Yazoo-Little Tallahatchie Flood Prevention Project of the U. S. Department of Agriculture.

The analysis produced two equations by which weights of the forest floor can be roughly estimated from stand data or from measurements of floor depth. Satisfactory sampling techniques for obtaining the weight of the floor were also worked out.

METHODS

The forest floor was sampled on 108 plots in 10 loblolly plantations ranging in age from 8 to 16 years. Each plot consisted of at least 25 planting squares. Sixty-three plots were in plantations that had been established on abandoned fields with a broomsedge cover, and 45 were in stands on dry ridges formerly occupied by sparse stands of hardwoods. Plots were unthinned, and at least 50 percent stocked. The trees had never been overtopped.

One completely stocked planting square was selected at random within each plot, and three samples of the floor were randomly taken within each square and composited.

An angle-iron frame 0.96-foot square was used in sampling. The L- and F-layers were collected by cutting along the inside of the frame with a knife. The H-layer was not found. Depth of the floor was measured to the nearest 0.1 inch at the midpoint of each side of the frame. Living grass was excluded; dead grass and hardwood leaves were included where found, but formed a small part of the floor in stands above 8 years of age. Twigs, bark, and miscellaneous debris less than 0.25 inch in diameter were included.

On 82 percent of the plots in stands 10 years and older, a mull type A_1 had begun to form, and there was ample evidence of earthworm

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activity. Some of the mull formation can be attributed to the decomposition of grass on the old fields and of hardwood leaves in conversion plantings. There was, however, evidence that the pine needles themselves were contributing in many of the stands.

Twenty-five floor-depth measurements to the nearest 0.1 inch were made at 1-foot intervals on a transect starting at the northeast corner of each plot and running diagonally towards the southwest corner. These were taken to determine if the point at which the floor was sampled was representative.

The four trees making up the planting squares sampled were measured to the nearest 0.1 foot of height and the nearest 0.1 inch of d.b.h. Age was determined from planting records. The presence or absence of an A_1 horizon was noted. Stand characteristics were based on the tree measurements in the planting square.

In the laboratory the soil and fine organic matter were screened from the samples. This material and the bulk of the sample were oven-dried at 105° C. and weighed separately. The fines were burned in a muffle furnace and reweighed to determine loss on ignition. Weights of the fine organic matter and of the rest of the floor were then summed in grams, multiplied by 100 to obtain pounds per acre, and converted to tons.

The average weight of the floor in all the plantations sampled was 7.31 tons per acre. The means and ranges of the stand characteristics measured are given in table 1. It should be remembered that the values were derived from measurements on a perfectly stocked planting square.

All possible combinations of five independent variables—age of trees, number per acre, height, basal area per acre, and depth of forest floor—were tested in regression analyses.

Table 1.—*Stand characteristics*

Item	Means	Range
Age (years)	12.2	8-16
Trees per acre (number)	1,637	589-5,556
Spacing (feet)	5.1x5.2	2.8-8.6
Tree height (feet)	28	16-46
Basal area per acre (sq. ft.)	134	36-307
Forest floor depth (inches)	.8	.1-2.7
Weight of floor per acre (tons, ovendry)	7.3	2.4-14.7

RESULTS

The most suitable regression equation for estimating weight of the forest floor (W, tons per acre) from stand characteristics included tree age (A) and basal area (BA) as independent variables. It was:

$$W = 1.38 + 0.246\,A + 0.0218\,BA \qquad R = .70$$

Weight-estimating curves computed from the equation are shown in figure 1. The equation explained 49 percent of the variation, and the addition of height or number of trees per acre, or both, did not significantly improve it.

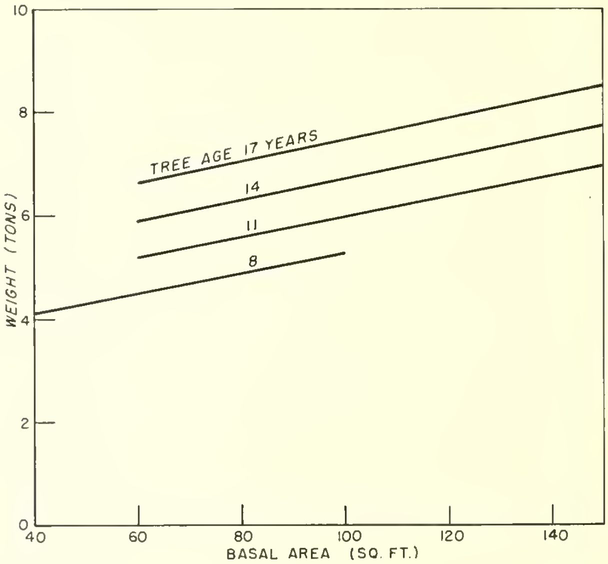

Figure 1.—*Ovendry weight of forest floor per acre in loblolly pine plantations.*

The best one-variable regression, that of basal area, explained 43 percent of the variation. In other one-variable regressions tree height accounted for 31 percent of the variation, age for 28 percent, and trees per acre for 0.2 percent.

To determine whether use of the planting square data biased the results, a t-test was made to compare the average of the 12 floor depths on the border of the litter samples with the average of the 25 depths measured across the gross plot. There proved to be no significant difference between the sample depths and plot depths. It is probable that needles do not fall vertically but are distributed by air currents. Average floor depth was 0.79 inch.

Depth alone accounted for 58 percent of the total variation and for 87 percent of the variation that could be explained by all five independent variables combined. If depth (D) is measured in inches, weight of floor can be roughly estimated from:

$$W = 3.28 + 5.07\ D \qquad R = .77$$

It would be convenient if age and spacing (number of trees per acre) were proportional to the weight of the forest floor. This relationship is explored in figure 2. Only the narrow spacings resulted in any great difference in floor weight. Litter from all of the spacings measured was adequately protecting the site from erosion. Among the more common spacings litter production varied hardly at all, probably because increased crown volume and needle size compensated for decreases in density. For these reasons also, judicious thinnings probably would not jeopardize the litter-producing capacity of a stand.

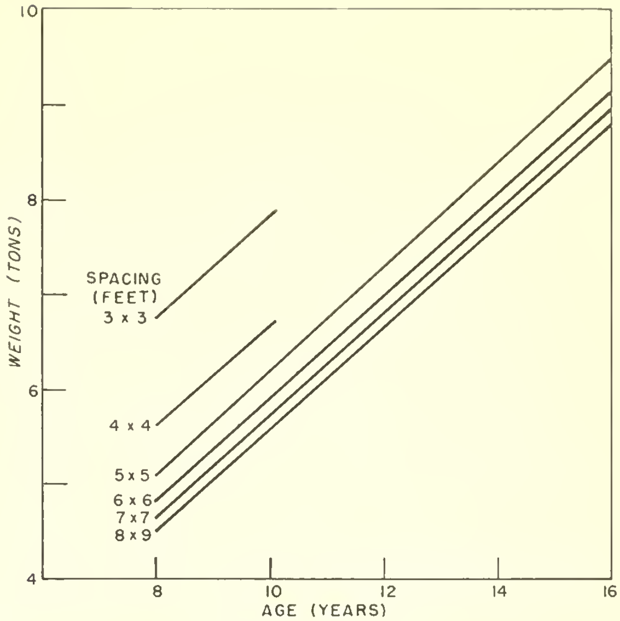

Figure 2.—*Forest floor weight per acre (ovendry) as related to age and spacing.*

SOUTHERN FOREST EXPERIMENT STATION

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-27

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SHORTLEAF PINE STANDS FIVE YEARS AFTER SEEDFALL ON PREPARED SITES

William R. Maple
SOUTHERN FOREST EXPERIMENT STATION

Five years after an excellent seed crop, north Arkansas sites on which a seedbed had been prepared with a rotary brushcutter had seven times as many shortleaf pine seedlings as untreated check areas. Prescribed burning or chemical treatment was considerably less effective.

The beds, under a pine overstory, were prepared in October, just prior to seedfall. They were in four contiguous blocks, with treatments—brushcutter, fire, chemicals, or check—randomly replicated in each block on 0.5-acre plots. All plots had a heavy stand of hardwood brush.

The brushcutter was one of several makes now on the market. It readily mowed vegetation up to 3 inches in diameter at the root-collar, and it scarified the soil surface without destroying litter and humus. Larger trees, both pine and hardwood, were left untreated on plots prepared by the brushcutter.

The chemical was propylene glycol butyl ether ester of 2,4,5-T (4 pounds acid equivalent per gallon), applied in a 16-pound ahg concentration in diesel oil. It was sprayed on the basal portions of all hardwoods less than 4 inches in diameter at breast height, and into frills on larger stems.

The burn was a backing fire that consumed the litter but did not destroy large hardwoods.

Check plots were left untreated.

Seedfall was extraordinarily heavy. An average of 477 thousand viable seeds per acre was estimated from traps placed on each plot. The range was from 202 thousand to 941 thousand seeds per acre.

RESULTS

At the end of the fifth growing season, the plots prepared with the brushcutter had more than 13,000 pine trees per acre, as compared to 4,500 on the chemically treated plots, 3,200 on the burned plots, and 1,800 on the checks (table 1). Differences in stocking between

Table 1.—*Shortleaf pine and hardwood seedlings per acre, 5 years after seedbed treatment*

Seedbed treatment	Shortleaf pine		Hardwood stocking
	Tree percent	Stocking	
		Number	*Number*
Brushcutter	2.9	13,312	4,988
Chemical	1.3	4,525	4,112
Burn	.4	3,212	5,900
Check	.4	1,788	5,475

treatments, as summarized in table 1, were significant at the 0.01 level.

Tree percent (yield of seedlings per hundred viable seeds thrown) after 5 years was best on the brushcutter plots. Like stocking, it is an indication of the effectiveness of initial seedbed preparation and total control of vegetation.

The distribution of the seedlings was clumpy. Even on the brushcutter plots, milacre stocking averaged no better than 70 percent. On the chemically treated and the burned plots the milacre stocking was 50 percent; on the check plots it was 30.

Beginning in the third year, heavy stands of hardwoods developed on all plots. Those on the brushcutter plots, though numerous, were concentrated near overstory trees that had not been killed by the machine. These patches contained relatively few pines, but the open areas were invaded by grasses, forbs, and vines that rapidly overtopped the pines. On the other sets of plots the hardwood brush was more evenly distributed and invading plants less numerous. But regardless of the method of site preparation, by the fifth year pines on all plots needed release.

As the hardwoods were too small to be treated individually, and since prescribed burning would have killed the pines, some form of chemical spray appeared necessary. Because of the nature and distribution of the competing plants, chemical release would have been effected more easily on the brushcutter plots than on the others.

As a matter of general observation, seedbed preparation seems essential to the establishment of shortleaf pine regeneration in the Ozark Mountains. In the study reported here, the brushcutter was superior to prescribed burning or chemical treatment of undesirable hardwoods. Its effectiveness following a less spectacular seed year has not been tested.

SOUTHERN FOREST EXPERIMENT STATION

Forest Service, U. S. Dept. of Agriculture

1965

U.S. FOREST SERVICE RESEARCH NOTE

SO-28

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FOREST SPECIES COMPARED IN OZARK PLANTATIONS

William R. Maple

SOUTHERN FOREST EXPERIMENT STATION

Fifteen years ago a series of plantations containing native and nonnative forest tree species was established on the Henry R. Koen Experimental Forest in Newton County. The sites, which were representative of abandoned fields in the Arkansas portion of the Ozark Mountains, included loamy sand, silty clay loam, and cherty silt loam soils. All had similar histories of row-cropping and pasturing. The cherty silt loam sites were on ridgetops.

Native species included shortleaf pine *(Pinus echinata* Mill.), eastern redcedar *(Juniperus virginiana* L.), black locust *(Robinia pseudoacacia* L.), and black walnut *(Juglans nigra* L.). Nonnative species included loblolly pine *(Pinus taeda* L.), eastern white pine *(P. strobus* L.), pitch pine *(P. rigida* Mill.), Virginia pine *(P. virginiana* Mill.), and yellow-poplar *(Liriodendron tulipifera* L.), all of which are being planted in neighboring States. Except for shortleaf pine grown from Arkansas seed and pitch pine from an unknown source, all stock was from seed collected in eastern Tennessee and grown in TVA nurseries. Seedlings were planted as 1-0 stock at a spacing of 6 by 6 feet.

Survival, height, and diameter after 15 years are summarized by species and site in table 1.

Survival of 50 percent or over after 15 years was selected as the index of adaptability on any particular site.

Shortleaf pine grew taller than any other native species, averaging more than 30 feet in height and 5.0 inches in diameter. Survival was unremarkable, but the seedlings were in poor condition when planted. Local plantations before and since have survived much better.

Black locust demonstrated acceptable survival only on silty clay loam, where it averaged 25 feet in height and 3.4 inches in diameter. It was heavily attacked by locust borers wherever planted. Black walnut survived acceptably on both loamy sand and silty clay loam sites but grew slowly, averaging 14 to 17 feet in height and 1.6 to 1.8 inches in diameter. Eastern redcedar grew reasonably well on loamy sand, becoming 19 feet tall and 3.6 inches in diameter. The seedlings, like those of shortleaf, were in low vigor when planted; in other trials survival has been good.

Table 1.—*Fifteen-year survival and growth of trees planted on abandoned fields on the Henry R. Koen Experimental Forest*

Species	Survival			Total height			Diameter at breast height		
	Loamy sand	Silty clay loam	Cherty silt loam ridgetop	Loamy sand	Silty clay loam	Cherty silt loam ridgetop	Loamy sand	Silty clay loam	Cherty silt loam ridgetop
	--- *Percent* ---			---- *Feet* ----			---- *Inches* ----		
NATIVE									
Shortleaf pine	59	39	53	33	34	31	5.0	5.5	5.3
Black locust	44	77	...	32	25	...	3.9	3.4	...
Black walnut	59	89	...	17	14	...	1.8	1.6	...
Eastern redcedar	17	44	0	19	15	...	3.6	2.6	...
NONNATIVE									
Loblolly pine	78	94	69	38	35	37	5.7	5.5	6.6
Pitch pine	80	78	78	25	24	24	3.8	3.9	4.5
Virginia pine	65	83	67	36	31	33	5.0	4.7	5.7
Eastern white pine	33	39	11	28	26	33	4.7	4.5	6.1
Yellow-poplar	24	11	78	35	25	41	3.7	2.9	4.6

The nonnative hard pines—loblolly, pitch, and Virginia—surpassed the acceptable level of survival on all sites and grew well. Loblolly was outstanding, growing several feet taller and almost an inch larger in diameter than either of the others on comparable soils. Virginia pine grew both taller and larger than pitch pine.

Eastern white pine survived poorly but made height growth almost equal to that of Virginia pine. The single nonnative hardwood, yellow-poplar, achieved acceptable survival only on the cherty silt loam ridgetop, where it averaged 41 feet tall and 4.6 inches in diameter.

It appears that Ozark residents will risk less by planting high-quality seedlings of native species than by choosing nonnatives. Nevertheless, the performance of loblolly, Virginia, and pitch pines on the three sites studied, and of yellow-poplar on cherty silt loam ridgetops, certainly qualifies these species for consideration.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-29

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

1965 HARVEST, CROSSETT FARM FORESTRY FORTIES

R. R. Reynolds

SOUTHERN FOREST EXPERIMENT STATION

In 1937 the Southern Forest Experiment Station set up two farm forestry forties at Crossett, Arkansas, to demonstrate the feasibility of managing small tracts of shortleaf and loblolly pine.

On one tract the timber stocking was reasonably adequate, and on the other it was badly depleted. The tracts therefore became known as the "good" and the "poor" forty (somewhat arbitrarily, as the latter comprises 34 acres). The aim of management was to grow as many large, high-quality logs as possible, together with pulpwood, posts, and perhaps poles. A system of partial, or selection, cutting was decided on, and a harvest was scheduled for each year, beginning in 1938 for the well-stocked forty and in 1939 for the depleted forty.

The 1965 harvest was the twenty-eighth consecutive one from the good forty, and the twenty-seventh from the poor forty. This year, the cut from the poor forty was largely pulpwood, because about 10 acres needed thinning. Much of the cut from the good forty was of trees 23 inches d.b.h. or over. Most of these trees were still growing at a good rate, but it was thought best to reduce potentially large losses from lightning and insects, especially since the trees were very close to financial maturity.

Stumpage returns, that is, values of the standing trees marked for cutting in 1965, were \$15.21 per acre from the poor forty and \$20.37 from the good forty (tables 1 and 3). The average stumpage returns over the life of the demonstration, which included some years when prices were low, have been \$9.15 per acre per year on the poor forty and \$12.01 on the good (tables 2 and 4). These are all gross values. It would be necessary to deduct annual costs and carrying charges, if any, to get net returns. For these comparisons, no adjustments for dollar value differences resulting from long-term inflation have been attempted.

In 1937 the management possibilities for these tracts did not appear bright. Both contained about as many cull and undesirable hardwoods as pine, and many of the pines were limby, crooked, or contained fire scars. Pine stocking on the good forty was reasonably satisfactory—about 21 cords per acre in trees of

Table 1.—*Good forty: products cut, 1965*

Item	Logs	Pulpwood	Total
	Bd. ft. (Doyle)	*Standard cords*	
Volume cut	19,559	7.02	...
	VALUE (DOLLARS) ON STUMP		
Total value	779.82	35.10	814.92
Per unit	39.87	5.00	...
Per acre	19.49	.88	20.37
	VALUE (DOLLARS) DELIVERED AT MARKET		
Total value	1,122.10	117.58	1,239.68
Per unit	57.37	16.75	...
Per acre	28.05	2.94	30.99

Table 2.—*Good forty: total harvest, 1938-65, inclusive*

Item	Logs	Pulpwood	Fuelwood	Posts	Total
	Bd. ft. (Doyle)	*Standard cords*	*Standard cords*	*Number*	
Volume cut	419,441	427.80	228.45	418	...
Per acre	10,486	10.70	5.71	10.45	...
	VALUE (DOLLARS) ON STUMP				
Total value	12,458.50	842.16	131.72	20.90	13,453.28
Per unit	29.70	1.97	.58	.05	...
Per acre	311.46	21.05	3.29	.52	336.32
Per acre-year	11.12	.75	.12	.02	12.01
	VALUE (DOLLARS) DELIVERED AT MARKET				
Total value	18,549.31	3,885.54	2,210.22	62.70	24,707.77
Per unit	44.22	9.08	9.67	.15	...
Per acre	463.73	97.14	55.25	1.57	617.69
Per acre-year	16.56	3.47	1.97	.06	22.06
	VALUE (DOLLARS) AT ROADSIDE				
			Total		Per acre
1965 cut			1,027.30		25.68
Cut to date			19,080.52		477.01

all sizes—but the poor forty had only about half the trees and volume needed.

By 1951, most of the hardwoods 4 inches and larger d.b.h. had been cut or girdled on both tracts. The early elimination of these hardwoods, plus annual harvests that were limited to about half of the pine growth, permitted the pine stocking on the poor forty to increase to 4,500 board feet plus 9 cords of pulpwood per acre by 1950. Of equal interest is the fact that products equivalent to the volume on each tract in 1937 had been cut from the good forty by 1955 and from the poor forty by 1956. Moreover, this was accomplished during the period that the volume and quality of the growing stock on each tract was increased.

The seventh 100-percent inventory of the growing stock on each forty was completed after the growing season of 1965. As is indicated in table 5, trees in the 4- to 12-inch d.b.h. size classes on both forties continued to increase in numbers during the 1960-65 period.

Over the same period there was an average increase of one saw log size tree per acre on the poor forty and a decrease of three saw log size trees per acre on the good forty. Such changes were in addition to, or in spite of, harvests that removed some trees of most size classes from each forty each year. However, during the 5-year period, much of the harvest cutting on the good forty was concentrated in the larger diameter classes.

Annual growth, both in cubic and board feet, was appreciably less for the years 1960-65 than for the 1956-60 period. This had been expected, because growing season rainfall was appreciably below normal during 3 out of the 5 years.

The once poor forty is no longer in that condition and the good forty continues to have excellent earning possibilities. It will be of interest to measure and compute the values of the harvests for the next 28 years.

Table 3.—*Poor forty: products cut, 1965*

Item	Logs	Pulpwood	Total
	Bd. ft. (Doyle)	*Standard cords*	
Volume cut	8,454	36.07	..
	VALUE (DOLLARS) ON STUMP		
Total value	337.06	180.35	517.41
Per unit	39.87	5.00	.
Per acre	9.91	5.30	15.21
	VALUE (DOLLARS) DELIVERED AT MARKET		
Total value	485.01	604.17	1,089.18
Per unit	57.37	16.75	..
Per acre	14.26	17.77	32.03

Table 4.—*Poor forty: total harvest, 1939-65, inclusive*

Item	Logs	Pulpwood	Fuelwood	Posts	Total
	Bd. ft. (Doyle)	*Standard cords*	*Standard cords*	*Number*	
Volume cut	207,259	342.91	158.42	220	.
Per acre	6,096	10.09	4.66	6.47	..
		VALUE (DOLLARS) ON STUMP			
Total value	7,203.45	1,094.74	94.71	8.09	8,400.99
Per unit	34.76	3.19	.60	.04	.
Per acre	211.86	32.20	2.79	.24	247.09
Per acre-year	7.85	1.19	.10	.01	9.15
		VALUE (DOLLARS) DELIVERED AT MARKET			
Total value	10,461.45	4,358.59	1,088.76	28.27	15,937.07
Per unit	50.48	12.71	6.87	.13	..
Per acre	307.69	128.19	32.02	.83	468.73
Per acre-year	11.40	4.75	1.18	.03	17.36
		VALUE (DOLLARS) AT ROADSIDE			
			Total		Per acre
1965 cut			803.29		23.63
Cut to date			12,169.03		357.91

GOOD FORTY

Table 5.—*Number of pine trees and volume per acre*

Year	Trees		Volume			Growth yearly	
	4 to 12 in. d.b.h.	12 + in. d.b.h.	4 + in. d.b.h.		12 + in. d.b.h.	4 + in. d.b.h.	12 + in. d.b.h.
	– – Number – –		*Cu. ft.*	*Standard cords*	*Bd. ft. (Doyle)*	*Cu. ft.*	*Bd. ft. (Doyle)*
1937	102	30	1,793	21.2	5,074		. . .
1941	91	31	1,872	22.1	5,766	81	244
1946	51	31	1,740	20.5	6,454	52	372
1951	46	36	1,968	23.2	8,295	98	596
1956	48	32	1,733	20.5	7,438	50	249
1960	82	34	2,008	23.7	8,364	125	504
1965	112	31	1,995	23.6	7,781	90	328

POOR FORTY

Year	Trees		Volume			Growth yearly	
	4 to 12 in. d.b.h.	12 + in. d.b.h.	4 + in. d.b.h.		12 + in. d.b.h.	4 + in. d.b.h.	12 + in. d.b.h.
	– – Number – –		*Cu. ft.*	*Standard cords*	*Bd. ft. (Doyle)*	*Cu. ft.*	*Bd. ft. (Doyle)*
1937	68	17	976	11.5	2,341	. .	. . .
1941	71	21	1,214	14.3	3,135	86	231
1946	68	19	1,179	13.9	3,701	57	251
1951	105	25	1,501	17.7	4,583	121	391
1956	131	24	1,480	17.5	4,339	75	264
1960	163	29	1,863	22.0	5,304	174	514
1965	173	30	1,952	23.0	4,982	144	404

SOUTHERN FOREST EXPERIMENT STATION

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SO-30

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

PINE SEEDLING SURVIVAL UNDER SIMULATED DROUGHT

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SOUTHERN FOREST EXPERIMENT STATION

In east Texas, the high probability of drought during the growing season makes it advisable to prepare pine planting sites by eliminating vegetation that competes with the seedlings for soil moisture (*4*). The seedlings are especially vulnerable during spring terminal elongation. At this time soil moisture stress retards their height growth considerably (*8*), while ample moisture often produces initial growth advantages that the young trees maintain for many years (*6*).

Field testing for drought endurance is often hampered by weather vagaries (*3*). In the study reported here, seedlings of three pine species were planted under a shelter that withheld rain from the test plots without otherwise altering their environment (*7*).

MATERIALS AND METHODS

The study was installed on the Stephen F. Austin Experimental Forest near Nacogdoches, Texas. Soil belonged to the Cahaba (fine sandy loam) series and was uniform as to texture and color. The site was level and densely covered with Bermuda and other grasses, together with a variety of broadleaved weeds.

Eight plots 10 feet square were laid out in a single east-west row. The plots at each end formed the isolation. The six interior plots were paired into three blocks. One randomly selected plot of each pair was scalped; i.e., its plant cover was removed along with 2 to 3 inches of surface soil. On the other three plots the sod remained undisturbed.

As soon as site preparation was completed (February 9, 1961), eight seedlings each of three pine species—loblolly (*Pinus taeda* L.), shortleaf (*P. echinata* Mill.), and slash (*P. elliottii* Engelm.)—were planted on each plot at 2- by 2-foot spacing. Species were randomly assigned to individual planting spots. A twenty-fifth seedling was planted in the plot center to ensure uniform use of soil moisture throughout the plot. The plants, grown at a nearby State nursery, were selected for uniform height (about 1 foot), well-developed tops and roots, and dormant apical buds.

The shelter's framework was erected over the test plots in January 1961, and its transparent plastic cover applied on May 2. To prevent seed-

[1] The authors are with the Wildlife Habitat and Silviculture Laboratory, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture. The Laboratory is maintained in cooperation with Stephen F. Austin State College, Nacogdoches, Texas.

ling mortality prior to covering, all plots were irrigated once with uniform amounts of water. The shelter withheld rain but did not greatly alter the temperature and humidity of the seedling environment (7).

Gravimetric soil moisture samples (to depths of 24 inches) were taken twice a week from April 26 to early July and then at monthly intervals until December. Texture classes at the various sampling depths were determined by Bouyoucos' hydrometer method (*1*). From the hydrometer data, the 15-atmosphere moisture (permanent wilting) percentages were estimated by the procedure of Nielsen and Shaw (*2*).

Seedling survival was recorded from biweekly needle moisture samples. A plant was termed dead if its needle moisture content, expressed on a dry-weight basis, dropped below 60 percent (5). Height measurements were taken soon after planting, then on May 3, June 26, Septembпr 21, and December 5, 1961.

RESULTS AND DISCUSSION

After 7 months under the shelter, survival on scalped plots averaged 99 percent for the three species, significantly (0.01 level) more than on sod plots, which averaged 30 percent.

Without sod competition, shortleaf and loblolly survived equally well (100 percent), followed by slash pine (96 percent). With competition, shortleaf survival was 63 percent, loblolly 19, and slash 8. Survival differences between shortleaf pine and the other two species were significantly different (0.01 level).

Mortality of slash and loblolly on sod plots began soon after the cover was put up, but shortleaf endured for almost 3 months without severe loss (fig. 1). This performance seems to corroborate the greater drought resistance attributed to shortleaf on the basis of field observations.

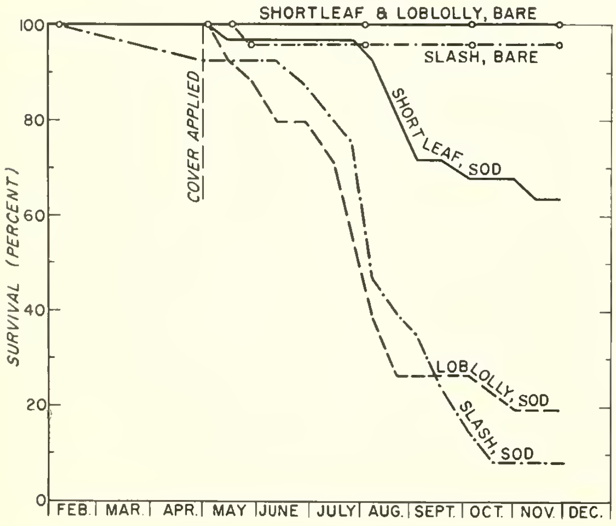

FIGURE 1.—*Seedling survival.*

Average height on bare and sod plots combined was the same for all three species (1.2 feet). Plants without competition made significantly (0.05 level) better height growth (1.3 feet) than those with competition (1.1 feet).

Loblolly made its height growth chiefly before the onset of drought. Shortleaf and slash pine initiated height growth somewhat later, and made most of it after the cover was applied. On sod plots, height growth of loblolly and slash pine slackened soon after the cover was applied, but shortleaf continued to grow at the initial high rate for about 6 weeks and made slight gains thereafter.

Immediately after the cover was installed, moisture depletion rates were greatest in the upper soil layers and decreased with increasing soil depth. Depletion was obviously faster in sod plots, where by May or June the soil moisture content dropped below the estimated 15-atmosphere wilting point at all depths. On scalped plots, soil moisture dropped below the wilting point only in the surface 6 inches.

LITERATURE CITED

1. Bouyoucos, G. J.
   1951. A recalibration of the hydrometer method for making mechanical analyses of soils. J. Amer. Soc. Agron. 43: 434-438.
2. Nielsen, D. R., and Shaw, R. H.
   1958. Estimation of the 15-atmosphere moisture percentage from hydrometer data. Soil Sci. 86: 103-105.
3. Stransky, J. J.
   1959. Site treatments have little effect during wet season in Texas. U. S. Forest Serv. Tree Planters' Notes 36, pp. 20-21.
4. ———
   1961. Weed control, soil moisture, and loblolly pine seedling behavior. J. Forest. 59: 282-284, 289-290.
5. ———
   1963. Needle moisture as mortality index for southern pine seedlings. Bot. Gaz. 124: 178-179.
6. ———
   1964. Site-preparation effects on early growth of loblolly pine. U. S. Forest Serv. Tree Planters' Notes 64, pp. 4-6.
7. ——— and Duke, W. B.
   1964. Shelter for testing drought-hardiness of planted southern pine seedlings. U. S. Forest Serv. Res. Note SO-11, 4 pp., illus. Southern Forest Exp. Sta., New Orleans, La.
8. ——— and Wilson, D. R.
   1964. Terminal elongation of loblolly and shortleaf pine seedlings under soil moisture stress. Soil Sci. Soc. Amer. Proc. 28: 439-440.

SOUTHERN
FOREST
EXPERIMENT
STATION

U.S. FOREST SERVICE
RESEARCH NOTE

1966

SO-31

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LITTER IN LONGLEAF PINE STANDS THINNED TO PRESCRIBED DENSITIES

W. D. Boyer and G. R. Fahnestock
SOUTHERN FOREST EXPERIMENT STATION

This note reports the effects of longleaf pine (*Pinus palustris* Mill.) stand density on the composition, deposition, and accumulation of litter on the forest floor.

The study was conducted from July 1960 through June 1963 in even-aged second-growth longleaf stands on the Escambia Experimental Forest in southeastern Alabama. Two blocks, each with five square 2.5-acre plots, were established in March 1957, and plots in each block were cut to randomly assigned densities of 9, 18, 27, 36, and 45 square feet of basal area per acre. All overstory hardwoods were destroyed at that time. When the stands were remeasured in February 1962, basal areas ranged from 10.4 to 49.5 square feet per acre, and average d.b.h. ranged from 13.7 to 14.8 inches. In one stand, tree age averaged 54 years, and site index, 76 feet; in the other, tree age averaged 59 years, and site index, 70 feet. Neither stand had been burned since 1954.

Falling litter was caught in nine ¼-milacre paperboard seed traps systematically located within a 1-chain square at the center of each plot. Once a month all material caught in the traps was collected and oven-dried to constant weight at 100° C. After oven-dry weight of litter in each trap was obtained, the contents of two different traps each month from each plot were allowed to come to moisture equilibrium in air, sorted into needles, leaves, miscellaneous coarse material, and miscellaneous fine material, and reweighed. Miscellaneous coarse material included cones, twigs more than ¼ inch in diameter, and other material more than ½ inch wide and 1/16 inch thick with one surface larger than 1 square inch. Miscellaneous fine included all remaining small material except needles and leaves. Relative amounts of the four litter components were calculated annually.

In February or March of each year the accumulated litter on the forest floor was collected from five 0.96-square-foot samples taken at random on undisturbed portions of each plot. These samples were oven-dried, weighed, sorted into needles, leaves, grass (including herbage), brush (up to 1-foot in height), wood, and miscellaneous partly decayed material, and reweighed.

LITTER DEPOSITION

Pine needles made up 70 percent of the trapped litter; leaves, 5 percent; miscellaneous coarse material, 7 percent; and miscellaneous fine material, 18 percent. Annual deposition of all litter increased from an average of 918 pounds (dry weight) per acre under the stand of lowest density to 3,004 pounds per acre under the highest. The weight of pine needles alone ranged from 618 to 2,102 pounds per acre. This annual deposition is somewhat less than the 2,307 to 3,168 pounds of needle litter per acre reported by Heyward and Barnette (*3*) in dense second-growth stands of longleaf pine. The weight of both miscellaneous fractions, as well as of needles, increased with increasing basal area. Thus, the pine overstory was the principal contributor to these categories. Litter fall differed little between blocks; one block accounted for 50.8 percent of the total catch; the other, 49.2 percent.

The relation of litter weight to stand basal area was exponential, and the logarithm of total litter weight bore a significant linear relation (0.05 level) to basal area. The regression for weight of needles alone was also significant; the curve is similar to but 30 percent lower than that for all litter (fig. 1).

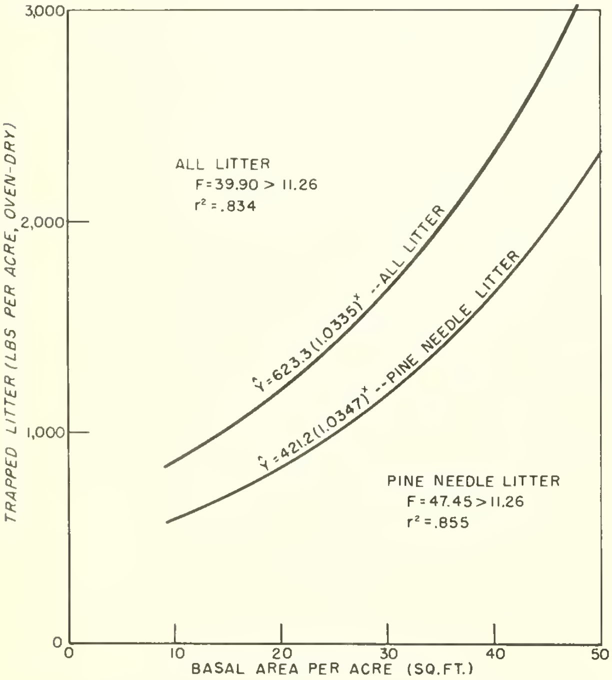

Figure 1.—*Annual litter deposition in relation to basal area of overstory.*

Total litter fall in the 3 successive years of the study was 1,930, 1,854, and 1,727 pounds per acre. This variation is small. Others have observed that the weight of needles deposited in 1 year may be two to three times that in another (*1*, *4*).

Litter deposition followed a predictable seasonal pattern. Forty-six to 48 percent of the yearly total fell in September, October, and November. During each of the remaining 9 months, deposition averaged very close to 6 percent.

LITTER ACCUMULATION

The average weight of material on the forest floor, excluding the miscellaneous partly decayed material, ranged from 2,587 pounds per acre under the lowest to 4,256 pounds per acre under the highest stand density. Pine needle litter plus grass and herbage accounted for 70 percent of this material.

Apparently, deposition and decay of needles had reached an equilibrium on the study area. The average weights of needles under all stands in the 3 years were 1,674, 1,697, and 1,548 pounds per acre. The total needle accumulation did not reach as much as 2 years' deposition under any of the stands.

Hardwood leaves and brush constituted only a small fraction of the material on the forest floor. Average weight of leaves per plot collected annually from the forest floor was more than twice that caught in traps (206 pounds vs. 96 pounds). Most of the leaves probably came from hardwood sprouts and brush below the level of the trap surface.

Wood on the forest floor averaged 804 pounds per acre, slightly more than six times the annual collection of miscellaneous coarse material from litter traps. The quantity of wood declined from 1,123 to 919 to 370 pounds per acre in the 3 years. In an undisturbed stand, wood on the forest floor should remain essentially constant. In this study, the quantity probably was high initially because of the recent thinning.

The weight of accumulated needles on the forest floor increased rapidly with stand density from a low of 460 pounds per acre under the thinnest stands to 2,903 pounds under the densest. As with needle deposition, the relation was curvilinear (fig. 2). The regression was considerably steeper than that for trapped needles, beginning at about 150 pounds (20 percent) below the latter, crossing it at a basal area of 23 square feet, and ending about 1,000 pounds (50 percent) above it.

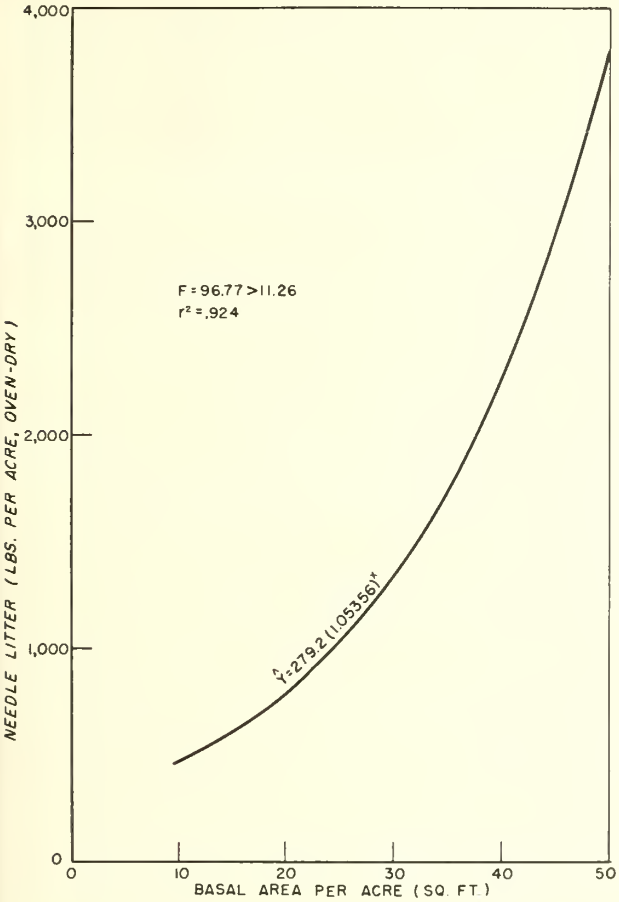

Figure 2.—*Accumulation of pine needle litter on the forest floor.*

The grass rough decreased from more than 1,100 pounds per acre under stands with 9 to 18 square feet of basal area to little more than 500 pounds on those with 36 to 45 square feet. The decline was curvilinear, and the relation of grass weight to stand density was significant (fig. 3). Others have found a similar, but less steep, downward trend in grass production with increase in basal area (2).

The combined weight of grass plus pine needles increased from 1,607 pounds per acre (71 percent grass) under the lowest to 3,481 pounds per acre (83 percent pine needles) under the highest density class. The total weight of these flash fuels had a linear relation to stand density (fig. 4).

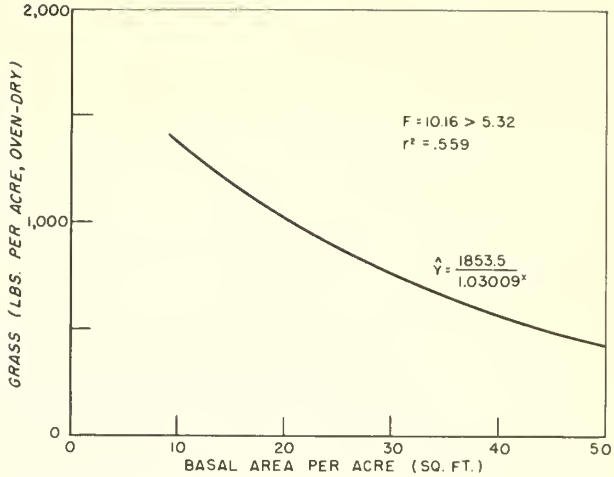

Figure 3.—*Grass rough on forest floor.*

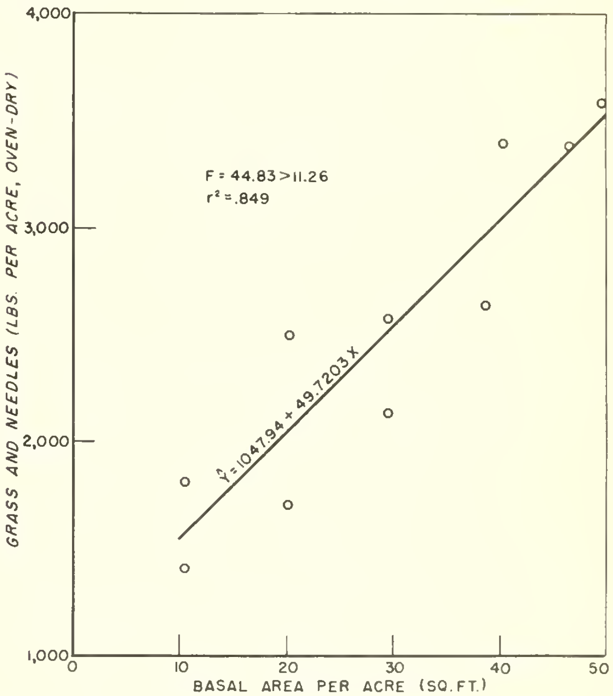

Figure 4.—*Combined accumulation of grass and needle litter rough.*

The amount of flash fuel built up rapidly as basal area increased, but total weight of these two components did not become great enough, under stands up to 50 square feet per acre, to either support a high intensity fire or equal 2 years' deposition of needles. Therefore, in the absence of significant quantities of flammable brush, prescribed burning for hazard reduction alone does not seem to be warranted in such light stands. Prescribed burning for other purposes could be accomplished biennially just as well as at longer intervals.

LITERATURE CITED

(1) Dimock, E. J., II.
1958. Litter fall in a young stand of Douglas-fir. Northwest Sci. 32(1): 19-29.

(2) Gaines, E. M., Campbell, R. S., and Brasington, J. J.
1954. Forage production on longleaf pine lands of southern Alabama. Ecology 35: 59-62.

(3) Heyward, Frank, and Barnette, R. M.
1936. Field characteristics and partial chemical analyses of the humus layer of longleaf pine forest soils. Florida Agr. Exp. Sta. Tech. Bull. 302, 27 pp., illus.

(4) Scott, D. R. M.
1955. Amount and chemical composition of the organic matter contributed by overstory and understory vegetation to forest soil. Yale Univ. Sch. Forest. Bull. 62, 73 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-32

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SURVIVAL AND FIRST-YEAR GROWTH OF HARDWOODS PLANTED IN SATURATED SOILS

F. T. Bonner[1]

SOUTHERN FOREST EXPERIMENT STATION

Up to 16 weeks of soil saturation from the time of planting did not significantly affect survival, date of bud-break, or initiation of height growth of sycamore, sweetgum, and Nuttall oak seedlings. But when soil temperatures were rapidly increasing in mid-April, saturation for more than 10 to 12 weeks did severely reduce height, root, and stem-diameter growth. Saturation was more detrimental in Commerce silt loam than in Sharkey clay.

This note describes a pot study to determine the response of sycamore (*Platanus occidentalis* L.), sweetgum (*Liquidambar styraciflua* L.), and Nuttall oak (*Quercus nuttallii* Palmer) to planting in saturated soils. Commerce silt loam and Sharkey clay were selected for the study because they are typical alluvial soils of the Mississippi River batture and the slackwater clay area, respectively.

Most hardwoods withstand flooding in the dormant season, but few tolerate it during the growing season. Although many hardwood planting sites in the South are saturated during the planting season, most previous studies have dealt with seedlings that were flooded after establishment in well-drained soil.

PROCEDURE AND METHODS

Two 18- by 40-foot reservoirs, 15 inches deep, were dug and lined with thick polyethylene to make them watertight. After the reservoirs were filled with water to a 10-inch depth, 324 10-inch clay pots filled with Sharkey clay and a like number filled with Commerce silt loam were placed in the reservoirs.

One-year-old sycamore, sweetgum, and Nuttall oak seedlings were lifted from the Southern Hardwoods Laboratory nursery in early February 1962. Roots were pruned to 6 inches and were washed free of all soil and organic matter. Root dry weights for all seedlings were estimated from root volumes as measured by water displacement. Relations between root volume and root weight were computed from 100 samples of each species.

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group. The work was done as partial requirement for the Doctor of Forestry degree at Duke University. The author thanks Dr. P. J. Kramer for advice before and during the research.

On February 9, 1962, 54 seedlings of each species were planted in individual pots of each soil in each reservoir. These seedlings were divided into nine treatment groups of six seedlings each. Original heights and stem diameters at the soil surface were recorded. One group, the check, was taken from the water immediately, and every 2 weeks for 16 weeks an additional group was removed. After pots were removed from a reservoir they were allowed to drain, then placed in the open where they received rain, plus artificial watering when needed.

Date of bud-break, date of height-growth initiation, and weekly height growth were noted. Final measurements of survival, height, and stem diameter were made on August 4, 9 weeks after the last seedlings had been drained. The root systems of all live seedlings were washed free of soil, and their dry weights were obtained after drying at 65° C. in a forced-air oven for 24 hours. Since the species studied sprout readily, a seedling was considered dead only if the roots as well as the top appeared to be dead.

Soil temperatures 3 inches below the surface were taken weekly with 22 mercury-bulb soil thermometers randomly distributed among all treatments. These measurements were intended to detect radical changes in soil temperature during the study rather than furnish detailed temperature records.

For observation of new root growth, 16 additional pots, each with three seedlings, were established with each soil for each species on February 13. Forty-eight pots contained Sharkey clay, and forty-eight contained Commerce silt loam. Half of the pots were placed in a reservoir, and half were not. A pot of each species in each soil was first removed from the reservoir and the check area on February 23. Roots were washed free of soil, and the total length of white, unsuberized rootlets was measured. This procedure was repeated every 2 weeks when a group of pots in the main study was drained.

Relative leaf moisture stress was measured on selected seedlings at various times by the relative turgidity method (7). Ten leaf disks, 0.7 cm. in diameter, were taken from each seedling, weighed to the nearest 0.1 mg., and floated in distilled water in petri dishes for 4 hours under 100 foot-candles of light. The disks were then blotted dry between eight sheets of Whatman No. 1 filter paper pressed together with a 2,500 g. weight, reweighed, and dried for 24 hours at 65° C. in an oven. Relative moisture stress was expressed as water deficit (WD):

$$WD = \frac{\text{Turgid weight—fresh weight}}{\text{Turgid weight—oven-dry weight}} \times 100$$

RESULTS

Bud-break and initiation of height growth.—Sweetgum buds broke an average of 16 days after planting; sycamore, 26 days; and Nuttall oak, 75 days. The first terminal growth appeared an average of 46 days after bud-break for sweetgum, 36 days for sycamore, and 14 days for Nuttall oak. Neither bud-break nor initiation of height growth were influenced by soil or saturation treatment.

Survival.—Survivals averaged 89.8 percent for sycamore, 94.0 for sweetgum, and 95.4 for Nuttall oak; they were not influenced by saturation.

Seedling growth.—Long saturation significantly decreased terminal, stem diameter, and root growth (fig. 1). In general, saturation for 10 weeks was required for large decreases in growth. A rapid rise in temperature (from 60° to 80° F.) of the saturated soils also occurred about 10 weeks after planting. A few weeks of saturation after planting seemed beneficial to growth.

Several differences between species were noted. Sycamore, for instance, made the best overall growth, but prolonged saturation curtailed its terminal growth more severely than that of other species. Nuttall oak did poorly in Commerce silt loam, especially in terms of root growth. There was no significant species effect in stem-diameter growth.

Seedlings that spent long periods in saturated soil had few lateral branches. Their foliage was small and often chlorotic.

Initiation of root growth.—In well-drained pots, new root growth started approximately 4 to 6 weeks after planting, and all three species had 20 to 40 cm. of white, unsuberized rootlets per seedling by mid-April. In saturated soil only sycamore roots grew appreciably. After 10 to 12 weeks, seedlings averaged about 25 cm. of growing root tips in saturated Sharkey clay and 12 cm. per seedling in saturated Com-

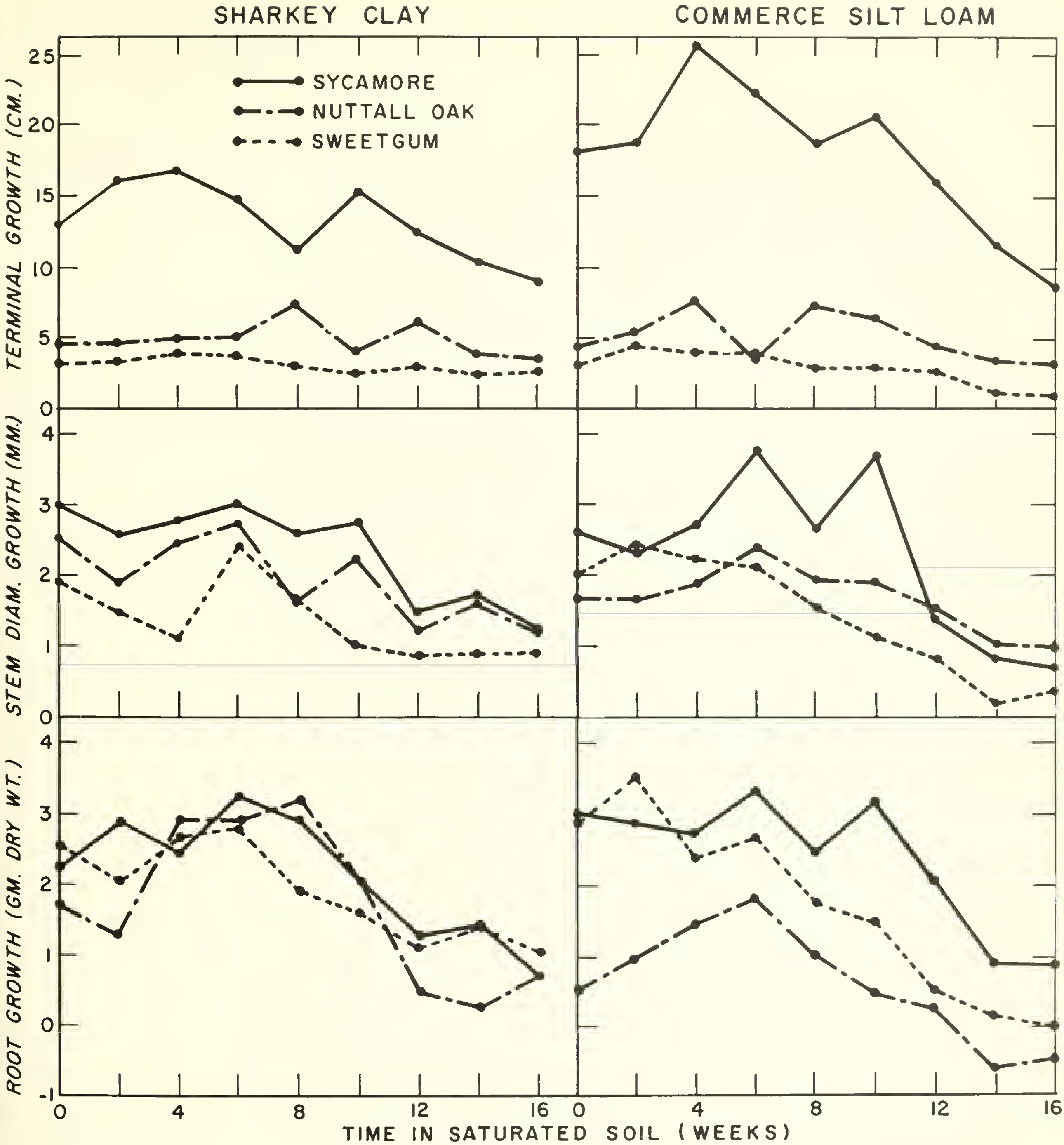

Figure 1.—*Growth responses to soil saturation, by species.*

merce silt loam. Sweetgum and Nuttall oak never had more than 10 cm. of growing root tips per seedling in Sharkey clay, nor more than 3 cm. in Commerce silt loam.

Relative leaf moisture stress. — Leaf WD measurements on May 17 and June 16 showed that soil saturation was detrimental to the water balance of most seedlings, especially those on Commerce silt loam. On May 17 all seedlings had slightly higher leaf WD values in saturated than in drained soils, except sycamore in Sharkey clay and Nuttall oak in Commerce silt loam. On June 16, 2 weeks after drainage, seedlings grown in saturated Sharkey clay for 16 weeks had leaf moisture stresses similar to those of check seedlings, but seedlings grown in saturated Commerce silt loam had consistently higher WD values than their checks (table 1).

Table 1.—*Leaf water deficits (WD) of seedlings in percent (sampling time was 11:00 a.m. to noon)*

SPECIES	SHARKEY CLAY		COMMERCE SILT LOAM	
	DRAINED	SATURATED	DRAINED	SATURATED
		May 17, 1962		
Sycamore	12.8	11.8	12.2	14.6
Sweetgum	11.6	13.2	11.4	16.1
Nuttall oak	16.0	22.5	24.1	20.7
		June 16, 1962		
Sycamore	12.9	[1]13.7	10.2	[1]16.1
Sweetgum	12.4	[1]12.2	13.0	[1]16.1
Nuttall oak	18.7	[1]18.7	17.2	[1]19.5

[1]Measurements taken 2 weeks after drainage.

DISCUSSION

All three species have been described as rather tolerant of flooding (*3, 4, 5, 6*). The present data do not conflict with previous evaluations if survival alone is considered, but they do show that extended periods of soil saturation from the time of planting can reduce shoot and root growth considerably. The "critical period" of soil saturation in this study was 10 to 12 weeks, but soil temperature probably strongly influences its length.

The apparent benefit to growth of several weeks of soil saturation (fig. 1) may not be real. Supplemental irrigation from overhead sprinklers following drainage may not have been sufficient to allow maximum growth, and may have reduced growth by compacting the soil.

Although drought effects were not measured directly, decline in root growth in saturated soil and increases in leaf moisture stress after saturation indicate that a drought immediately after drainage may be very damaging to seedlings planted in saturated soil. This kind of damage has been observed on larger trees (*1, 2*).

LITERATURE CITED

(1) Broadfoot, W. M.
1960. Soil-water shortages and a means of alleviating resulting influences on southern hardwoods. *In* Southern Forest Soils. Louisiana State Univ. Eighth Ann. Forest. Symp. Proc. 1959: 115-119.

(2) Fraser, D. A.
1962. Tree growth in relation to soil moisture. *In* Tree Growth, pp. 183-204. New York: Ronald Press Co.

(3) Hosner, J. F.
1959. Survival, root, and shoot growth of six bottomland tree species following flooding. J. Forest. 57: 927-928.

(4) McAlpine, R. G.
1961. Yellow-poplar seedlings intolerant to flooding. J. Forest. 59: 566-568.

(5) McDermott, R. E.
1954. Effects of saturated soil on seedling growth of some bottomland hardwood species. Ecology 35: 36-41.

(6). U. S. Army Corps of Engineers.
1955. Timber protection in reservoirs. Civil Works Invest. Proj. CW-515, 44 pp. New Orleans Dist., New Orleans.

(7) Weatherley, P. E.
1950. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol. 49: 81-97.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-33

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

APPALACHIAN LOBLOLLY GROWS WELL IN ARKANSAS OZARKS

William R. Maple
SOUTHERN FOREST EXPERIMENT STATION

In northern Arkansas, loblolly pine grown from seeds collected in the eastern part of the species' range has survived and reached pulpwood size in 15 years.

A 1.6-acre plantation was established in March 1960 in cooperation with the Tennessee Valley Authority to compare survival and growth of 1-0 loblolly seedlings from nine sources. Seeds were collected from northern and southern Alabama, northern Georgia, Maryland, eastern and northern Mississippi, South Carolina, southeastern Tennessee, and Virginia.

The plantation is on an old field in Newton County, Arkansas. The soil is a deep loamy sand. Trees were hand-planted at 8- by 8-foot spacing in three randomized blocks.

During its 15 years, the plantation has been subjected to all the rigors of the Ozark Mountains—insect attacks, extended droughts, wind, hail, sleet, and temperatures ranging from a low of –14° F. to a high of 110° F. The venture appeared risky when 22 percent of the 2-year-old trees were top-killed by an early November frost,[1] but the plantation recovered and has grown well since.

Survivals range from 90 percent for Tennessee trees to 8 percent for South Carolina trees. If 50 percent survival after 15 years is an indication of species adaptability, seedlings from all sources except South Carolina appear to be suited to Arkansas' climate.

Survival, stocking, and growth for all sources except South Carolina are shown in table 1. In 1965, average diameters by source ranged from 7.1 to 7.7 inches, and average heights ranged from 39 to 40 feet. Merchantable volumes were from 12 to 23 cords per acre. Trees from six areas produced at least 1 cord per acre per year.

Because growth characteristics were similar for trees from many of the areas, survival and volume production are probably the best criteria for source selection. Seedlings from the Appalachian Mountains in southeastern Tennessee and northern Georgia survived best. In terms of volume produced, seedlings from northern Alabama—also in the highlands—

[1] Shoulders, Eugene. Cold hurts loblolly in Ozarks. U. S. Forest Serv. Southern Forest Exp. Sta. Southern Forest. Notes 82. 1952.

Table 1.—*Fifteen-year loblolly pine survival and growth, by seed source*

Seed source	Survival	Stocking (per acre)	D.b.h.	Total height	Merchantable volume (per acre)
	Percent	*Trees*	*Inches*	*Feet*	*Cords*
Tennessee	90	613	7.3	39	19
Georgia	81	552	7.5	40	23
North Mississippi	73	497	7.2	39	17
East Mississippi	69	470	7.5	39	18
South Alabama	69	470	7.1	39	12
North Alabama	65	443	7.7	40	19
Virginia	58	395	7.4	40	13
Maryland	56	381	7.3	39	15

performed as well as the seedlings from the other mountain sources. Probably the similarity in soil, topography, and climate of the Appalachians and Ozarks accounts for the success of Appalachian trees.

Until larger plantings than the one in this test are made and evaluated, native shortleaf pine is recommended for large plantations in the Ozarks. Forward-looking land managers, however, may want to consider planting loblolly on a small scale for post, pulpwood, and small saw log production on deep loamy sands in the area. Seeds from the southern Appalachians are recommended for such ventures, at least until seeds from southern Arkansas and other points close to the Ozarks are tested.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-34

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FIVE YEARS OF NITROGEN FERTILIZATION IN A SWEETGUM-OAK STAND

W. M. Broadfoot [1]
SOUTHERN FOREST EXPERIMENT STATION

Diameter and height growth were significantly increased in a 20-year-old sweetgum-oak stand by annual surface application of ammonium nitrate and of complete N-P-K fertilizer. Nitrogen fertilization significantly increased the nitrogen content of foliage. With increasing nitrate application, exchangeable potassium in the soil 1 year after treatment decreased.

Responses to surface application of fertilizer were measured in a natural sweetgum-oak stand on Sharkey clay near Tallulah, Louisiana.[2] The soil is alluvial and relatively fertile, receiving nutrients from uplands. Plots were fertilized primarily with nitrogen, the element often lacking in southern soils.

Annually for 5 years, 1/10-acre plots in a well-stocked 20-year-old stand of sweetgum (*Liquidambar styraciflua* L.), water oak (*Quercus nigra* L.), and willow oak (*Quercus phellos* L.) were top-dressed with one of five amounts of fertilizer. Rates applied per acre were (1) zero (control), (2) 75 pounds of nitrogen, (3) 150 pounds of nitrogen, (4) 300 pounds of nitrogen, and (5) 150 pounds of nitrogen plus 35 pounds of phosphorus and 66 pounds of potassium. Treatments were replicated four times. The source of nitrogen was ammonium nitrate, and the phosphorus and potassium were from a 0-20-20 mixed fertilizer.

Five dominant and codominant trees of sweetgum and five of oak were randomly selected on each plot. Because willow and water oak resembled each other in form and growth, oaks were combined and treated as one in this test.

D.b.h. was measured at the beginning and end of the study to the nearest tenth of an inch at a marked position on each sample tree. Heights were measured to the nearest foot with a Haga altimeter placed at a staked position out from each tree. At the beginning of the study, oak sample trees averaged 5.9 inches in diameter and 45 feet in height, and sweetgum trees averaged 4.6 inches in diameter and 37 feet in height.

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] The study was on land owned by Chicago Mill and Lumber Company.

A year after the last fertilizer application, tree foliage and soil samples were analyzed for N-P-K. Sample leaves were picked at random from the middle of the crown of each tree, composited by species, plot, and treatment, dried at 60° C., ground in a Wiley mill, and stored in ½-pint jars. For each treatment, representative samples of the upper 4 feet of soil were taken, air-dried, sieved, and stored in 1-pint ice cream cartons.

Nitrogen content of leaves and soil was determined by the standard Kjeldahl procedure; phosphorus in leaves, by the chlorostannous-reduced molybdophosphoric blue color method in a hydrochloric acid system with a spectrophotometer; phosphorus in soil, by the ammonium molybdate-sulphuric acid method with a spectrophotometer; potassium in leaves, by the flame method with a Beckman DU spectrophotometer; and exchangeable potassium in soil, by extraction with slightly acid ammonium acetate and flame spectrophotometer.

Statistical tests of differences between species and treatments were made at the 0.05 level of confidence.

RESULTS AND DISCUSSION

Growth response.—All fertilizer treatments increased diameter and height growth of both sweetgum and oaks (table 1). The best diameter growth for the 5 years was 1.99 inches in sweetgum fertilized with 300 N, and the best height growth was 12 feet in sweetgum fertilized with N-P-K. Responses of the oaks, though smaller, were similar to those of sweetgum. For oak and sweetgum combined, 300 N produced a 65-percent increase in diameter growth, and N-P-K produced a 44-percent increase in height.

Table 1.—*Five-year growth by species and treatment* [1]

Treatment (pounds per acre)	Sweetgum		Oak	
	D.b.h.	Height	D.b.h.	Height
	Inches	*Feet*	*Inches*	*Feet*
0	1.07	6.9	1.64	8.8
75 N	1.50	9.8	1.96	8.9
150 N	1.59	10.0	2.62	9.1
300 N	1.99	11.4	2.51	8.9
150 N, 35 P, 66 K	1.80	12.0	2.31	10.5

[1] Each value in the table is the average for 20 sample trees.

For diameter growth, 75 N was significantly better than none. There was no difference between N-P-K and 150 N, but each was better than 75 N. And 300 N was better than any other treatment (table 2). For height growth, all nitrogen applications were better than none, but there was no difference between rates of application; N-P-K was better than 75 N and 150 N, but not 300 N.

Table 2.—*Growth responses to fertilizing by all species combined*

Five-year growth	Treatment				
	Control	75 N	N-P-K	150 N	300 N
	Inches				
Diameter	1.36	1.73	2.05	2.10 [1]	2.25
	Control	75 N	150 N	300 N	N-P-K
	Feet				
Height	7.8	9.4	9.5	10.2	11.2

[1] Horizontal lines connect values not significantly different at the 0.05 level when analyzed by Duncan's multiple range test.

Foliage analysis.—Leaves from trees fertilized with 150 N, N-P-K, and 300 N contained more nitrogen than leaves from unfertilized trees (table 3). The nitrogen content of leaves

Table 3.—*Nutrient content of foliage*

Treatment (pounds per acre)	Sweetgum			Red oak		
	N	P	K	N	P	K
	Percent by weight					
0	1.507	0.186	0.59	1.564	0.089	0.71
75 N	1.449	.160	.52	1.521	.096	.62
150 N	1.687	.170	.62	1.670	.096	.58
300 N	1.868	.122	.68	2.149	.131	.63
150 N, 35 P, 66 K	1.620	.170	.69	1.640	.115	.60

from trees fertilized with 300 N was greater than that of other leaves.

Phosphorus content of foliage was not significantly affected by fertilizing. However, in terms of foliar phosphorus, sweetgum and oak responded significantly differently to fertilization. Apparently, there was a slight decrease in phosphorus content of sweetgum as nitrogen was increased, whereas the reverse appeared to be true for oak.

The potassium content of leaves was not affected by fertilizer treatment.

Soil analysis.—A year after the last fertilizer application, there were no differences, by treatment, in nitrogen and phosphorus content of the soil (table 4). With increasing nitrogen application, however, the potassium content of soil decreased (fig. 1). The reason for this decrease is not known. An imbalance created by heavy N applications seems unlikely, since Sharkey clay soils usually have much exchangeable potassium and little nitrogen. Probably, the trees grew faster when fertilized and used more exchangeable potassium as a result.

Table 4.—*Average nitrogen and phosphorus in upper 4 feet of soil 1 year after last fertilizer application*

Treatment (pounds per acre)	Nitrogen	Phosphorus
	Pounds per acre-foot	
0	[1] 2,952	83
75 N	2,880	86
150 N	3,168	88
300 N	2,952	92
150 N, 35 P, 66 K	2,808	95

[1] Each value in the table is the average of four plots.

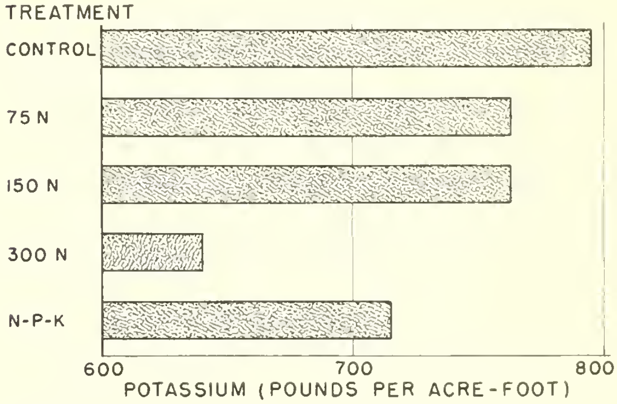

Figure 1.—*Exchangeable potassium in upper 4 feet of soil 1 year after treatment.*

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-35

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

AN EIGHT-DAY VOLUMETRIC POLLEN SAMPLER

Charles X Grano

SOUTHERN FOREST EXPERIMENT STATION

The pollen sampler described, unlike commonly used stationary adhesive-bearing slides and similar devices, provides accurate, continuous, volumetric estimates of atmospheric pollen load. The sampler is simple to construct.

Accurate, around-the-clock estimates of atmospheric pollen per unit volume of air are often needed in seed production studies of pine and other wind-pollinated species. Commonly used traps, such as adhesive-bearing slides, globes, and cylinders, which depend solely on wind, air turbulence, or gravity for impaction and entrapment, are incapable of yielding such data *(1, 2, 3, 5, 6)*[1]. Hirst discussed the prerequisites for accurate aerosol sampling and designed a trap embodying them. His vacuum-powered spore trap had a constant air intake of known volume, sampled into the wind, completely filtered out spores, and produced a continuous 24-hour record. Pady (*4*) modified Hirst's sampler to obtain discrete hourly spore records. Both samplers used a moving, adhesive-bearing glass slide to catch the spores, and both were limited to a 24-hour record. The need for longer records prompted the design of the sampler described in this note.

The new sampler, although similar in principle, differs from Hirst's trap in being easy to construct with ordinary hand tools, and in producing continuous records for as long as 8 days. This increased capacity saves time under any circumstances, and is especially useful in remote locations where daily trips are impractical. The sampler has performed satisfactorily for 3 years.

CONSTRUCTION DETAILS

An ordinary thermograph clock mechanism or similar device, enclosed in an airtight housing, moves a transparent plastic band coated with adhesive past an orifice slit. Interchangeable gears enable the clock to make a complete revolution in 1, 4, or 8 days, as required. Into-the-wind sampling is achieved by mounting the housing on a turntable actuated by a vane. A continuous, controlled volume of air is drawn into the orifice by a vacuum pump. The completely assembled unit is shown in figure 1.

The housing, its contents, and the method for mounting it on the turntable are illustrated in figure 2. A 2-pound coffee can equipped with a polyethylene seal serves as the housing.

[1] Italicized numbers in parentheses refer to Literature Cited, page 4.

[2] Neoprene Tire Shield, by Auto-Vacation Products, P. O. Box 276, San Dimas, California, or a similar product.

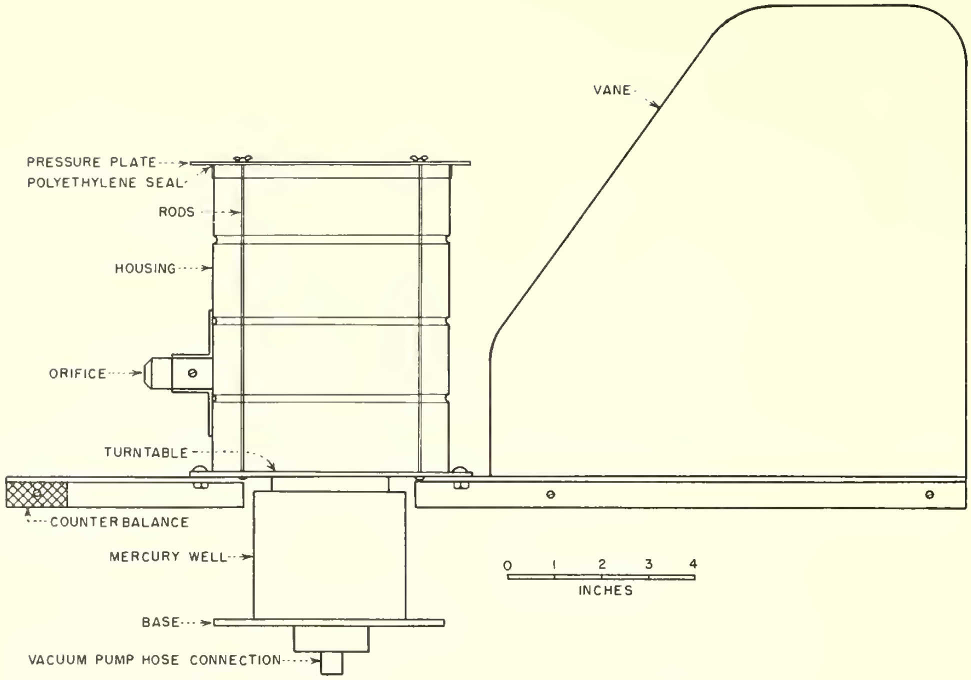

Figure 1.—*Completely assembled pollen sampler.*

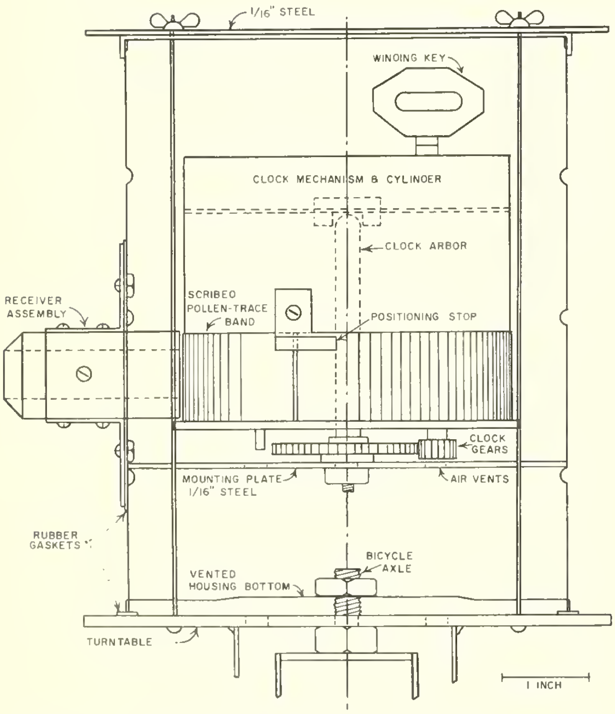

Figure 2.—*Sampler housing with its contents.*

Several simple modifications should be made on the cylinder of the clock mechanism. Cylinder height should be cut to a minimum to reduce bulk, and an adjustable stop should be attached to the cylinder with a set screw. The stop will hold the plastic band in place and position the cylinder and band in relation to the orifice at the start of each sampling run. Vents drilled in the clock mounting drive plate and housing bottom permit airflow.

The orifice should be fixed in position with a set screw so that its discharge end is less than 1 mm. from the plastic band.

The clock mechanism slips off the arbor and is easily removed from the housing for servicing by unscrewing the pressure plate rod wing nuts and lifting off the pressure plate and polyethylene seal. A notch cut in the flange that protrudes from the cylinder bottom permits passage of the clock over the rear portion of the orifice.

At the start of a run, the clock with band in place should be lowered into the housing so that the position stop is an inch or so to the left of the orifice (facing the orifice). After the gears are meshed, turning the cylinder counterclockwise places the first interval on the pollen band behind the orifice and takes up slack in the timing gears.

Any competent welder can fabricate the turntable (fig. 3). None of the dimensions are critical. A bicycle axle assembly makes a sensitive ball-bearing hub. In welding the hub in position the wheel-spoke holes should be left

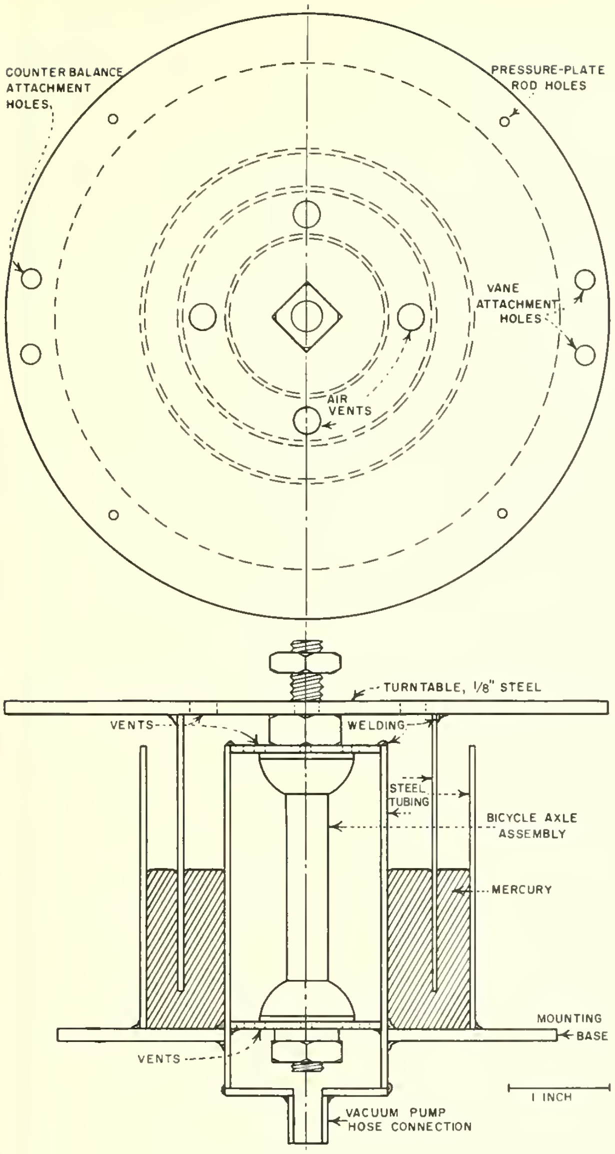

Figure 3.—*Turntable and well.*

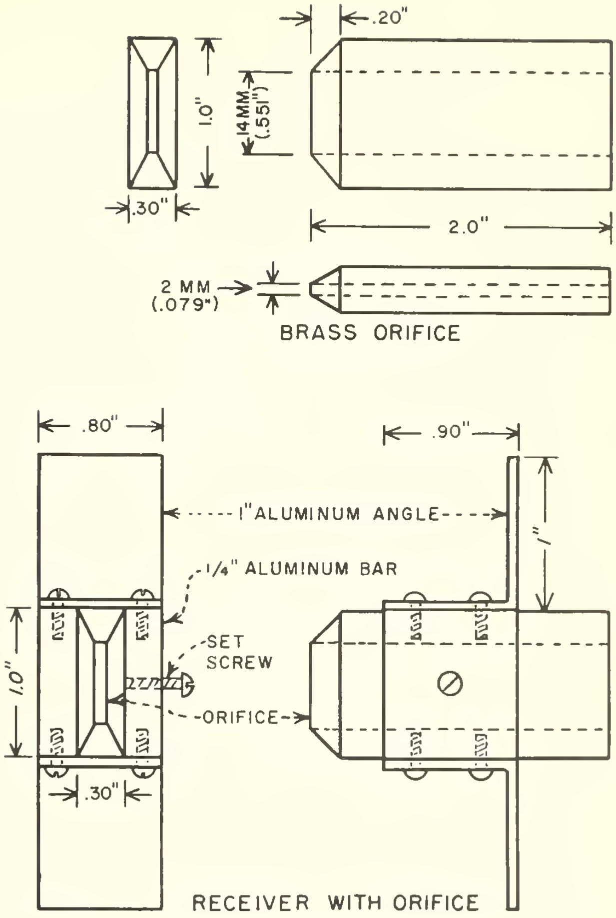

Figure 4.—*Orifice and receiver assembly.*

open for air vents. Welds should be of steel only because the air seal is mercury.

Orifice construction also is simple (fig. 4). The slit in the orifice should be smooth and polished, and the dimensions exact. The two brass plates that serve as sides are separated by two brass spacers 2 mm. thick. These parts are soldered to form an orifice with correct slit dimensions. Beveling the orifice mouth to a knife edge is desirable to reduce air turbulence. The orifice receiver is made of standard aluminum stock available in any hardware store. To keep rain off the orifice the pressure plate can be extended, or a small sheet metal canopy can be attached to the housing.

Rubber gaskets are needed to prevent air leaks. In addition, all rubber gaskets and metal-to-metal joints on the orifice receiver assembly should be treated with a sealing compound that is easy to apply and can withstand the temperature extremes expected.

Any electrically powered vacuum pump (AC or DC) rated for continuous operation and capable of moving 10 liters of air or more per minute will serve. An airflow meter should be temporarily interposed in the rubber line between the pollen sampler and the vacuum pump to regulate airflow to the proper rate. A safety bottle should be permanently installed in the line to prevent mercury overflow from entering the vacuum pump in the unlikely event that the orifice becomes obstructed.

A 0.02-inch-thick, water-clear, flexible cellulose acetate sheet works well as a pollen band. The band can be divided into convenient time intervals by scribing. It is best to place numbers that identify scribed sections outside the pollen trace area.

Silicone grease is recommended as an adhesive because it has high impaction efficiency, good optical qualities, and is water repellent. A thin, uniform coating can be applied in seconds with Dow Silicone 4X Spray or a comparable aerosol preparation. Bands can be used repeatedly by washing them with xylene to remove used silicone adhesive. An extension of plexiglass or similar material is required on the microscope stage to accommodate the 11.5-inch-long band during pollen counting.

Determining sampling efficiency is complicated and requires equipment beyond the reach of most researchers. Sampling efficiency varies with external wind velocity. Hirst tested his sampler in a wind tunnel with wind velocities of 5 to 20 miles per hour and an air intake by the sampler of 10 liters per minute. He found that the relationship of efficiency to wind velocity was curvilinear with the lowest efficiency rate (66 percent) at intermediate velocities. For practical purposes most experimenters settle upon a fixed efficiency factor. Using Hirst's data as a guide and making allowances for structural differences between the two samplers, the one described in this paper was assumed to have 50 percent efficiency. Assuming this, it is a simple matter to convert the pollen count for any band interval to number of pollen grains per cubic meter of air—the conventional expression of pollen load.

LITERATURE CITED

1. Boyer, W. D.
   1966. Longleaf pine pollen dispersal. Forest Sci. 12: (accepted for publication).

2. Gregory, P. H.
   1961. The microbiology of the atmosphere. Plant Sci. Monogr. 251 pp. New York: Interscience Publishers, Inc.

3. Hirst, J. M.
   1952. An automatic volumetric spore trap. Ann. Appl. Biol. 39: 257-265.

4. Pady, S. M.
   1959. A continuous spore sampler. Phytopathology 49: 757-760.

5. Sarvas, R.
   1952. On the flowering of birch and the quality of seed crop. Commun. Inst. Forest. Fenniae 40(7): 1-35.

6. ————
   1955. Investigations into the flowering and seed quality of forest trees. Commun. Inst. Forest. Fenniae 45(7): 1-35.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-36

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

EAST TEXAS' TIMBER HARVEST, 1964

Charles C. Van Sickle

SOUTHERN FOREST EXPERIMENT STATION

The 1964 timber harvest in east Texas totaled 264 million cubic feet. The timber provided the bulk of the raw material for more than 240 primary wood-using plants in the area. Logs and bolts were also shipped to about 30 plants outside the region. A canvass of all 270 plants, together with a survey of nonindustrial wood use, provided the data summarized in table 1.

Saw logs made up more than half of the 1964 output.—Nearly three-fourths of the saw logs were softwood, mostly pine with some cypress. Oak made up most of the hardwood; the remainder was largely gum.

Saw logs produced in 1964, nearly equal in total to those produced in 1954 when the last survey was made, went to fewer mills. East Texas had at least 177 active sawmills in 1964, of which 73 produced more than 3 million board feet apiece. About a third of all logs sawn in the region were cut at only six mills. Approximately one mill was active for every three that were operating a decade ago. East Texas has some of the largest sawmills in the South.

Mills sawing mostly pine are larger than those sawing mostly hardwood. In 1964, lumber production of an average pine mill was more than 8 million board feet while production of an average hardwood mill was less than 3 million. Two-thirds of the small sawmills cut primarily hardwoods. They frequently specialized in making crossties or pallet lumber from low-grade logs.

Use of sawmill residues for pulp chips rose sharply in the decade ending in 1964. In that year, 41 sawmills with chipping equipment supplied about one-fourth of the region's pulpwood requirements. Other sawmill byproducts included pine handle squares, charcoal, and fuel for industrial and domestic use.

Pulpwood production in east Texas reached an alltime high in 1964.—The harvest totaled 1.6 million cords, of which 446 thousand were chips derived largely from sawmill residues. Pulpwood bolts, mainly pine, accounted for a third of the 1964 roundwood output. As in much of the South, the use of hardwood rose steadily. In 1954, for example, hardwoods supplied 5 percent of the round pulpwood cut; in 1964, 25 percent. Pulping capacity of east Texas mills doubled during the decade, rising to almost 2,600 tons of pulp daily.

Pine poles, piling, and posts made up the third largest product group.—In 1964, 4 percent of the pine output was for these products. On a volume and value basis, poles were by far the most important item; 505 thousand trees were harvested for poles.

Pine posts provide a lively market for small trees. The 3.5 million commercial posts produced in 1964 were used primarily for fencing and highway guard rails.

Most of the piling, poles, and posts are pressure-treated with preservatives. The remainder of the posts and short construction poles are soaked in preservative not under pressure. A small number of pilings are used untreated in the coastal areas.

Veneer-log production was dominated by hardwoods.—Hardwood logs accounted for more than three-fourths of the 1964 production. They were about equally divided between the firm-textured species, such as oak, and the soft-textured species, such as sweetgum, blackgum, and cottonwood. Veneers were produced at 16 east Texas plants, 8 of which made container veneers. Container plants used one-third of the hardwood logs, almost entirely soft-textured species. The remainder went to plants manufacturing veneers used chiefly for furniture panels and flooring.

Pine veneer logs found new uses in making sheathing-grade pine plywood. Two plants, at Diboll and Silsbee, began limited production in 1964. Together, their capacity was reported to be 110 million square feet of 3/8-inch plywood. This is equivalent to almost 50 million board feet of logs (International 1/4-inch scale).

Domestic roundwood use by 1964 had dropped to about 8 million cubic feet.—Most of this wood was used for fuel; the total also includes noncommercial fenceposts. In 1954, when the previous estimate was made, the total domestic use was 13 million cubic feet. Not only had the number of homes using wood for heating and cooking declined, but there were indications that most of the fuelwood users had other sources of fuel. Two-thirds of those contacted had facilities for gas cooking, and more than half were equipped to heat with gas, usually propane or butane.

All other industrial products make up less than 1 percent of the roundwood output.—Among these are handle stock, cooperage, dimension stock, fence lath, and mine props.

Tables 2 through 7 constitute a 1964 directory of primary wood-using plants in east Texas. Plant locations are mapped in figure 1. While reasonable effort was made to locate all active plants, some may have been omitted. Omission of a firm is no reflection upon its activities, nor does inclusion constitute a recommendation.

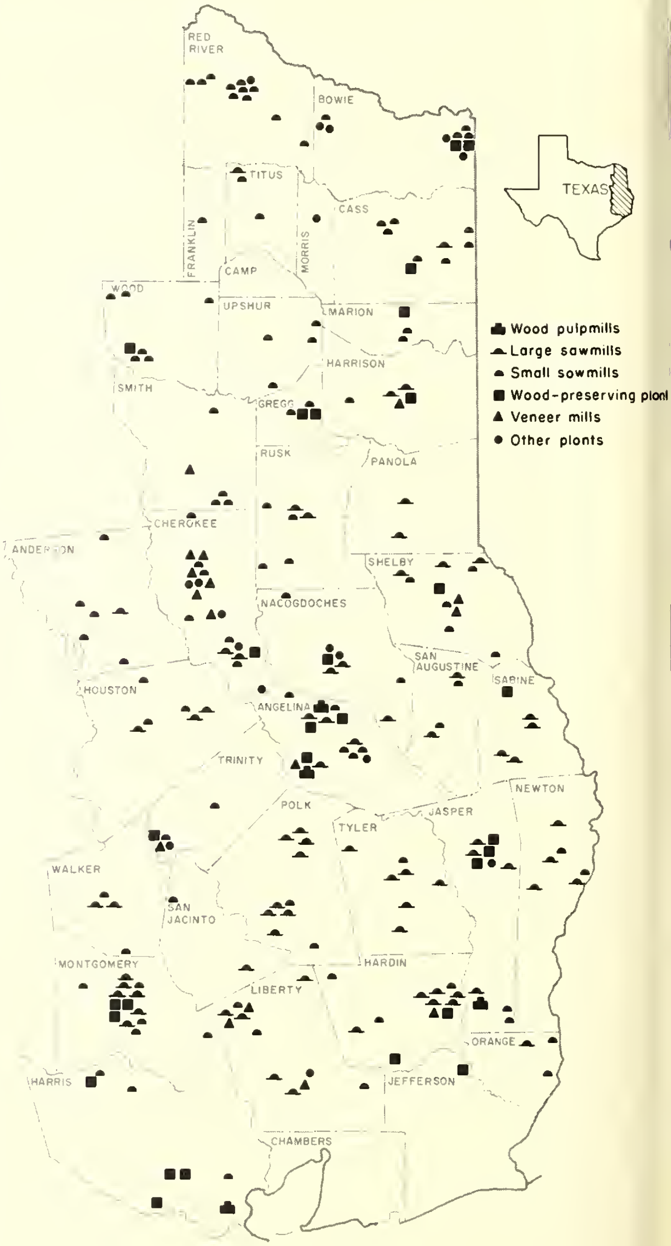

Figure 1.—*Location of primary wood-using plants in east Texas, 1964.*

Table 1.—*Output of roundwood by product*

Product	Standard units				Roundwood volume		
	Unit	All species	Softwood	Hardwood	All species	Softwood	Hardwood
					----- M Cubic feet -----		
Saw logs	M bd. ft.[1]	928,268	676,982	251,286	153,253	111,364	41,889
Veneer logs	M bd. ft.[1]	43,750	9,734	34,016	7,310	1,601	5,709
Pulpwood	Std. cords[2]	[3] 1,129,940	848,595	281,345	85,873	63,984	21,889
Piling	M linear ft.	766	766		633	633	
Poles	M pieces	505	505		5,504	5,504	
Posts	M pieces	4,501	3,695	806	2,195	1,679	516
Fuelwood	Std. cords[2]	[4] 103,426	12,191	91,235	7,762	919	6,843
Miscellaneous products[5]	M cu. ft.	[6] 1,505	859	646	1,505	859	646
All products					264,035	186,543	77,492

[1] International ¼-inch rule.
[2] Rough wood basis.
[3] Not including 33.7 million cubic feet of wood from mill residues used for pulp.
[4] Not including 15.6 million cubic feet of wood from mill residues used for domestic and industrial fuel.
[5] Includes cooperage, mine timbers, handle stock, chemical wood, and other miscellaneous industrial products.
[6] Not including 4.9 million cubic feet of wood from mill residues used for miscellaneous products.

Table 2.—*Wood pulpmills*

County	Firm	Location	Type[1]
Angelina	Southland Paper Mills, Inc.	Lufkin	S, G
	Temple Industries, Inc.	Diboll	S-C
Harris	Champion Papers, Inc.	Pasadena	S, G
Jasper	East Texas Pulp and Paper Co.	Evadale	S

[1] S indicates sulfate process.
S-C indicates semichemical process.
G indicates groundwood and other mechanical processes.

Table 3.—*Large sawmills*[1]

County	Firm	Location	Address[2]
Anderson	Ross Singletary	Neches	Rt. 1, Jacksonville
Angelina	Angelina County Lumber Co.[3]	Keltys	
	Lowrey Lumber Co., Inc.	Huntington	Drawer L
	Owens Lumber Co.	Lufkin	P. O. Box 998
	Temple Industries[3]	Diboll	
Cass	Atlanta Lumber Co.[3]	Atlanta	P. O. Box 91
Cherokee	Bauman Lumber Co.[3]	Alto	P. O. Box 38
	Grogan Lumber Co.	Alto	P. O. Box 475
Hardin	Allen-Peavy Lumber Co.[3]	Kountze	P. O. Box 0
	Batson Lumber Co.	Batson	P. O. Box 688
	W. B. Cariker Lumber Co.[3]	Kountze	P. O. Box 100
	Roy D. Duncan Tie Mill	Silsbee	P. O. Box 1145
	Kirby Lumber Corp.[3]	Silsbee	P. O. Box 53029, Houston
	Kountze Hardwood Lumber Co.[3]	Kountze	P. O. Box K
Harrison	Pyle Lumber Co.	Marshall	
	Snider Lumber Co.[3]	Marshall	P. O. Box Q
Houston	Houston County Lumber Co.	Kennard	P. O. Box 717
	Steed Brothers Lumber Co.	Kennard	P. O. Box 22
	Stowe Lumber Co.[3]	Crockett	P. O. Box 805
Jasper	Azar A. Bean Lumber Co.	Roganville	P. O. Box 181, Kirbyville
	Ealand-Wood Lumber Co., Inc.[3]	Jasper	P. O. Box 6021
	Hart Stud Mill[3]	Evadale	P. O. Box 300, Jasper
	Martindale Lumber Co.[3]	Jasper	150 S. Bowie St.
Liberty	Cedar Bayou Sawmill[3]	Dayton	P. O. Box 955
	Liberty Lumber Co., Ltd.[3]	Liberty	P. O. Box 409
	P and R Lumber Co., Inc.	Cleveland	P. O. Box 237
	P. A. Racki Lumber Co., Inc.[3]	Rye	
	Williams Lumber Co.[3]	Cleveland	P. O. Box 788
Montgomery	Brabham-Parker Lumber Co.	Willis	P. O. Box 406
	Emmick Lumber Co.	Willis	P. O. Box 215
	Grogan Brothers Lumber Co.[3]	Conroe	
	L and M Lumber Co., Inc.[3]	Willis	
	Vendors Lumber Co., Inc.	Willis	P. O. Box 156
	Roy L. Willis Lumber Co., Inc.[3]	Conroe	P. O. Box 746
Nacogdoches	Bobo Brothers Lumber Co.	Nacogdoches	P. O. Box 522
	Nacalina Lumber Co., Inc.	Etoile	P. O. Box 68
	Nacogdoches County Lumber Co.[3]	Nacogdoches	P. O. Box 667
Newton	C. P. Hughs Lumber Co.[3]	Bon Wier	P. O. Box 196
	Berton McDonald Lumber Co.	Bleakwood	Drawer J, Kirbyville
	Newton Lumber Co.[3]	Newton	P. O. Box 457
	Wiergate Lumber Co., Inc.[3]	Wiergate	P. O. Box 268

Table 3.—*Large sawmills*[1] (Continued)

County	Firm	Location	Address[2]
Orange	Texla Lumber Co.	Mauriceville	P. O. Box 128
Panola	K. L. Barton and Son	Gary	P. O. Box 306, Garrison
	Darnell Lumber Co.[3]	Carthage	P. O. Box 248
Polk	W. T. Carter and Brother[3]	Camden	
	E and L Lumber Co.	Corrigan	P. O. Box 402
	Goodrich Lumber Co.	Livingston	Rt. 4
	Fred Grimes	Goodrich	P. O. Box 144
	Leggett Lumber Co., Inc.	Livingston	P. O. Box 352
	Livingston Wood Products, Inc.[3]	Livingston	P. O. Box 312
	Parrish Tie and Lumber Co.	Corrigan	P. O. Box 174
	Southwest Forest Industries, Edens-Birch Wood Products Division[3]	Corrigan	P. O. Box 338
Rusk	Henderson Lumber Manufacturing Co.[3]	Henderson	
	McKnight Lumber Co.	Henderson	2505 Hwy. 79, South
Sabine	Chambers Sawmill Co., Inc.	Pineland	P. O. Box 67
	Chandler Brothers, Inc.	Hemphill	Rt. 1, Box 95
	Ealand-Wood Lumber Co., Inc.	Hemphill	P. O. Box 518
	Temple Industries[3]	Pineland	
San Augustine	W. M. Carrell	Broaddus	P. O. Box 98
	San Augustine Lumber Co.[3]	San Augustine	P. O. Box 536
San Jacinto	Ed Grimes Lumber Co.	Shepherd	P. O. Box 304 X
Shelby	Anderson Manufacturing Co.[3]	Tenaha	P. O. Box 368
	May Brothers, Inc.	Haslam	Rt. 1, Joaquin
	L. D. Tyer Lumber Co.	Timpson	P. O. Box 277
Titus	A. Brandt Co., Inc.—Branco Corp.	Talco	P. O. Box 391, Fort Worth
Tyler	Beech Creek Lumber Co., Inc.	Warren	P. O. Box 38
	Hillister Lumber Co.[3]	Hillister	
	L. H. Martindale Lumber Co.[3]	Town Bluff	P. O. Box 341, Jasper
	Stephens and Weatherford[3]	Woodville	P. O. Box 968
	J. L. Veal Lumber Co., Inc.	Chester	P. O. Box 8
	Woodville Lumber Co., Inc.	Woodville	P. O. Box 8
Walker	Boettcher Lumber Co., Inc.	Huntsville	P. O. Box 630
	Walker Brothers Lumber Co.[3]	Huntsville	P. O. Box 88

[1] Output of 3 million board feet or more.

[2] Specified only if different from plant location.

[3] Produces chips for sale to pulpmills.

Table 4.—*Small sawmills*

County	Firm	Location	Address [1]
Anderson	Herbert Dowling	Frankston	Rt. 1, Jacksonville
	Pete Gray	Elkhart	P. O. Box 365
	L. F. Nance	Palestine	Rt. 4, Box 91, Troup
	L. D. Pope	Long Lake	Jacksonville
	Texas Tie and Timber Co.	Palestine	c/o Ray Baley
Angelina	Allen Stud Mill, Division of Allen Associates	Pollok	P. O. Box 550, Lufkin
	O. D. Langford	Lufkin	
	Marvin Mattox	Huntington	
	Junior Richardson Sawmill	Huntington	Rt. 2
	E. W. Walker Sawmill	Huntington	Rt. 2
Bowie	Ouachita Lumber Co.	Nash	
	Cecil Phillips	Oak Grove	Rt. 4, De Kalb
	Charles Stewart Lumber Co.	Texarkana	
	Talbert Lumber Co.	Texarkana	824 Talbert St.
Cass	Burkhalter Mill Co.	Linden	Rt. 2
	F. O. Graves	Bloomburg	Rt. 2, Box 37, Atlanta
	L. E. Lofferd Lumber Co.	Marietta	
	Havard Lummus	Bloomburg	Rt. 2
	Carrol Pyle	Bloomburg	
	Joe T. Robinson	Marietta	
	A. C. Tenbrook	Marietta	
Cherokee	Andrews Lumber Co.	Jacksonville	P. O. Box 1152
	L. M. Bolton	Jacksonville	
	The Lindsey Lumber Co.	Alto	P. O. Box 96
	Maxwell Lumber Co.	Bullard	P. O. Box 1105, Jacksonville
	Jack Pryor	Maydelle	
	Wallace Lumber Co.	Alto	Rt. 3, Rusk
Franklin	McCoullers Sawmill	Mt. Vernon	Rt. 1, Talco
Gregg	Harrison Rd. Wood Products	Greggton	P. O. Box 5306, Longview
	Underwood Lumber Co.	Longview	751 Hwy. 259
Hardin	Coley Lumber Co.	Saratoga	P. O. Box 575, Livingston
	Jeff Davis Lumber Co.	Votaw	P. O. Box 215
	C. B. Harville Sawmill	Silsbee	Rt. 1, Box 9
Harris	Baird Lumber Co.	Houston	7101 John Ralston Rd.
	Kleb and Thiess Lumber Co.	Spring	Rt. 1
	Ed Oualline Lumber and Penta Co.	Hufsmith	P. O. Box 5
Harrison	E. R. Welch	Hallsville	Rt. 2
Houston	Harvey Ainsworth	Kennard	P. O. Box 32
	Noble Curry Sawmill	Crockett	Kennard
	C. H. Ingrahm Lumber Co.	Grapeland	

Table 4.—*Small sawmills* (Continued)

County	Firm	Location	Address [1]
Jasper	Alvin Smith	Buna	
	T. D. Smith	Buna	
Liberty	Le Mieux Lumber Co., Inc.	Devers	P. O. Box 306
	Kenneth Page	Cleveland	
	Rice Lumber Co.	Cleveland	P. O. Box 58
Marion	McDonald Lumber Mill	Jefferson	P. O. Box 104
	Mauldin Brothers Lumber Co.	Jefferson	Rt. 3
Montgomery	H. P. Coleman Lumber Co.	Splendora	P. O. Box 185
	A. H. Curry and Son Lumber Co.	Conroe	P. O. Box 1203
	Giles Brothers Lumber Co.	Montgomery	Rt. 2
	Howard Lumber Co.	Conroe	Rt. 3, Box 253
	Don W. Phillips Lumber Co.	Conroe	P. O. Box 678
Nacogdoches	James Cloyd Mill	Chireno	P. O. Box 72
	Cushing Lumber Co.	Cushing	P. O. Box 331
Newton	Delaney and Merritt	Bon Wier	P. O. Box 402, Newton
	McCorquodale Lumber Co.	Newton	P. O. Box 365
Orange	Andrews and Andrews Lumber Co.	Hartsburg	P. O. Box 85, Mauriceville
	Rogers and Son Lumber Co.	Orange	P. O. Box 1164
Polk	Choates Creek Lumber Co.	Livingston	P. O. Box 916
	Harrison Sawmill	Segno	Rt. 1, Leggett
Red River	E. L. Green	Clarksville	Rt. 6
	McCoin Brothers	Detroit	Rt. 2
	McKinney and Upchurch	Annona	
	Magnolia Handle Co.	Clarksville	P. O. Box 920
	Albert Raulston	Bagwell	
	Red River Lumber Co.	Bagwell	
	Southwestern Pallet Co. [2]	Clarksville	P. O. Box 830
	A. A. Walker Sawmill	Lydia	Rt. 4, De Kalb
Rusk	George Brown	Price	Rt. 6, Box 348, Henderson
	L. J. Hodge Lumber Co.	New Salem	Rt. 3, Henderson
	B. B. Pirtle	Laneville	P. O. Box 33
	W. D. Townly and Son Lumber Co.	Henderson	2100 Jacksonville Dr.
San Augustine	J. H. Busbee	Broaddus	P. O. Box 44
	Castle Lumber Co.	San Augustine	P. O. Box 459
San Jacinto	J. E. Street	Oakhurst	Rt. 1, Box 105, Coldsprings
Shelby	Chambers Sawmill Co., Inc.	Center	P. O. Box 67, Pineland
	Gee Lumber Co.	Center	
	Joaquin Tie and Lumber Co.	Joaquin	P. O. Box 65
	Price and Ross Lumber Co.	Timpson	Rt. 1
	Toledo Bend Lumber Co., Inc.	Patroon	P. O. Box 903, Center

Table 4.—*Small sawmills* (Continued)

County	Firm	Location	Address [1]
Smith	A. W. Bates Sawmill	Troup	Rt. 3
	John Cornelison	Troup	Rt. 1, Box 22
	J. S. Jackson Sawmill	Winona	Rt. 1
	Randall's Ties and Lumber	Troup	Rt. 1, Box 22
Titus	Cypress Lumber Co.	Mt. Pleasant	1401 Proctor
	John Stephens	Talco	Rt. 1, Bogata
Trinity	Groveton Manufacturing Co.	Groveton	P. O. Box 575
	Marsh Lumber Co.	Trinity	P. O. Box 4, Moscow
Tyler	F and H Lumber Co.	Colmesneil	P. O. Box 233
Upshur	Dean Lumber Co.	Gilmer	Rt. 4
	A. V. Haigwood	Gladewater	2615 Gay Ave.
	Newsom Sawmill	Ore City	P. O. Box 37
	O. H. Smith Lumber Co.	Diana	Rt. 5, Gilmer
Walker	Archie Brown Lumber Co.	New Waverly	P. O. Box 117
	A. A. Steely Sawmill	Huntsville	Rt. 4, Box 145
Wood	Bowden Lumber Co.	Mineola	P. O. Box 293
	McIntosh Brothers	Yantis	Rt. 1, Quitman
	C. T. McIntosh Hardwood Lumber	Mineola	1621 N. Pacific
	Durwood Minick	Perryville	Rt. 2, Winnsboro
	Oscar Parmenter	Yantis	Rt. 1
	Earl Taylor Lumber Co.	Mineola	P. O. Box 481

[1] Specified only if different from plant location.

[2] Operates four small sawmills.

Table 5.—*Wood Preserving plants* [1]

County	Firm	Address	Type [2]
Angelina	Higgins Creosoting, Inc.	Box 1388, Lufkin	P
	Lufkin Creosoting Co.	Box 1207, Lufkin	P
	Temple Industries	Diboll	P
Bowie	International Creosoting & Construction Co. [3]	Box 688, Galveston	P
	Texarkana Wood Preserving Co.	Box 156, Texarkana	P
Cass	Cass County Treating Co.	Drawer C, Linden	P
Cherokee	Iley and Linsey	Alto	N
Gregg	Garland Creosoting Co.	Box 589, Longview	P
	Longview Creosoting Co.	Box 2202, Longview	P
Hardin	Mack's Post, Pole, & Lumber Yard	Rt. 1, Box 960, Silsbee	P
	Toups Post Yard	Sour Lake	P
Harris	Houston Chemical Service	Rt. 3, Box 451, Houston	P
	Koppers Co., Inc.	Box 16188, Houston	P
	Ed Oualline Lumber and Penta Co.	Box 5, Hufsmith	P
	Southern Pacific Railroad	Box 1319, Houston	P
Harrison	Marshall Wood Preserving Co.	Box 846, Marshall	P
Jasper	Hart Creosoting Co.	Box 300, Jasper	P
	Jasper Creosoting Co.	Box 6021, Jasper	P
	Texas Electric Cooperatives, Inc.	Box 510, Jasper	P
Jefferson	International Creosoting & Construction Co. [3]	Box 688, Galveston	P
Marion	Texas Wood Preserving Co.	Box 550, Jefferson	P
Montgomery	Conroe Creosoting Co.	Box 109, Conroe	P
	Grogan Brothers Lumber Co.	Conroe	P
	United Creosoting Co.	Conroe	P
Nacogdoches	East Texas Wood Treating Co.	Box 972, Nacogdoches	N
Sabine	Counts Post Yard	Geneva	N
Shelby	Shelby Wood Treating Co.	Box 188, Tenaha	N
Trinity	McCarley's Post Treating	Box 345, Trinity	N
Wood	Texas Creosoting Pole and Post Co.	Star Route, Mineola	P

[1] Only plants treating roundwood are listed.
[2] P indicates pressure treating.
N indicates nonpressure treating.
[3] Plants located at Texarkana and Beaumont.

Table 6. *Veneer plants*

County	Type [1]	Firm	Location	Address [2]
Angelina	O	Temple Industries [3]	Diboll	
Cherokee	C	Aber Box and Basket Factory	Jacksonville	P. O. Box 1270
	O	Halbert Mill Co.	Dialville	
	C	Newton-Shank Manufacturing Co.	Jacksonville	P. O. Box 1110
	C	Peacock Crate Factory	Jacksonville	1529½ S. Jackson St.
	C	F. A. Shinalt and Sons	Turney	Rt. 1, Jacksonville
	C	Bruce Slover Crate and Lumber Mill Co., Inc.	Rusk	P. O. Box 6
Hardin	O	Kirby Lumber Corp. [3]	Silsbee	P. O. Box 53029, Houston
Harrison	C	Key Brothers Manufacturing Co.	Marshall	P. O. Box 1177
Liberty	O	E. L. Bruce Co. of Texas	Cleveland	P. O. Box 505
	O	Liberty Veneer and Panel Co.	Liberty	P. O. Box 231
	O	Walker Veneer and Plywood Co.	Cleveland	P. O. Box 425
Shelby	O	E. L. Bruce Co. of Texas [3]	Center	
	O	Center Veneers, Inc.	Center	P. O. Box 511
Smith	C	B. C. Slover Crate Factory	Gresham	Rt. 8, Tyler
Trinity	C	American Box Co.	Trinity	P. O. Box 591

[1] C indicates plants producing chiefly container veneer.
O indicates plants producing chiefly commercial and other veneers.

[2] Specified only if different from plant location.

[3] Produces chips for sale to pulpmills.

Table 7.—*Miscellaneous plants*

County	Firm	Location	Address[1]
Angelina	C. T. Sigmon Hickory Mill[2]	Huntington	P. O. Box 329
Bowie	Beavers and Beavers[3]	Oak Grove	P. O. Box 449, De Kalb
	Larkotex Co.[4]	Texarkana	1002 Olive Street
	K. C. Tutt[2]	De Kalb	
	Walmead Industries, Inc.[4]	Texarkana	P. O. Box 852
Cherokee	The A. C. Miller Co.[2]	Jacksonville	P. O. Box 1232
	Lone Star Charko[5]	Wells	P. O. Box 1551
	Norris Fence Co.[6]	Alto	P. O. Box 416, Lufkin
	Peacock Crate Factory[7]	Jacksonville	1529½ S. Jackson St.
	Bruce Slover Box and Crate Mill, Inc.[7]	Rusk	P. O. Box 6
Jasper	Ramoneda Brothers[3]	Jasper	2509 Rousseau St., New Orleans, La.
Liberty	H and L Hardwood Mill[2]	Hardin	P. O. Box 106, Liberty
Morris	T.C. Collins Dimension Mill[4]	Omaha	P. O. Box 673
Nacogdoches	Lacy H. Hunt Lumber Co., Inc.[8]	Nacogdoches	P. O. Box 1331
	Old Smokey Hickory Chips	Nacogdoches	P. O. Box 972
Red River	Texas Fence Co.[6]	Clarksville	P. O. Box 724
Trinity	Earl C. Reed Mill[7]	Trinity	P. O. Box 107

[1] Specified only if different from plant location.
[2] Handle stock mill.
[3] Cooperage mill.
[4] Miscellaneous dimension mill.
[5] Charcoal producer.
[6] Fence lath producer.
[7] Basket bottoms.
[8] Produces mine props. Yards are located at Appleby, Garrison, Nacogdoches, and Troup.

SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

1966

SO-37

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

PERIODIC CUBIC GROWTH IN NATURAL LOBLOLLY STANDS NEAR CROSSETT, ARKANSAS

John R. Bassett
SOUTHERN FOREST EXPERIMENT STATION

The Southern Forest Experiment Station is studying the effects of stand density, site quality, and method of thinning upon the growth of even-aged natural stands of loblolly pine *(Pinus taeda* L.) in southeastern Arkansas and northeastern Louisiana. This note reports annual cubic-foot growth for the 5 years from 1959-64 and compares it with growth of similar stands elsewhere.

METHODS

In the winter of 1949-50, 27 circular 0.1-acre plots surrounded by 0.5-chain isolation strips were established in each of two areas near Crossett, Arkansas. One area is 8 miles east of Crossett in Arkansas, and the other is 25 miles southwest of Crossett in Louisiana.[1] In 1949, stands were 20 years old and from 70 to 130 percent stocked *(11)*.

Soils on the Arkansas plots are predominantly Grenada and Calloway silt loams underlain by a fragipan at a depth of 18 to 25 inches. Grenada is moderately well drained; Calloway is somewhat poorly drained. Site index averaged 92 feet (range 86-98) when estimated in 1964 from Zahner's curves *(12)*. On Louisiana plots, soils are Stough and Myatt silt loams underlain by a weak fragipan or silty clay loam layer at a depth of 23 to 26 inches. Stough is somewhat poorly drained, and Myatt is poorly drained. Site index averaged 74 feet (range 68-84).

In 1949, nine treatments were randomly replicated three times in each area. Eight consisted of thinning from above or below to four basal areas: 70, 85, 100, and 70-100 square feet per acre. In the last-mentioned treatment, the prescription was to thin to 70 square feet initially, but increase density in subsequent thinnings by 5 square feet until 100 square feet is reached at age 50. In the ninth treatment, plots were thinned according to the directions of a group of visiting foresters; basal areas were not specified.

To extend the range of densities studied, nine additional plots were established in the winter of 1954-55 in Arkansas. Plots, replicated three times, were thinned from below to 55, 115, and 130 square feet of basal area per acre.

[1] The Crossett Division of the Georgia-Pacific Corporation makes these areas available and helps to inventory the plots.

In 1959, according to plan, plots on which the basal area is specified were all thinned from below. In future thinnings this procedure will be repeated to avoid removing trees that were previously favored.

Merchantable (3.6 inches d.b.h. and larger) hardwoods were removed in the first thinning; hardwoods 1.0 inch and larger at the root collar were poisoned in 1959.

In 1949 submerchantable hardwoods and pines were not tallied; hence plots with such trees contained more growing stock than was prescribed. Submerchantable trees were tallied in 1954 but only merchantable ones were removed in thinning. As a result, although basal areas were as prescribed, stocking on some plots did not consist wholly of merchantable trees. In 1959 all submerchantable pines were removed. Because thinnings before 1959 were not uniform, and because of the shock likely in initial thinning, the present analysis is confined to 1959-64.

Pine stems were tallied to the nearest 0.1 inch d.b.h. Height was measured with an altimeter to a point on the bole estimated to be 3.0 inches in diameter (i.b.). Form class was estimated in 1959 but measured on large trees in 1954 and on most trees in 1964. Merchantable cubic-volume in individual trees was computed from Mesavage's tables *(7)*.

The relation of growth to site and density was analyzed with the model:

$$G = b_0 + b_1(S) + b_2(S^2) + b_3(D) + b_4(D^2) + b_5(SD)$$

where

G = periodic 5-year net annual merchantable growth of all trees in cubic feet per acre

S = site index of stand at base age 50 years

D = 1959 density

b (with subscripts) = coefficients derived from the data

Similar models have been used by others *(3, 5, 6, 8, 9)*. Data were processed with a program that computes a sequence of multiple linear regressions in a step-wise manner.

RESULTS AND DISCUSSION

The method of thinning (from above or below) did not affect cubic-foot growth significantly (0.05 level). Maximum volume was produced at densities of about 115 square feet of basal area per acre, which is about 70 percent of full stocking *(11)* (figs. 1 and 2). However, plots with 90 to 130 square feet of basal area—55 to 80 percent stocked—produced within 10 cubic feet of the maximum.

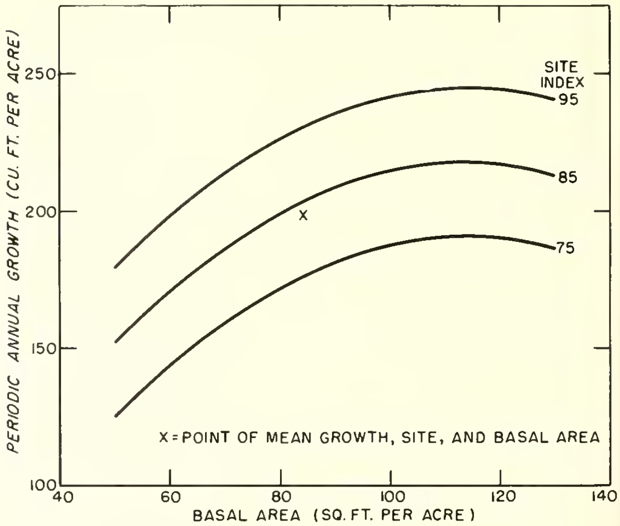

Figure 1.—*Relation of periodic growth to site and basal area at age 30.*

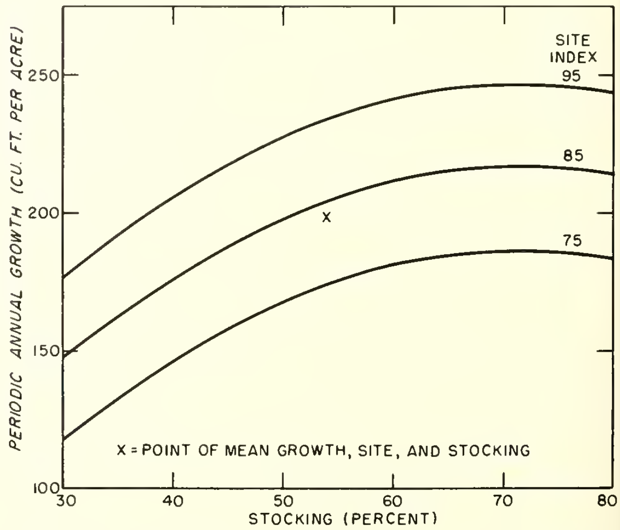

Figure 2.—*Relation of periodic growth to site and stocking at age 30.*

The relation of annual merchantable cubic-foot growth per acre (G) to site index (S) and basal area after thinning at age 30 (B) was:

(1) $G = -220.3 + 2.70(S) + 3.67(B) - 0.016(B^2)$

When percent of full stocking after thinning (P) was the expression of stand density, the relation was:

(2) $G = -240.7 + 3.00(S) + 5.56(P) - 0.038(P^2)$

Each equation is significant (0.01 level), accounts for 88 percent of the variation in growth, and has a standard error of 11 cubic feet.

Site and density individually influenced growth but, in contrast with other findings *(5, 6, 10)*, their interaction was negligible. Perhaps the ranges of site and density were too narrow to detect an interaction.

A study similar to but broader in scope than this one is being conducted in South Carolina, Georgia, and Virginia *(10)*. Both studies indicate that near-maximum volume can be produced over a wide range of densities. However, on good sites, growth near Crossett culminated at lower densities than in the Southeast. On site 95, maximum annual growth of trees 30 to 35 years old was similar in both regions—245 versus 242 cubic feet; on site 75, the maximum was higher at Crossett—191 versus 135 cubic feet (fig. 3).

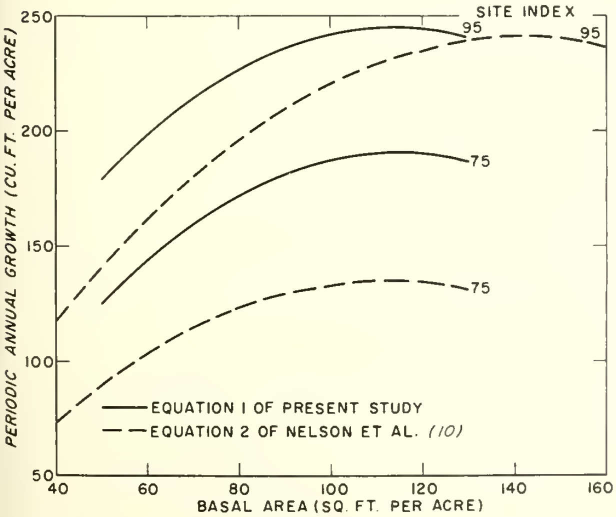

Figure 3.—*Comparison of periodic growth near Crossett and in the Southeast.*

There are several reasons why the growth curves from the regions do not coincide. First, availability of soil moisture, which strongly affects growth *(1, 2)*, can differ greatly between regions. Second, volume tables and merchantability limits differed between studies. Third, sites may not have been comparable because site-index estimates were not made at the same stand age in both studies. Although different site curves were used, they nearly coincide for the ages and sites compared *(4, 12)*. However, stands equally tall at age 50 need not be the same height at any other age, and even when they are, they may not be equally productive.

LITERATURE CITED

1. Bassett, J. R.
   1964. Diameter growth of loblolly pine trees as affected by soil-moisture availability. U. S. Forest Serv. Res. Pap. SO-9, 7 pp., illus. Southern Forest Exp. Sta., New Orleans, Louisiana.

2. ——————
   1964. Tree growth as affected by soil moisture availability. Soil Sci. Soc. Amer. Proc. 28: 436-438, illus.

3. Brender, E. V.
   1960. Growth predictions for natural stands of loblolly pine in the lower Piedmont. Georgia Forest Res. Counc. Rep. 6, 7 pp., illus.

4. Coile, T. S.
   1952. Soil productivity for southern pines. Part I. Shortleaf and loblolly pines. Forest Farmer 11(7): 10-11, 13, illus.

5. Gruschow, G. F., and Evans, T. C.
   1959. The relation of cubic-foot volume growth to stand density in young slash pine stands. Forest Sci. 5: 49-55, illus.

6. McClay, T. A.
   1955. The relation of growth to site and residual density in loblolly pine pulpwood stands. U. S. Forest Serv. Southeastern Forest Exp. Sta. Res. Notes 78, 2 pp., illus.

7. Mesavage, Clement.
   1947. Tables for estimating cubic-foot volume of timber. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 111, 71 pp.

8. Nelson, T. C.
1964. Diameter distribution and growth of loblolly pine. Forest Sci. 10: 105-114, illus.

9. ———— and Brender, E. V.
1963. Comparison of stand density measures for loblolly pine cubic-foot growth prediction. Forest Sci. 9: 8-14, illus.

10. ———— Lotti, T., Brender, E. V., and Trousdell, K. B.
1961. Merchantable cubic-foot volume growth in natural loblolly pine stands. U. S. Forest Serv. Southeastern Forest Exp. Sta., Sta. Pap. 127, 12 pp., illus.

11. Stahelin, R.
1949. Thinning even-aged loblolly and slash pine stands to specified densities. J. Forest. 47: 538-540, illus.

12. Zahner, Robert.
1962. Loblolly pine site curves by soil groups. Forest Sci. 8: 104-110, illus.

SOUTHERN FOREST EXPERIMENT STATION

1966

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SO-38

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

CONTROLLING TEXAS LEAF-CUTTING ANTS WITH MIREX

Hamp W. Echols and Robert C. Biesterfeldt
SOUTHERN FOREST EXPERIMENT STATION

Colonies of Texas leaf-cutting ants, *Atta texana* (Buckley), can be destroyed with a pelleted bait containing the insecticide mirex. U. S. Forest Service research at Alexandria, Louisiana,[1] reveals that treatment with mirex is surer, safer, and more convenient than fumigation, the only other control known.

Texas leaf-cutting ants, known locally as town ants, are a serious problem on sandy sites in central Louisiana and east Texas. They damage young trees, gardens, and crops by cutting off leaves, buds, and bark, which they carry to underground gardens for the culture of a fungus.

Until recently, entomologists believed that town ants fed solely on this cultivated fungus, and, hence, that they would not eat bait. A small cylindrical pellet containing 8.5 percent soybean oil and 0.45 percent mirex, with citrus pulp as a carrier, proved them wrong (fig. 1). Soybean oil attracts the ants; they carry the pellets underground and eat the oil.

Mirex is dissolved in the oil. It is slow acting: toxic symptoms do not appear for 3 to 5 days. Lethal doses are transferred from ants that have fed on the pellets to others by regurgitation. After 10 to 14 days, foraging and nest building cease. All ants in the colony die in about 10 weeks.

For about 25 years, the standard treatment has been fumigation of nests with either methyl bromide or carbon disulfide during cold weather when all ants are inside. The chemicals must be placed in central nest tunnels at least 2 feet underground, and, because they are volatile liquids, they must be handled very carefully. In addition, it has been standard practice to treat with at least 1 pound of chemical, regardless of the size of nest. Even when conditions appear perfect, however, failures are frequent.

With adequate quantities of mirex bait, on the other hand, 100-percent kill is assured. Tests show that the minimum effective dosage for a nest is about 1 gram of pellets for each mound in the central nest area. This means that approximately ¼ pound—1 measuring cupful—will treat the average nest of 50 to 100 mounds. A handful will suffice for colonies with less than 50 mounds.

[1] The research was done with the cooperation of the Allied Chemical Corporation.

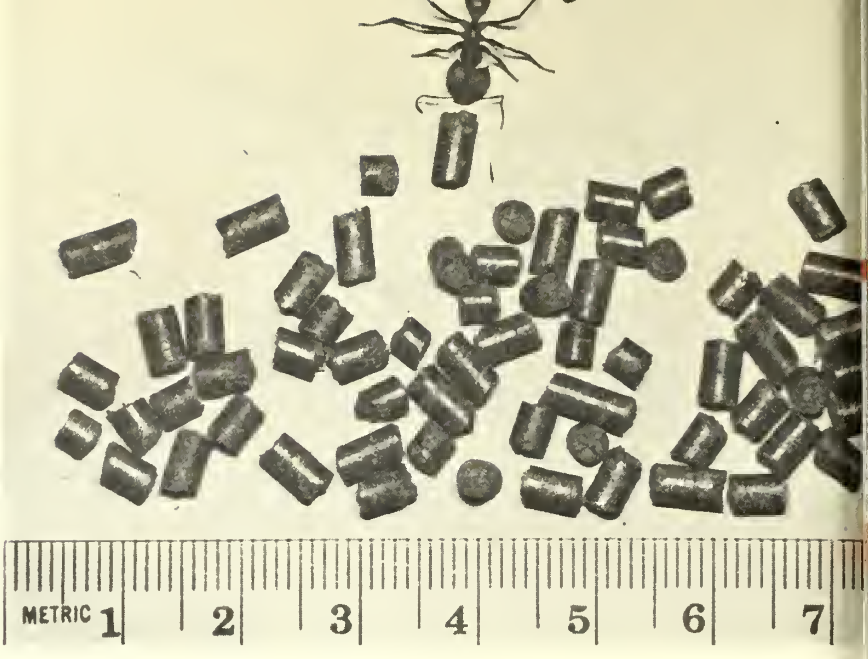

Figure 1.—*Pellets attract foraging workers.*

Pellets should be scattered over the central nest area (fig. 2) plus a 20-foot buffer zone surrounding it. Simple hand broadcasting is adequate because no special placement is required.

Aerial application is feasible where nests are numerous enough to justify the expense. Two pounds of bait per acre, uniformly broadcast, are sufficient, regardless of the number or size of colonies.

Pellets lose effectiveness if applied before, during, or shortly after a rain. They should be scattered when there is a forecast of no rain during the next 24 hours. Town ants do not forage during extended periods of freezing weather, but nests can be treated at any other time of year. Occasionally, a colony that has been treated becomes active again. In such cases, the nest has probably been occupied by ants from neighboring colonies.

Mirex bait is safer to handle than a fumigant. Rubber gloves should be worn, and pellets should be kept out of reach of children and animals, but no other special safety precautions are needed. The Wildlife Research Unit of Louisiana State University has found that the bait is not hazardous to wildlife when used as recommended.

Pellets should be stored in a cool dry place. They should not be stored near other chemicals or oils, because even a small amount of contamination will make them unattractive to ants.

In areas where Texas leaf-cutting ants are a problem, bait can be obtained in local seed stores. It is marketed under the name Mirex Pelleted Bait "450" R.

Figure 2.—*Central area of a nest.*

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-39

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

CLEARWING BORER IN RED OAKS

J. D. Solomon and R. C. Morris[1]

SOUTHERN FOREST EXPERIMENT STATION

A little known borer in red oak is the Aegeriid, *Paranthrene palmii* (Hy. Edwards).[2] Typically it bores into the bases of trees below their merchantable portions, especially between root flanges (fig. 1). The galleries may encourage growth of rot- and stain-producing fungi that degrade the butt log.

The observations reported here of this borer's biology in Mississippi were made in the summers of 1963 and 1965 in the Delta Experimental Forest at Stoneville and the Bluff Experimental Forest near Vicksburg.

The colorful orange and black adult (fig. 2) is a clearwing moth resembling the queen yellowjacket. The female has a heavy body, simple antennae, and a wing expanse of about 1½ inches. The male differs from the female only in its smaller size, lighter body, and bipectinate antennae. The pupa is brown and has maxillary palpi. The abdominal segments have two rows of spines, and the cremaster is indicated only by a tuft of spines. The larva (fig. 3) is mostly pale purplish brown with a black head and yellowish brown thoracic shield. The eggs are light brown, measuring about 1 by 0.5 mm., and with very finely reticulated surfaces. They

Figure 1.—*Borer attack at base of Nuttall oak. Note the pile of frass below the entrance hole, which has been ringed in white for photographing.*

[1] The authors are stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] The adults were identified by W. D. Duckworth of the U. S. National Museum, Washington, D. C.

Figure 2.—*Adult female moth of* Paranthrene palmii.

Figure 3.—*Fully developed larva, 1 inch long, taken from a gallery.*

are probably laid in bark crevices at the base of the tree.

Trees over 12 inches d.b.h. are most heavily infested. Two to five active attacks on a tree are common, but as many as 20 have been found. In Mississippi, no attacks have been found in trees smaller than 6 inches, but the insect's habits may vary with location. For instance, Engelhardt (1946)[3] states that in New York injury is most serious on small trees, saplings, and branches.

On the alluvial soils of Mississippi, *P. palmii* shows a marked preference for certain species within the red oak group. It was not observed in any of the white oaks. It was found most commonly in Nuttall oak (*Quercus nuttallii* Palmer) and cherrybark oak (*Q. falcata* var. *pagodaefolia* Ell.), and less frequently in Shumard oak (*Q. shumardii* Buckl.) and black oak (*Q. velutina* Lam.). It was not found in willow oak (*Q. phellos* L.), water oak (*Q. nigra* L.), or southern red oak (*Q. falcata* Michx. var. *falcata*), even though these species occurred in mixture with oaks that had been attacked. The scanty literature indicates that the hosts vary with location. For instance, in New York Forbes[4] reports *P. palmii* in the red oaks. But Engelhardt[3] states that on Long Island, New York, *P. palmii* infests trees of the white oak group, while a closely related species, *P. simulans*, is found in the red oaks.

P. palmii is known from New York southward to Florida and the Gulf Coast, and westward to Mississippi (Forbes,[4] Engelhardt[3]). Engelhardt states that it is mostly a southern species and that the closely related *P. simulans* is a more northern species, although their ranges overlap.

For the study reported here, over 50 adult clearwing moths were snared in 1963 and 1965 between June 16 and July 7 by placing screen cages over the grubs' entrance holes on infested trees. Screen traps baited with virgin females failed to capture any males. On one occasion males were observed hovering cautiously near a caged female, but they flew away when approached by observers. Captured adult moths lived 3 to 8 days, averaging about 6 days.

Although male and female pairs were caged together, only one mated successfully. This pair had been placed in a small-screen sleeve cage on an oak branch about 6 feet above the ground. Mating began in late afternoon on the same day as emergence and continued for 2½ hours. The female laid 459 eggs in 5 days. Eggs incubated for 15 to 18 days, and 95 percent hatched.

The life cycle of *P. palmii* is 2 years. In Mississippi, heavy emergences occurred in 1963 and 1965 and a very light brood emerged in 1964 and 1966. The phenomenon of light brood emergences in even-numbered years was also observed by Forbes,[4] who stated that *P. palmii* moths fly during odd-numbered years in New York.

[3] Engelhardt, G. P. The North American clear-wing moths of the family Aegeriidae. U. S. Nat. Mus. Bull. 190, p. 222. 1946.
[4] Forbes, W. T. M. Lepidoptera of New York and neighboring states. Cornell Univ. Agr. Exp. Sta. Mem. 68, pp. 516-520. 1923.

Galleries made by this borer (fig. 4) are relatively uniform in size and shape. Entrance holes in the bark are 3/8 to 5/8 inch in diameter. Just beneath the surface there is typically an ovoid enlargement which the larva makes by chewing away the inner bark and wood. Most galleries slope upward into the wood for 1½ to 1¾ inches, then turn straight upward for another 2 to 2½ inches. Galleries range in length from 3½ to 4 inches and in diameter up to 3/8 inch. They are shaped much like those made by the carpenterworm but are much narrower and shorter.

Although most of the attacks are in the base of the tree below its merchantable portion, vacated galleries are frequently widened and lengthened by the carpenterworn, a more destructive borer. Fungi then have opportunity to extend farther upward.

Woodpeckers are important natural control agents of *P. palmii*. Predations by woodpeckers were observed most commonly during January and February. One large tree was found from which woodpeckers had recently removed seven grubs.

Figure 4.—*Gallery made by the larva.*

SOUTHERN FOREST EXPERIMENT STATION

Forest Service, U. S. Dept. of Agriculture

U.S. FOREST SERVICE RESEARCH NOTE

1966

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PROPERTIES OF FORESTED LOESS SOILS AFTER REPEATED PRESCRIBED BURNS

D. M. Moehring, C. X Grano, and J. R. Bassett

SOUTHERN FOREST EXPERIMENT STATION

Nine annual burns have had little effect on the nutrient content and structure of the surface 4 inches of loess soils on flat terrain.

Because prescribed burns must often be repeated to obtain desired results, many foresters are apprehensive about the possible deleterious effects on soils. In 1954 the Timber Management Laboratory at Crossett, Arkansas, in cooperation with the Crossett Division of Georgia-Pacific Corporation, undertook a study of repeated burns in shortleaf-loblolly pine stands. The primary objective was to compare the efficacy of annual and biennial burns in eradicating small understory hardwoods. This note reports effects of the fires on the nutrient content and physical structure of the surface 4 inches of soil as measured after 10 years.

Figure 1.—*High pine overstory and dense hardwood ground cover originally occupied the study area.*

METHODS

The test was made in an even-aged shortleaf-loblolly pine stand on Grenada and Calloway silt loams. These are imperfectly drained loess soils underlain by a fragipan at a depth of 18 to 24 inches. A 2 percent north-to-south slope provides good surface drainage. At the beginning of the study (fig. 1) the overstory consisted of pine averaging 64 square feet of basal area per acre and 15 inches d.b.h., and 17 square feet of oaks and gum averaging 8 inches d.b.h. The site was also occupied by a very dense understory consisting of 10,000 small hardwood stems per acre. The understory trees averaged 1.6 inches in diameter measured 6 inches above ground. They were predominantly southern red oak, sweetgum, and blackgum.

The effectiveness of annual and biennial fires in eradicating the small hardwoods was tested on eight 0.1-acre plots—four for each treatment. Although not required in the original study, unburned check plots were needed to evaluate the effects of the fires on the soil. Therefore, in the autumn of 1964 four 0.1-acre check plots were established in the unburned strip surrounding the burned area. Differences in soil properties between the burned and check plots were tested in a completely randomized design: the hypothesis was that the soil properties measured did not differ significantly among plots. This evaluation assumed that soil properties on all plots were similar in 1954 (as the vegetative cover was known to be), and that soil differences in 1964, if any, were attributable to burning.

Treatments.—One set of four plots was first burned in the winter of 1954-55 and then reburned in the summer of 1956 and each summer thereafter except during 1958. A second set of four plots was first burned in the winter of 1954-55 and reburned in the summer of 1957 and at 2-year intervals thereafter.

To determine the amount of fuel, litter was sampled prior to each burn at four fixed points adjacent to each plot. Fire severity was classified visually into three broad categories:

(1) *Light*: fire sluggish and discontinuous, leaving unburned patches. Surface litter consumed but lower layers largely intact. Leaves of hardwood understory scorched and base of stems lightly charred.

(2) *Medium*: momentum of fire well sustained, resulting in a clean, even burn of litter over the entire area. Some green hardwood leaves consumed and the remainder completely scorched. Decided charring of hardwood stems.

(3) *Intense*: clean, hot burn over the entire area. Litter, including lower layer, completely consumed. The leaves and the stem and branch ends of most small hardwoods ignited. Small hardwood stems deeply charred or destroyed.

Soil sampling and analysis.—Soil samples were collected in the autumn of 1964 before leaves fell. Near the four corners of each plot, one 70-cc. and two 250-cc. undisturbed cores were removed from each of two depths (0- to 2-inch and 2- to 4-inch) to determine soil porosity *(3)* and bulk density, respectively. Total pore space (P), in percent, was calculated as

$$P = 100 - \frac{(100)(\text{Bulk density})}{2.65}$$

Chemical properties were determined on duplicate composite samples taken along transects across each plot. Prior to analysis, each sample was air dried, thoroughly mixed, and ground to pass through a 2-mm. sieve. Samples were analyzed for pH (calomel-glass electrode, soil-water ratio of 1:1), organic matter content (wet combustion), total nitrogen (Kjeldahl), phosphorus (Bray and Kurtz No. 2), and exchangeable cations (neutral, 1.0 *N* ammonium acetate extract). Detailed analytical procedures are outlined in Jackson *(2)*.

RESULTS AND DISCUSSION

Effects on physical properties.—Bulk density and pore space are indexes to compaction, penetrability, aeration, infiltration, and percolation—properties important to soil stability and the growth of plants. In medium-textured soils such as loess, bulk density ranges from less than 1.0 for porous soils to about 1.6 for compact ones. An increase in bulk density tends to curtail root penetration, reduce aeration, and decrease rates of infiltration and percolation.

Pores may be divided into two types—large and small. Large pores detain water for 1 or 2 days and then permit ready movement of air. In contrast, small pores retain water for long periods and impede airflow. For purposes of this report, large-pore space is equivalent to the volume of water extractable from a soil in the range between saturation and 0.06 atmosphere (atm.) tension.

On both burned and check plots the bulk density of the 0- to 2-inch depth was less, and the total pore space was greater, than in the 2- to 4-inch depth (table 1). The difference may be attributable to the higher organic matter content in the surface layer (table 2), which increases soil aggregation and thus reduces bulk density.

Bulk density and small-pore space did not vary by treatment, but in the 0- to 2-inch layer large-pore space was significantly less (0.01

level) on the annually burned than on the check plots. On the burned plots some soil aggregates probably crumbled and plugged large pores. In these flatwoods such plugging has small effect on the soil water regime; on steep terrain, infiltration and runoff might be adversely affected.

Table 1.—*Bulk density and pore space related to fire treatments*

Burning treatment	Bulk density	Pore space	
		Large pores	Small pores
	G. per cc.	*– Percent –*	
		0- to 2-inch depth	
Annual	1.18	5.9	49.6
Biennial	1.19	7.3	47.8
None (check)	1.12	8.5	49.2
		2- to 4-inch depth	
Annual	1.34	5.8	43.6
Biennial	1.35	4.6	44.5
None (check)	1.34	4.5	44.9

Table 2.—*Amount of organic matter present in autumn of 1964*

Burning treatment	0- to 2-inch depth		2- to 4-inch depth	
	Percent dry weight	*Pounds per acre*	*Percent dry weight*	*Pounds per acre*
Annual	4.5	24,100	2.0	12,100
Biennial	4.7	25,300	1.9	11,600
None (check)	5.2	26,400	2.1	12,700

These results generally agree with those of metz *et al. (4)*, who studied the effects of burning in pine flatwoods in South Carolina on very fine sandy loam soils with poor surface drainage and very slow permeability. They found that various burning treatments neither benefited nor adversely affected bulk density, pore space, or percolation rate.

Effects on soil nutrients and organic matter content.—Prior to the 1954 burn, the accumulated pine and hardwood litter averaged 11,300 pounds per acre. After 1959 the litter originated almost entirely from the overstory, and tended to stabilize at approximately 5,000 pounds per acre (fig. 2). This being the case, fire severity during the last 6 years was related to weather conditions rather than to fluctuations in the fuel supply. Although the fires killed the aboveground portions of practically all small hardwoods (fig. 3), the even distribution and quick-burning quality of the fuel virtually prevented incineration of the humus (A_{00}) layer and incrustation of the mineral soil surface.

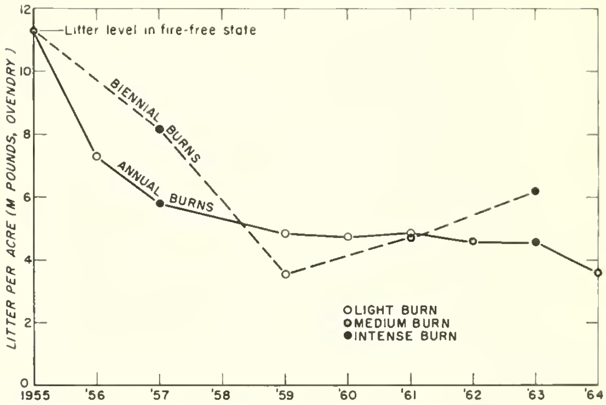

Figure 2.—*Litter supply trends and fire severity.*

Figure 3.—*Open aspect of area subjected to nine annual burns.*

When sampled in 1964, soil organic matter and nutrients varied by depth but not by treatment (tables 2 and 3). Other researchers have found that burning did not affect soil organic matter content, some have found that burning reduced it, and still others have reported an increase following burning *(1)*. Contradictory results are not surprising, for the extent to which soil organic matter is affected by fire varies with soils, preburn vegetation, climate, humus type, and fire intensity.

Table 3.—*pH and amounts of nutrients related to fire treatments*

Treatment	pH	Exchangeable cations						Base sat.	N	C:N ratio	P
		Ca	Mg	Na	K	H	Total				
		– Meq./100 g. dry soil –						*Percent*	*Percent weight*		*P.p.m.*
						0- to 2-inch depth					
Annual	5.9	4.3	1.2	0.2	0.2	3.4	9.3	63	0.13	20.3	10
Biennial	6.0	4.2	1.3	.2	.2	3.3	9.2	64	.15	18.3	7
None (check)	5.9	4.5	1.5	.2	.3	3.3	9.8	66	.16	19.0	6
						2- to 4-inch depth					
Annual	5.3	2.0	.7	.2	.1	3.0	6.0	49	.08	14.8	3
Biennial	5.5	1.8	.8	.2	.1	2.8	5.7	52	.08	14.1	3
None (check)	5.5	2.1	1.0	.2	.2	2.8	6.3	56	.08	14.4	3

These results show that nine annual burns have had little effect on the surface 4 inches of soil. If in practice no more than this number of burns are made, it is reasonable to conclude that no harm will be done to loess soils on relatively flat terrain.

LITERATURE CITED

1. Ahlgren, I. F., and Ahlgren, C. E.
   1960. Ecological effects of forest fires. Bot. Rev. 26: 483-533.
2. Jackson, M. L.
   1958. Soil chemical analysis. 498 pp., illus. Englewood Cliffs, N. J.: Prentice-Hall.
3. Leamer, R. W., and Shaw, B.
   1941. A simple apparatus for measuring noncapillary porosity on an extensive scale. J. Amer. Soc. Agron. 33: 1003-1008, illus.
4. Metz, L. J., Lotti, T., and Klawitter, R. A.
   1961. Some effects of prescribed burning on coastal plain forest soil. U. S. Forest Serv. Southeastern Forest Exp. Sta., Sta. Pap. 133, 10 pp., illus.

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LOBLOLLY SEED DORMANCY INFLUENCED BY CONE AND SEED HANDLING PROCEDURES AND PARENT TREE

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SOUTHERN FOREST EXPERIMENT STATION

*The dormancy of seeds from 20 loblolly pines (*Pinus taeda *L.) varied between trees but was relatively constant for 4 years for individual trees. Hand-extracted seed from early collections was immature. Kilning early-collected cones increased seed maturity, and stratification further benefited germination. Hand-extracted seed from the late collection was least dormant before stratification; kiln-extracted seed from the same collection was least dormant after stratification.*

Among southern pines, loblolly has relatively dormant seeds. This characteristic is a problem in direct seeding where fast, complete germination is usually desired. The seeds are commonly placed in cold, moist stratification *(2)* to break dormancy, but germination is still slower than with other species. In the present study, the influences of tree variation and common cone and seed handling procedures on dormancy were measured.

STUDY METHODS

Cones were collected twice a year for 4 years from each of 20 loblolly pine trees on a small area of the Palustris Experimental Forest in Louisiana. Cones were picked early—between September 21 and 28—and late—between October 7 and 23. Cones from the early collection were not ripe enough to float in SAE 20 oil *(9)*. The late collection was made when the cones were fully ripe and opening on the trees.

Cones from each tree were divided into two lots—one for hand extraction and the other for kilning at 100° to 105° F. Hand extraction was always done on the day of collection, and seeds were placed in germination dishes or in stratification immediately thereafter. Kilning was also started on the day of collection. Most of the cones that were picked early casehardened and had to be opened mechanically after a week or 10 days of drying. Nearly all cones from the late collection opened after 48 hours of kilning.

Four samples of cones were taken from each tree in the early collections (for two methods of extraction $\times$ two replications). Each sample consisted of 5 to 15 cones. Six samples were taken from each tree in the late collections. Seeds from the two extra samples were extracted by kilning, and stored for 1 year at 34° F. before testing germination.

Empty seeds were removed from lots by water flotation. One hundred full seeds were selected at random from each cone sample. On 50, germination tests were begun immediately. The other 50 were stratified for 30 days in moist vermiculite at 34° F. before germination was tested. One thousand seeds from each tree were tested annually, and a total of 80,000 were tested from all trees during the 4 years.

Germination was tested at 72° F. with 150 foot-candles of light and a 16-hour photoperiod. Normal and abnormal germination were recorded daily until it was evident that the peak day was past, and periodically thereafter until germination was complete. All tests lasted at least 30 days; some lasted as long as 90 days. A germination value *(4, 7)*, which is a measure of speed and completeness of germination, was computed at the end of 30 days for each sample.

RESULTS

Potential germination was uniformly high for all trees each year. At least one replication of stratified seed from every tree had 100 percent normal germination every year. Since all trees consistently yielded seed with potentially high germination, significant differences in speed or completeness of germination by treatment are attributed to dormancy or immaturity.

Data for the 4 years were averaged for this presentation because overall trends in germination and degree of dormancy were the same each year.

Early collection.—Hand-extracted seeds from the early collection had the lowest germination values (table 1). Germination was extremely slow, extending over periods of 60 to 90 days. Moreover, abnormal germination averaged 19 percent while normal germination was only 68 percent. Stratification of these seeds did not increase speed or completeness of germination, and failed to reduce abnormal germination appreciably. The average germination value for stratified seed was only 8.28 compared with 5.55 for unstratified seed. The high percentage of abnormal germination, coupled with the lack of response to stratification, indicates that hand-extracted seeds from the early collection were immature rather than dormant. Apparently seeds in early stages of ripening will germinate abnormally. All seedlings from a seed lot collected on August 18 in a supplementary study were abnormal.

Unstratified, kiln-extracted seeds from the early collection germinated consistently better than those extracted by hand. Germination was faster and more complete, and there were fewer abnormals. Kiln-extracted seed also responded better to stratification than hand-extracted seed. Stratification doubled germination values of kiln-extracted seed, and reduced the percentage of abnormal germination. Apparently, drying the cones increased seed maturity.

Late collection.—Hand-extracted seeds from the late collection were the least dormant unstratified seeds from any treatment. They had

Table 1.—*Average germination values (GV) and percents of germination for loblolly pine seed from 20 trees for 4 years*

Collection period and method of extraction	Unstratified seed			Stratified seed		
	GV	Germination		GV	Germination	
		Normal	Abnormal		Normal	Abnormal
		Percent			*Percent*	
Early, hand	5.55	68	19	8.28	72	17
Early, kiln	9.54	85	7	18.19	88	4
Late, hand	18.29	90	5	25.68	93	3
Late, kiln	16.57	96	2	30.12	98	2
Late, kiln, stored	10.71	91	4	27.21	97	1

an average germination value of 18.29. Unlike hand-extracted seeds from the early collection, they had relatively high normal and low abnormal germination. Moreover, stratification greatly increased germination value and the percentage of normal germination, and decreased the percentage of abnormal germination.

Unstratified, kiln-extracted seeds from the late collection were slightly more dormant than hand-extracted seeds, as evidenced by lower germination values. However, normal germination was higher and abnormal germination lower than for hand-extracted seeds. This is additional evidence that drying is beneficial. Stratification of late-collected kiln-extracted seeds stimulated germination, resulting in the highest average germination values in the study—30.12.

Storage of kiln-extracted seeds from the late collection for 1 year at 34° F. consistently induced dormancy, although total germination was not greatly affected. Stratification greatly hastened germination of stored seeds. Their germination values almost equaled those of fresh seeds.

Differences among trees.—Differences in germination values of unstratified seed among trees were statistically significant (0.01 level). Some trees consistently produced relatively dormant seeds—e.g., tree number 16 (table 2)—while others yielded less dormant seed—e.g., tree number 8. This was true for all seeds in the early collection and for fresh, kiln-extracted seeds in the late collection (table 3). The patterns were inconsistent for hand-extracted and stored seed from the late collection.

The high correlation coefficients obtained for germination values of early collected seed between all years are probably due, in part, to the order of cone or seed ripening. McLemore and Derr *(8)* showed that longleaf trees ripen their cones at widely varying times, but always in the same order each year. Similar observations have been made for loblolly. Hence, when all seeds are not mature, the high correlations for dormancy of seed from individual trees are to be expected.

Table 2.—*Germination values of unstratified, kiln-extracted seed from the late collection*

Tree number	Year of collection 1959	1960	1961	1962
	Germination value			
1	11.10	10.69	14.01	7.40
2	15.76	17.80	10.63	15.35
3	19.30	21.76	18.86	16.12
4	16.69	20.66	13.98	12.92
5	20.46	19.48	18.21	22.86
6	14.86	16.64	10.65	10.01
7	19.46	25.34	20.71	18.66
8	24.62	23.21	21.06	20.88
9	15.28	17.11	17.94	14.88
10	14.62	16.59	22.75	16.20
11	18.64	19.97	19.62	13.45
12	17.30	20.59	16.86	10.94
13	16.54	23.54	23.76	14.23
14	15.64	18.27	15.07	14.14
15	13.70	19.13	14.92	15.07
16	11.55	10.12	7.12	10.72
17	12.76	13.62	11.74	10.98
18	15.38	19.54	20.81	18.93
19	15.83	19.06	18.64	19.21
20	14.04	15.40	19.80	13.33
Average	16.18	18.43	16.86	14.81

However, order of ripening fails to account for the significant correlations obtained with kiln-extracted seeds from the late collection. These seeds were collected from completely

Table 3.—*Correlation coefficients for germination values of unstratified seed from individual trees between years* [1]

Years compared	Early collection: Hand extraction	Early collection: Kiln extraction	Late collection: Hand extraction	Late collection: Kiln extraction	Late collection: Kiln extraction stored 1 year
1959 vs. 1960	0.915	0.678	0.466	0.805	0.287
1959 vs. 1961	.859	.674	.503	.522	− .084
1959 vs. 1962	.824	.669	.265	.698	− .382
1960 vs. 1961	.827	.744	.424	.642	.613
1960 vs. 1962	.786	.597	.035	.612	.510
1961 vs. 1962	.861	.695	.387	.565	.423

[1] A value of ± 0.444 is necessary for significance at the 0.05 level.

mature cones. The strong correlations between years for germination values of seed in this treatment suggest that degree of dormancy is a characteristic of individual trees; i.e., a tree with extremely dormant seed in one year can be expected to produce extremely dormant seed in subsequent years, while a tree with nondormant seed will yield relatively nondormant seed in future years.

DISCUSSION

Stratified, kiln-extracted seeds from the late collection germinated best. Fortunately, this treatment combination is used almost exclusively on loblolly pine seeds.

Results obtained with loblolly seeds in the present study agree closely with those reported by Allen *(1)* for western hemlock and Douglas-fir. Allen noted considerable variation among parents in maturity of seed on a given date. Further, he reported that rate and amount of germination increased from early to late collections. In his study immature seeds suffered from stratification, however, whereas in the present study immature loblolly seeds were virtually unaffected by stratification.

The beneficial effect of drying seeds at about 40° C. in the extraction process agrees with results obtained by others. Koller and Roth *(6)* found that germination of *Panicum turgidum* seeds was improved when they were dried at 30° C. prior to imbibition. Brown *et al. (3)* reported that most cereals completely after-ripen when dried at 40° C. for 1 to 6 months. And Koller *et al. (5)* cited desiccation at fairly high temperatures as a common means of after-ripening seeds of various species.

Differences in degree of dormancy of seed among trees may be an important consideration in stocking seed orchards. Other things being equal, it would be highly desirable to establish orchards that produce relatively nondormant seeds. It is not known if degree of seed dormancy is heritable in loblolly pine. Until more knowledge is gained, it may be best to assume that it is. Koller *et al. (5)* reported that seed dormancy is highly heritable in *Trifolium subterraneum*.

LITERATURE CITED

1. Allen, G. S.
   1958. Factors affecting the viability and germination behavior of coniferous seed. I. Cone and seed maturity, *Tsuga heterophylla* (Rafn.) Sarg. II. Cone and seed maturity, *Pseudotsuga menziesii* (Mirb.) Franco. Forest. Chron. 34: 266-282, illus.
2. Barton, L. V.
   1928. Hastening the germination of southern pine seeds. J. Forest. 26: 774-785, illus.
3. Brown, E., Stanton, T. R., Wiebe, G. A., and Martin, J. H.
   1948. Dormancy and the effect of storage on oats, barley, and sorghum. U. S. Dep. Agr. Tech. Bull. 953, 30 pp., illus.
4. Czabator, F. J.
   1962. Germination value: an index combining speed and completeness of pine seed germination. Forest Sci. 8: 386-396, illus.
5. Koller, D., Mayer, A. M., Poljakoff-Mayber, A., and Klein, S.
   1962. Seed germination. Annu. Rev. Plant Physiol. 13: 437-464.
6. ———— and Roth, N.
   1963. Germination-regulating mechanisms in some desert seeds. VII. *Panicum turgidum* (Gramineae). Israel J. Bot. 12: 64-73.
7. McLemore, B. F., and Czabator, F. J.
   1961. Length of stratification and germination of loblolly pine seed. J. Forest. 59: 267-269, illus.
8. ———— and Derr, H. J.
   1965. Longleaf cone maturity is independent of pollination date. Silvae Genet. 14: 133, illus.
9. Wakeley, P. C.
   1954. Planting the southern pines, p. 33. U. S. Dep. Agr., Agr. Monogr. 18, 233 pp., illus.

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GIBBERELLIN-INDUCED GROWTH OF DORMANT SWEETGUM

Robert E. Farmer, Jr. [1]

SOUTHERN FOREST EXPERIMENT STATION

One-percent solutions of GA applied to leaves and buds of dormant seedlings caused growth resumption. Dimethyl sulfoxide (30 percent) and water with Tween 20 were equally effective as GA carriers and were both better than lanolin.

The relationship between gibberellins and dormancy in woody plants may vary with species. In most trials, applications of gibberellic acid (GA) have delayed the onset of dormancy under short photoperiods or promoted growth resumption in dormant but unchilled or partially chilled material *(1, 2, 4, 6, 9)*. Other species have not responded in these ways *(2, 8)*, and in some GA has induced or prolonged dormancy *(3, 10)*. This note reports a study of GA-induced growth resumption in dormant sweetgum *(Liquidambar styraciflua* L.). One of the GA carriers tested was dimethyl sulfoxide (DMSO). This chemical has exceptionally good solvency and membrane penetrant properties *(5)* and has been the subject of much recent investigation *(7)*.

METHODS AND RESULTS

In a series of greenhouse pot tests during November and December of 1964 and 1965, partially chilled and unchilled plants from a central Mississippi source were treated with 1 percent GA in lanolin, H_2O, or 30-50 percent DMSO, then observed under short natural photoperiods and average temperatures of 70-80° F.

Foliated plants.—Two tests included foliated, unchilled plants. In the first, groups of 10 rooted juvenile cuttings were treated with GA in lanolin and in 50 percent DMSO; the lanolin mixture was applied to apical buds and the DMSO to leaf surfaces. Controls, which included untreated and carrier-treated plants, did not break dormancy. Results on treated plants were as follows:

	Mean number days from treatment to bud-break	Mean apical growth 34 days after treatment (cm.)
GA-lanolin	9	1.1
GA-DMSO	9	7.9

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Mississippi, by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

The difference in growth between GA in lanolin and DMSO was statistically significant (0.05 level).

In the second test, leaves of 2-year-old seedlings were treated with GA in lanolin, 30 percent DMSO, or H_2O with 0.1 percent Tween 20.[2] Controls included untreated plants and plants treated with lanolin, DMSO, and H_2O with Tween 20. Treatments were applied to a 1-square-centimeter area on two leaves near the apex of each plant. No response was observed on controls or from GA-lanolin; 6 of the 10 plants treated with GA-DMSO and all of those treated with GA-H_2O resumed growth within 10 days. Thirty days after treatment, new apical bud growth on plants treated with GA-H_2O averaged 8.2 cm. while that on plants treated with GA-DMSO was 1.8 cm.; within-treatment variation was wide, however, and the difference was not statistically significant.

Defoliated plants.—In 1964, two preliminary tests with partially chilled (170 hours at outdoor temperatures below 45° F.) defoliated plants also indicated that GA in lanolin or 50 percent DMSO induced bud-break, and that GA-DMSO stimulated growth significantly more than did GA in lanolin. Tests were repeated in 1965 on larger (60-120 cm. high) 2-year-old trees that had been chilled outdoors less than 100 hours. These plants were deeply dormant, and would have required at least 600 hours' chilling to resume growth within 30-40 days under short-day greenhouse conditions. Solutions of GA in H_2O, DMSO, or lanolin were applied to two lateral branches on each plant.

In one 10-replication experiment, all 30 GA-treated plants broke dormancy in 10 to 24 days; 2 of the 40 control plants resumed growth. Mean values for the three GA treatments were:

Treatment	Days from treatment to bud-break	Number of buds growing 40 days after treatment
GA-lanolin	20	2.4
GA-DMSO	23	5.1
GA-H_2O	20	7.4

The number of buds growing 40 days after treatment was significantly (0.05 level) less on GA-lanolin treated plants than on plants in the other two treatments, but the difference between GA-DMSO and GA-H_2O was statistically nonsignificant. Buds that broke dormancy commonly grew less than 2 cm., and bud length was not recorded.

In another 10-replicate 1965 test, GA-DMSO produced significantly (0.05 level) more growing buds than did either GA-H_2O or GA-lanolin:

Treatment	Mean number of growing buds 60 days after treatment
GA-lanolin	1.9
GA-DMSO	4.0
GA-H_2O	1.4

With few exceptions in these two 1965 tests, only buds immediately adjacent to treated areas broke dormancy. This was in contrast to a 1964 test in which GA-DMSO resulted in more general bud growth. In all tests with defoliated plants, 30-50 percent DMSO caused some necrosis near the point of application.

DISCUSSION AND CONCLUSIONS

Results of the study generally support the hypothesis that GA can replace the chilling requirements of juvenile sweetgum. In the six tests, a total of 139 unchilled or partially chilled plants treated with GA in various mediums were compared with 149 controls. Eighty-seven percent of the treated plants resumed growth; 12 percent of the controls responded.

The degree of GA effect, however, varied from test to test and related in some tests to the carrier used for GA application. In all six tests, GA in DMSO gave a decidedly better response than GA in lanolin. On the other hand, DMSO was not a better medium than the commonly used H_2O with Tween 20. H_2O was significantly better than DMSO in one test, poorer in a second, and equal in a third.

Movement of GA (or a GA-mobilized growth factor) from leaves to buds was demonstrated with both H_2O and DMSO, but consistent extraordinary spread of effect within stems was not observed with either. While further tests might show the way to more effective use of DMSO with GA, the variable results from the present series indicate lack of spectacular carrier properties under the experimental conditions. The necrotic effects of DMSO may, in fact, limit its use at the concentrations tested.

[2] Mention of trade names is solely for necessary information. No endorsement by the U.S. Department of Agriculture is implied.

LITERATURE CITED

(1) Bourdeau, P. F.
1958. Interaction of gibberellic acid and photoperiod on the vegetative growth of *Pinus elliottii*. Nature 182: 118.

(2) Brian, P. W., Petty, J. H. P., and Richmond, P. T.
1959. Effects of gibberellic acid on development of autumn colour and leaf-fall of deciduous woody plants. Nature 183: 58-59.

(3) ———— Petty, J. H. P., and Richmond, P. T.
1959. Extended dormancy of deciduous woody plants treated in autumn with gibberellic acid. Nature 184: 69.

(4) Donoho, C. W., Jr., and Walker, D. R.
1957. Effect of gibberellic acid on breaking of rest period in Elberta peach. Science 126: 1178-1179.

(5) Herschler, R. J., and Jacob, S. W.
1965. DMSO—a new drug from lignin. TAPPI 48: 43A-46A.

(6) Larson, P. R.
1960. Gibberellic acid-induced growth of dormant hardwood cuttings. Forest Sci. 6: 232-239.

(7) Leake, C. D.
1966. Dimethyl sulfoxide (Report on an international conference). Science 152: 1646-1649.

(8) Lockhart, J. A., and Bonner, J.
1957. Effects of gibberellic acid on the photoperiod-controlled growth of woody plants. Plant Physiol. 32: 492-494.

(9) Schoeneweiss, D. F.
1963. Methods for breaking dormancy of oak seedlings in the greenhouse. Amer. Soc. Hort. Sci. Proc. 83: 819-824.

(10) Weaver, R. J.
1959. Prolonging dormancy in *Vitus vinifera* with gibberellin. Nature 183: 1198-1199.

SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

1966

SO-43

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

DIAMETER GROWTH AND FOLIAR NITROGEN IN FERTILIZED LOBLOLLY PINES[1]

D. M. Moehring

SOUTHERN FOREST EXPERIMENT STATION

One or two annual applications of nitrogen to an 8-year-old loblolly pine plantation increased diameter growth of the trees and the amount of nitrogen in the foliage. But neither response extended beyond 2 years after the last application.

Application of nitrogen fertilizers to the soil often increases diameter growth of southern pines, but the stimulation from a single application seldom lasts more than 2 years (Zahner, 1959).[2] Apparently the added nutrient is quickly removed from the nitrogen cycle, possibly by assimilation within the tree or by fixation within the litter and soil. The study reported here was made to test the hypothesis that a second fertilizer application would overload the nitrogen balance of the forest ecosystem and, as a result, would prolong nitrogen availability and tree growth response.

METHODS

Tree diameter growth and amount of nitrogen (hereafter N) were measured over a 4-year period in a loblolly pine (*Pinus taeda* L.) plantation near El Dorado, Arkansas. Three treatments were compared: (1) a single broadcast application in April with ammonium nitrate to supply 100 pounds of N per acre, (2) two successive broadcast applications in April with ammonium nitrate to supply 100 pounds of N per acre per year, and (3) unfertilized control plots. Very heavy rains fell immediately after the initial fertilizer application in April 1958, and, as it was thought that they washed much of the fertilizer from the plots, a second application of 100 pounds of N per acre was made in May 1958.

Treatments were replicated four times each in a randomized block design. A test plot consisted of 12 trees arranged in two rows of 6 trees each. Four rows of trees served as an isolation strip between plots.

At establishment of the study, the plantation was 8 years old and averaged 900 trees per acre. Trees ranged in diameter from 3 to 7 inches and in height from 25 to 40 feet. The forest canopy was completely closed, and the ground was heavily shaded. The soil is Sawyer sandy loam with a 14-inch surface layer over-

[1] This study was made in cooperation with the Deltic Farm and Timber Co., Inc., and the Monsanto Chemical Corp.

[2] Zahner, R. Fertilizer trials with loblolly pine in southern Arkansas. J. Forest. 57: 812-816, illus. 1959.

lying a brown sandy clay. The slope gradient over the study area varies from 3 to 5 percent. The site index for loblolly pine, as determined by soil variables, is 80 to 85 feet at age 50 years.

Foliar N content was determined during January, April, July, October, and November in the first 2 years of the study and during October in each of the last 2 years. Each time samples consisting of 35 to 40 needle fascicles were collected from 3 trees selected at random from the 12 trees on a plot. Needles were taken from the current (new) and previous year's (old) foliage in the uppermost three whorls on the north side of each sample tree. The November sample was collected as freshly fallen litter near the base of three trees on a plot. Total N content, determined by the macro-Kjeldahl procedure, was expressed in percent of the weight of foliage ovendried at 70° C.

Diameter at 4.5 feet above the ground was measured to 0.1 inch in January of each year. Growth of individual trees was converted to basal area and then summed for the plot.

RESULTS

Foliar N was greater (0.05 level of significance) for fertilized trees than for controls in the year of fertilizer application (table 1), but the difference dwindled sharply during the succeeding years (fig. 1). The rapid loss of N began during the dormant season. Thus from October 1958 to April 1959 the average N content in needles of fertilized trees fell from 1.58 to 1.18—a drop of 26 percent, as compared to a reduction of 10 percent in the unfertilized control.

The N content of needles that returned to the soil in litter during 1958 and 1959 was similar for both fertilized and control trees. This observation suggests that N uptake was retained within the tree and, therefore, removed from the nitrogen cycle. However, in April 1961 the needle N content was higher in the fertilized trees than in the control. The difference, if real, may have resulted from the gradual release of N either from the soil or from older, less active tissue within the trees on the fertilized plots.

Table 1.—*Mean nitrogen content in needles of treated and control trees at selected dates during the 1959-61 growing seasons*

Year	Treatment	January	April	July		October		November—old, fallen needles
				Old	New	Old	New	
		Percent by weight						
1958	1		[1] 1.24	1.50	1.91	1.18	1.64	0.68
	2		1.24	1.61	1.77	1.18	1.53	.66
	Control		1.25	1.18	1.50	1.03	1.27	.54
	d' [2]		.13	.28	.08	.24	.27	.17
1959	1	1.33	1.21	.80	.88	.99	1.09	.47
	2	1.23	1.14	.93	1.07	1.14	1.23	.46
	Control	1.16	1.14	.80	.89	.90	1.00	.42
	d'	.11	.18	.20	.17	.36	.50	.10
1960	1					.98	1.31	
	2					.95	1.33	
	Control					.90	1.24	
	d'					.13	.17	
1961	1		1.40			.98	1.13	
	2		1.42			.94	1.13	
	Control		1.30			.92	1.12	
	d'		.12			.16	.16	

[1] All values are averages of 12 trees per treatment except that November is average of four composite samples per treatment.

[2] Dunnett's value for significant difference between a treatment and control mean at 95-percent confidence level:

Dunnett, C. W. A multiple comparison procedure for comparing several treatments with a control. J. Amer. Statist. Assoc. 50: 1096-1121. 1955.

———— New tables for multiple comparisons with a control. Biometrics 20: 482-491. 1964.

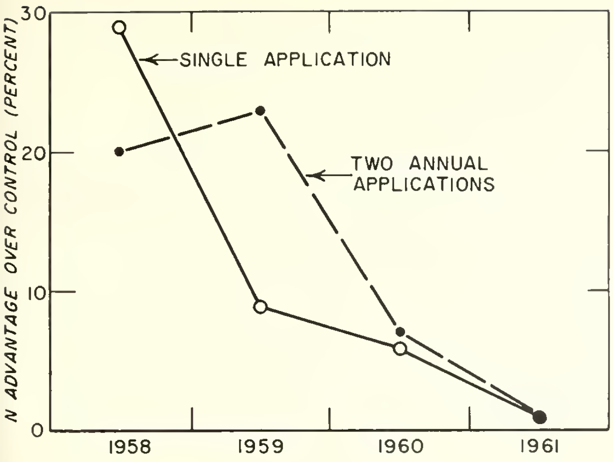

Figure 1.—*October nitrogen content in new needles of treated plots as an advantage over the control.*

The N content of new needles on the control trees was lower in 1959 and 1961, when the summers had above-average rain, than in 1958 and 1960, when the summers were dry. The difference may reflect a dilution in foliar N (percent by weight) corresponding to increased dry-matter production per needle during the wet years.

In basal area growth the fertilized trees surpassed the controls (0.05 level of significance) in 1958 and 1959, the period when treatments and control also differed most in foliar N content. Growth and foliar N content were similar for both treatment and control trees in 1960 and 1961.

The lack of prolonged response to nitrogen applications may be explained by recent work of Curlin,[3] who found that dense stocking greatly reduced response to fertilization in natural stands of shortleaf pine. His results indicate that stand density must be low enough at the time of fertilizer application to allow growth to proceed unhindered. Competition for soil moisture, nutrients, and light is very keen in densely stocked stands, and the lack of growing space curtails lateral development of crowns. Also, heavy ground shading slows down litter decomposition (Boggess, 1959),[4] thus delaying the release of nutrients for further plant use. Since no measure of dry-matter production was included, the present study provides no information upon N cycling to explain the fate of the N applied to the plantation.

It can be concluded from these results that, in heavily stocked loblolly pine plantations on good sites, N fertilization at the rate tested does not stimulate diameter growth for more than 2 years after the last application. This falling-off in growth response corresponds with a rapid reduction in foliar N advantage of fertilized over unfertilized trees.

[3] Curlin, J. W. Response of natural stands of shortleaf pine to thinning and fertilization with nitrogen and phosphorus. Soil Sci. Soc. Amer. Proc. 27: 234-236, illus. 1963.

[4] Boggess, W. R. Foliar nitrogen content of shortleaf pine as influenced by thinning. Ill. Agr. Exp. Sta. Forest. Note 80. 1959.

SOUTHERN FOREST EXPERIMENT STATION

1966

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SO-44

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

THINNING LOBLOLLY PINE FROM ABOVE AND BELOW

John R. Bassett

SOUTHERN FOREST EXPERIMENT STATION

Stands thinned from above or below, beginning at age 20, did not differ much in yield or size of residual trees at age 35. If trees need early release, thinning from above once or twice at ages 15 to 20 may prove successful both silviculturally and economically.

Near-maximum growth can be obtained in loblolly pine (*Pinus taeda* L.) stands over a wide range of stocking. Hence, thinning may be more important silviculturally or economically than thinning intensity. Even-aged stands often need thinning before the majority of trees become merchantable. Landowners cannot afford to cut submerchantable trees, yet many hesitate to cut merchantable dominants and codominants at the risk of downgrading the residual stand. Faced with this dilemma, they delay thinning until most trees reach merchantability, thereby retarding diameter growth and inviting mortality. To evaluate the consequences of early removal of dominants and codominants, the Southern Forest Experiment Station in 1949 initiated a study in unthinned stands then 20 years old. Fifteen-year results suggest that profitable early thinning does not seriously downgrade the residual stand.

STUDY AREA

Twenty-four circular 0.1-acre plots with 0.5-chain isolations were established on each of two areas near Crossett, Arkansas—one 8 miles east and the other 25 miles southwest, in Louisiana.[1] Soils are silt loams. Drainage varies from moderately good to poor. Mean 50-year site index for loblolly pine is 92 feet (range 86-98) in Arkansas and 74 feet (range 68-84) in Louisiana. In 1949 basal area per acre of the unthinned stands ranged from 85-138 square feet in Louisiana and from 109-166 square feet in Arkansas.

METHODS

In 1949, eight treatments were replicated three times in each area: thinning from above or below at 5-year intervals to basal areas of 70, 85, 100, and 70-100 square feet per acre. In the last-mentioned treatment, the plots were thinned to 70 square feet, but in each subsequent thinning stocking was increased by 5 square feet; this procedure will continue until 100 square feet is reached at age 50. To avoid continual removal of trees previously favored, thinning from above was scheduled only twice —in 1949 and 1954. From 1959 on, all plots were thinned from below. Merchantable hard-

[1] The Crossett Division of the Georgia-Pacific Corporation makes these areas available and helps to inventory plots.

woods were removed in the first thinning; hardwoods 1.0 inch and larger at the root collar were poisoned in 1959.

Thinning from below generally removed merchantable (3.6 inches d.b.h. and larger) suppressed and small intermediate trees and, on heavily thinned plots, some large intermediates and small codominants. Thinning from above removed a few merchantable suppressed and intermediate trees, many rough and crooked codominants, and most dominants. After the initial thinning, 15 trees per plot were designated as crop trees. The percentages of crop trees by crown classes were:

Crown class	Thinned from above	Thinned from below
	– – *Percent* – –	
	Site 74	
Dominant	4	74
Codominant	36	26
Intermediate	60	0
	Site 92	
Dominant	15	86
Codominant	39	12
Intermediate	46	2

On site 74, for example, dominants comprised 4 percent of the crop trees on plots thinned from above but 74 percent on plots thinned from below.

Measurements.—Merchantable pine stems were tallied to the nearest 0.1 inch d.b.h. Height was measured with an altimeter to a point on the bole estimated to be 3.0 inches in diameter (i.b.). Form class was estimated in 1949 and 1959 but measured on large trees in 1954 and on most trees in 1964. Merchantable cubic-foot and board-foot volumes in individual trees were computed from tables.[2, 3] Logs that contained fewer than 13 small (less than 2.0 inches in diameter) knots in the best 14 feet were graded #2; all other logs were graded #3. Crown diameter, crown length, and clear bole were measured on crop trees.

RESULTS

On site 74 plots, trees cut in 1949 and 1954 on plots thinned from above averaged 0.5 and 0.7 inch larger in diameter (b.h.) than trees cut on plots thinned from below, and had 33 and 58 cubic feet more cumulative volume per acre (table 1). On site 92, too, thinning from above removed larger trees and more volume than thinning from below. In 1959, when all plots were thinned from below, the reverse was true—plots that had always been thinned from below produced 46 cubic feet per acre more than thinned-from-above plots on site 74 and 13 cubic feet more on site 92. Fifteen-year yields were similar for both thinning methods: plots thinned from above produced 79 cubic-feet per acre less than plots thinned from below on site 74 but 16 cubic feet more on site 92 (table 1).

Volume per acre in trees of sawtimber size (9.6 inches and larger b.h.) at the time of each inventory is shown in table 2. Mean annual sawtimber growth per acre (International ¼-inch rule) has been:

Period	Thinned from above	Thinned from below
	– – – *Bd. ft.* – – –	
	Site 74	
1929-54	2	5
1929-59	14	27
1929-64	74	100
	Site 92	
1929-54	16	24
1929-59	105	162
1929-64	275	421

In 1964, the average numbers of trees per acre sawtimber-size and smaller were:

	Site 74	Site 92
Sawtimber-size		
Thinned from above	51	98
Thinned from below	62	118
Smaller than sawtimber-size		
Thinned from above	272	103
Thinned from below	218	49

Obviously, sawtimber volume ingrowth will continue longer on plots thinned from above than on plots thinned from below. Although thinning from above has delayed sawtimber production, differences in sawtimber volume associated with thinning method will decrease until all trees reach sawtimber size.

[2] Mesavage, C. Tables for estimating cubic-foot volume of timber. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 111, 71 pp. 1947.

[3] ———— and Girard, J. W. Tables for estimating board-foot volume of timber. U. S. Dep. Agr., 94 pp. 1947.

Table 1.—*D.b.h. and volume per tree of thinned and residual trees, 1949-64*

Trees 3.6 inches d.b.h. and larger	Mean d.b.h., on plots thinned from		Mean volume		
			Thinned from		Difference (above minus below)
	Above	Below	Above [1]	Below	
	– *Inches* –		– – – – – – – *Cu. ft.* – – – – – – –		
Site 74					
All trees, before 1949 cut	5.0	4.9	1,293	1,252	41
Trees cut in 1949	5.4	4.9	443(402)	369	33
Trees cut in 1954	5.7	5.0	568	510	58
Trees cut in 1959	4.6	4.9	181	227	−46
All trees, before 1964 cut	8.0	8.7	2,331	2,455	−124
Yield (1964 minus 1949 plus cuts)	.	.	2,230	2,309	−79
Site 92					
All trees, before 1949 cut	5.4	5.4	1,796	1,741	55
Trees cut in 1949	5.6	5.2	792(737)	686	51
Trees cut in 1954	6.4	5.8	552	526	26
Trees cut in 1959	5.9	6.5	534	547	−13
All trees, before 1946 cut	10.3	11.2	3,012	3,060	−48
Yield (1964 minus 1949 plus cuts)	.	.	3,094	3,078	16

[1] Number in parentheses is the 1949 cut reduced by an amount equal to the mean difference between thinned-from-above and thinned-from-below plots before the 1949 cut.

Table 2.—*Sawtimber volume per acre (International ¼-inch rule)*

Site and year	Thinned from	
	Above	Below
	– – – *Bd. ft.* – – –	
Site 74		
1949, before cut	0	0
1954, cut	25	98
1954, after cut	29	25
1959, cut	0	0
1959, after cut	389	721
1964, before cut	2,570	3,400
Site 92		
1949, before cut	0	0
1954, cut	145	128
1954, after cut	253	482
1959, cut	102	88
1959, after cut	2,903	4,639
1964, before cut	9,376	14,504

Thinning method has not affected log grade. Of the total saw-log volume present in 1964, the percentages in grade-2 logs were:

	Percent
Site 74	
Thinned from above	18
Thinned from below	23
Site 92	
Thinned from above	42
Thinned from below	39

In 1964, crop trees on plots thinned from above had smaller diameters (b.h.), shorter merchantable heights, and smaller crowns than crop trees on plots thinned from below (table 3). Thinning method has had little or no effect on length of clear bole or form class.

Table 3.—*Size and form of mean crop trees at age 35 years*

Characteristic	Thinned from	
	Above	Below
Site 74		
D.b.h., in.	9.2	9.9
Form class	78	78
Merchantable height, ft.[1]	47	49
Crown diameter, ft.[2]	17	18
Crown length, ft.[3]	23	25
Clear bole length, ft.[4]	27	27
Site 92		
D.b.h., in.	11.2	11.9
Form class	80	80
Merchantable height, ft.[1]	60	63
Crown diameter, ft.[2]	20	22
Crown length, ft.[3]	26	28
Clear bole length, ft.[4]	32	31

[1] To 3-inch (d.i.b.) top.

[2] Average of north-south and east-west measurements.

[3] Distance between tip and lowermost whorl containing at least two live branches.

[4] Distance from stump to average height of highest and lowest persistent branch stubs.

SOUTHERN FOREST EXPERIMENT STATION

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1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-45

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FACTORS FOR CONVERTING MIDSOUTH PULPWOOD FROM CORDS TO CUBIC FEET

Charles C. Van Sickle

SOUTHERN FOREST EXPERIMENT STATION

Volume of solid wood per standard cord is greater in pine pulpwood than in hardwood, and higher in the West Gulf than in the East Gulf.

A cord of pulpwood from the Midsouth contains more wood now than it did 15 years ago. A recent study by the Southern Forest Experiment Station found an average of 81 cubic feet of solid wood per cord of pine pulpwood. In 1950, the Station estimated a pine cord at 75 cubic feet. The solid-wood content of hardwood cords appears to have increased also, though by a lesser amount.

The new factors are from a special study made by the Station's Forest Survey project. The Survey measured stacked pulpwood at mills, woodyards, and rail sidings throughout the Midsouth. The samples were selected systematically so as to eliminate locational bias. The probability that a sample would fall within a given county was also weighted by the amount of pulpwood harvested in the county. Sampling was done separately for the East Gulf (Alabama, Mississippi, and Tennessee) and for the West Gulf (Arkansas, Louisiana, Oklahoma, and Texas). Thirty samples were taken for pine and 30 for hardwood in each of these two regions—a total of 120. The locations are shown in figure 1. The East Gulf samples were taken in November and December of 1964 and the West Gulf samples 1 year later.

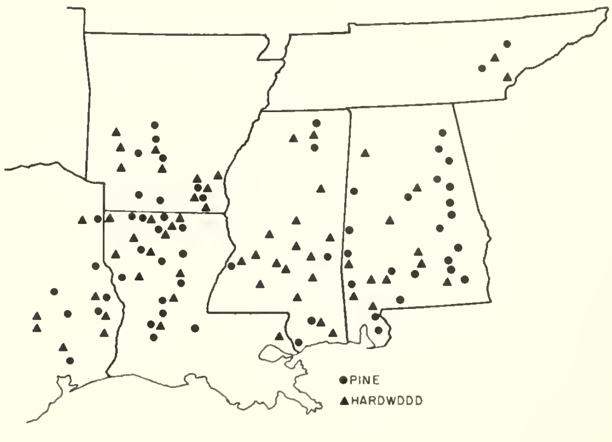

Figure 1.—*Location of pulpwood samples.*

At each location 10 observations were made. An observation consisted of placing a section of steel tape, 10 feet long, diagonally across the ends of stacked wood. The number of 1/10-foot marks falling on wood, bark, and air was recorded for the 10-foot interval. The result for each observation was an estimate of the percent of the cross-sectional area occupied by wood, bark, and air. The percentage for wood, when multiplied by 128 (the number of cubic feet in a standard cord) gave the solid-wood volume per cord.

Table 1 shows the factors thus obtained. The factors can be converted from cords to other measures by applying the appropriate volume ratio—for example, multiplying by 1.25 converts them to 160-cubic-foot units.

Table 1.—*Volume of wood per cord of pulpwood in the Midsouth*

Region	Year	All species	Pine	Hardwood
		Cubic feet per standard cord		
Midsouth	1950		75	78
Midsouth [1]	1965	81	81	80
East Gulf	1964	80	80	79
West Gulf	1965	82	82	81

[1] East and West Gulf factors are combined in proportion to annual pulpwood production.

As the table indicates, the amount of solid wood per cord is greater for pine than for hardwood, and greater in the West Gulf than in the East Gulf. Although the differences between species and between locations were small, they were found to be statistically significant (at the 0.05 level for species and the 0.01 level for location).

What accounts for these differences? The causes are somewhat conjectural, but most of them relate to bolt diameter.

In a pile of wood made up of perfectly smooth cylinders of identical diameter, the solid-wood content would be the same regardless of whether the diameter was large or small. But if diameters vary, the solid-wood content increases, because small sticks fill up some of the space between large ones. On the other hand, anything that causes deviation from the cylindrical—crook or roughness, for example—will lessen the solid wood content.

When average diameter of bolts increases, both these causes of variation operate to raise the solid-wood content. This is because the range in diameters in a pile usually becomes greater as average diameter of bolts in the pile increases, and also because large bolts tend to be less crooked and rough than small ones.

Utilization studies have shown that larger timber is now being cut for pulpwood than was used in 1950. Small sawmills, which relied heavily upon trees of small sawtimber size, have dwindled in number. As a result, more of these trees are available for pulpwood. In addition, changes in handling equipment at the pulpmill and the woodyard, and in the woods, permit harvesting bigger bolts.

Timber size also differs between the East Gulf area and the West Gulf. For example, recent forest surveys show that trees larger than 9 inches d.b.h. now comprise 74 percent of the pine growing stock in Alabama and 82 percent in Louisiana. Again, the difference in the size of timber is likely to affect the solid content of the cord.

Thus, solid wood volume is not a constant. It is an estimate that should be revised when there are major changes in timber inventories, harvesting methods, and the demand for wood.

SOUTHERN FOREST EXPERIMENT STATION

Forest Service, U. S. Dept. of Agriculture

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-46

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

SURFACE SOIL RECOVERS QUICKLY AFTER BURN

David R. Bower

SOUTHERN FOREST EXPERIMENT STATION

Prescribed burns in the Ouachita Mountains of Arkansas temporarily increased bulk density and reduced surface-soil aggregation, but the detrimental effects disappeared within 4 year.

The study described here was designed to measure changes in physical soil properties following prescribed burns in the Ouachita Mountains on slopes up to 15 percent. A shortleaf pine stand averaging 5,000 board feet of pine per acre was cut in June 1958. Six seed trees per acre and about 35 square feet of understory-hardwood basal area remained after cutting. Six half-acre plots were laid out on the logged area; half were burned and half were not. All hardwoods over 1 inch in diameter were injected immediately after the pine was cut with undiluted 2,4,5-T (40 pounds of acid equivalent per hundred gallons).

The plots were burned in September 1958 on a day when the relative humidity ranged from 38 to 54 percent, the air temperature from 88 to 95 degrees, and the wind velocity from 0 to 5 miles per hour. Much of the 8,000 pounds (ovendry weight) of litter, exclusive of slash, was consumed by the fire; many patches of mineral soil were exposed.

Slopes varied from 0 to 15 percent. The soils were Herndon and Goldston loams with high gravel content. All measurements were confined to the surface 3 inches. Here, prior to treatment, averages of 38 percent sand, 47 percent silt, and 15 percent clay were found by the Bouyoucos hydrometer method *(1)*.

Soil porosity, moisture holding capacity, and bulk density were determined by Leamer and Shaw's method *(2)* on 144 undisturbed soil samples taken in June 1958 and 1, 2, and 4 years later. Aggregation was measured in 36 samples each year by the Yoder wet-sieve method *(3)*.

RESULTS

Burning influenced soil aggregation, porosity, and bulk density, but did not influence moisture holding capacity or texture. Moisture by weight averaged 43 percent at saturation and 26 percent at field capacity throughout the study. All plots showed a slight decline in clay content from 1958 to 1962.

Aggregates increase a soil's resistance to weathering. Therefore, the decrease in particles and aggregates 2 mm. and larger from 45 to 28 percent of total weight in the 2 years after burning, and the increase in particles smaller than 0.1 mm. from 14 to 28 percent (table 1) indicate a sharp increase in erodibility. A

Table 1.—*Size distribution of particles and aggregates*[1]

Treatment and time	> 2 mm.	2 mm.-1 mm.	1 mm.-0.5 mm.	0.5 mm.-0.25 mm.	0.25 mm.-0.1 mm.	< 0.1 mm.
	Percent					
Check						
Before treatment	52.8	13.6	9.0	6.0	6.5	12.1
After 1 year	34.8	11.5	11.2	9.5	11.8	21.2
After 2 years	34.2	13.8	13.5	9.2	10.0	19.3
After 4 years	50.8	10.3	9.7	7.2	7.7	14.3
Burn						
Before treatment	44.7	13.3	10.0	7.9	9.8	14.3
After 1 year	33.3	11.2	12.2	10.3	11.8	21.2
After 2 years	28.0	12.0	11.3	9.0	11.7	28.0
After 4 years	45.3	11.5	11.8	8.5	8.7	14.2

[1] Each figure in data columns is the average of 72 samples (two laboratory soil samples per field sample).

smaller increase in the smallest particles occurred on plots that were not burned.

During the third and fourth years after burning, as ground cover increased, aggregation improved. By the end of the fourth year, aggregation was about the same as before treatment on both burned and unburned plots.

Soil bulk density, corrected for particles larger than 2 mm., was slightly lower on burned (1.013) than unburned (1.026) areas 1 year after burning. But in the second year, bulk density on burned areas rose sharply to 1.169, compared to 1.042 on check plots. After 4 years, there was no significant difference in bulk density between burned and unburned plots. The low density 1 year after burning was probably caused by decay of small roots of fire-killed stems. The subsequent rapid increase was probably caused by silting in of root holes.

Changes in detention porosity (macropore space) while retention porosity (micropore space) remained constant support this contention. Detention porosity increased from 23.4 to 27.8 percent during the first year after burning. The following year, it dropped to 21.1 percent and little change has been observed since.

Generally, all the detrimental effects of burning on the physical properties of the soil were most evident 2 years after burning. They disappeared within 4 years after burning.

LITERATURE CITED

1. Bouyoucos, G. J.
1936. Directions for making mechanical analyses of soils by the hydrometer method. Soil Sci. 42: 225-229, illus.

2. Leamer, R. W., and Shaw, B.
1941. A simple apparatus for measuring noncapillary porosity on an extensive scale. J. Amer. Soc. Agron. 33: 1003-1008, illus.

3. Yoder, R. E.
1936. A direct method of aggregate analysis of soils and a study of the physical nature of erosion losses. J. Amer. Soc. Agron. 28: 337-351, illus.

SOUTHERN FOREST EXPERIMENT STATION

1966

U.S. FOREST SERVICE RESEARCH NOTE

SO-47

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

1966 HARVEST, CROSSETT FARM FORESTRY FORTIES

R. R. Reynolds

SOUTHERN FOREST EXPERIMENT STATION

Annual selective cutting from two "farm forties" established in 1937 by the Southern Forest Experiment Station at Crossett, Arkansas, is continuing to demonstrate the feasibility of managing small tracts of shortleaf and loblolly pine by this method. The 1966 stumpage return from the tract that long ago was called the "good forty" was $1,009 and from the tract called the "poor forty" was $633.

Originally the good forty was reasonably well stocked with timber, and the poor forty—really 34 acres but dubbed "forty" for convenience—was badly depleted. Annual harvests began on the good forty in 1938 and on the depleted tract in 1939. The tracts have been managed to grow as many large, high-quality logs as possible, with pulpwood, posts, and perhaps poles as important secondary production. By 1952, the poor forty had about the same cubic-foot stocking per acre as the other tract, because up to this time annual harvests had been held to less than the annual growth. Since then annual cuts have been about equal to growth, as was the case from the beginning on the good forty.

In 1966, the harvest from the good forty was obtained by cutting only 39 trees—mostly in the 20-26 inch d.b.h. classes. Many of these trees were still growing well, but had reached, or would soon reach, financial maturity. About half of the 1966 harvest from the poor forty was pulpwood, because the stand is still young and rapid crown development has made repeated thinning desirable. The remainder of the 1966 harvest from the poor forty was logs.

A different comparison of current and past financial returns from harvests of forest products has been adopted for this and subsequent reports. Stumpage, roadside, and market values of all products cut since 1937, shown for this report in tables 2 and 4, will be based on prices that are current for the year of the publication. Previously, stumpage and market values were used applicable to the year in which the products were cut. Using dollar figures whose values have lessened over the years made for more and more distorted comparisons. Such reckoning has also favored the poor forty because much less volume was cut from this tract during the early years, when stumpage prices were lower, than from the good forty.

Table 1.—*Good forty: products cut, 1966*

Item	Logs	Pine pulpwood	Total
	Bd. ft. (Doyle)	*Standard cords*	
Volume cut	24,954	2.24	..
VALUE (DOLLARS) ON STUMP			
Total value	998.16	11.20	1,009.36
Per unit	40.00	5.00	..
Per acre	24.95	.28	25.23
VALUE (DOLLARS) DELIVERED AT MARKET			
Total value	1,409.90	36.96	1,446.86
Per unit	56.50	16.50	.
Per acre	35.25	.92	36.17

Table 2.—*Good forty: total harvest, 1938-66, inclusive. (Dollar values of 1966 have been applied to total production.)*

Item	Logs	Pine pulpwood	Hardwood pulpwood, chemical wood, and fuelwood	Posts	Total
	Bd. ft. (Doyle)	*Standard cords*	*Standard cords*	*Number*	
Volume cut	444,395	430.04	228.45	418	.
Per acre	11,110	10.75	5.71	10.45	.
VALUE (DOLLARS) ON STUMP					
Total value	17,775.80	2,150.20	228.45	20.90	20,175.35
Per unit	40.00	5.00	1.00	.05	.
Per acre	444.40	53.76	5.71	.52	504.39
Per acre-year	15.32	1.85	.20	.02	17.39
VALUE (DOLLARS) DELIVERED AT MARKET					
Total value	25,108.32	7,095.66	2,969.85	62.70	35,236.53
Per unit	56.50	16.50	13.00	.15	.
Per acre	627.71	177.39	74.25	1.57	880.92
Per acre-year	21.65	6.12	2.56	.05	30.38
VALUE (DOLLARS) AT ROADSIDE					
			Total		Per acre
1966 cut			1,228.11		30.70
Cut to date			27,705.94		692.65

Annual stumpage returns, based on current values, have averaged $17.39 per acre from the good and $11.36 from the poor forty. They are not net returns, of course; costs would have to be deducted for the labor of timber stand improvement, timber marking, or other work usually performed by the owner. Also, there are undeducted miscellaneous costs, currently averaging about $1.00 per acre per year, for such things as land taxes, fire protection, tree marking paint, and tools.

Management at Crossett has been worthwhile. Returns to owners of similar tracts will vary as site quality and local markets vary, and will depend in part upon initial cost of the land. But—assuming a reasonable base and growth to work with—practical management by the small landowner can also be worthwhile.

Table 3.—*Poor forty: products cut, 1966*

Item	Logs	Pine pulpwood	Total
	Bd. ft. (Doyle)	*Standard cords*	
Volume cut	12,351	27.86	...
	VALUE (DOLLARS) ON STUMP		
Total value	494.04	139.30	633.34
Per unit	40.00	5.00	.
Per acre	14.53	4.10	18.63
	VALUE (DOLLARS) DELIVERED AT MARKET		
Total value	697.83	459.69	1,157.52
Per unit	56.50	16.50	.
Per acre	20.52	13.52	34.04

Table 4.—*Poor forty: total harvest, 1939-66, inclusive. (Dollar values of 1966 have been applied to total production.)*

Item	Logs	Pine pulpwood	Hardwood pulpwood, chemical wood, and fuelwood	Posts	Total
	Bd. ft. (Doyle)	*Standard cords*	*Standard cords*	*Number*	
Volume cut	219,610	370.77	158.42	220	.
Per acre	6,459	10.90	4.66	6.47	.
	VALUE (DOLLARS) ON STUMP				
Total value	8,784.40	1,853.85	158.42	11.00	10,807.67
Per unit	40.00	5.00	1.00	.05	.
Per acre	258.36	54.52	4.66	.32	317.86
Per acre-year	9.23	1.95	.17	.01	11.36
	VALUE (DOLLARS) DELIVERED AT MARKET				
Total value	12,407.96	6,117.70	2,059.46	33.00	20,618.12
Per unit	56.50	16.50	13.00	.15	.
Per acre	364.94	179.93	60.57	.97	606.41
Per acre-year	13.03	6.43	2.16	.03	21.65
	VALUE (DOLLARS) AT ROADSIDE				
			Total		Per acre
1966 cut			895.43		26.34
Cut to date			15,712.89		462.14

GOOD FORTY

Table 5.—*Number of pine trees and volume per acre*

Year	Trees		Volume			Growth yearly	
	4 to 12 in. d.b.h.	12 + in. d.b.h.	4 + in. d.b.h.		12 + in. d.b.h.	4 + in. d.b.h.	12 + in. d.b.h.
	– – Number – –		*Cu. ft.*	*Standard cords*	*Bd. ft. (Doyle)*	*Cu. ft.*	*Bd. ft. (Doyle)*
1937	102	30	1,793	21.2	5,074		. . .
1941	91	31	1,872	22.1	5,766	81	244
1946	51	31	1,740	20.5	6,454	52	372
1951	46	36	1,968	23.2	8,295	98	596
1956	48	32	1,733	20.5	7,438	50	249
1960	82	34	2,008	23.7	8,364	125	504
1965	112	31	1,995	23.6	7,781	90	328

POOR FORTY

Year	Trees		Volume			Growth yearly	
	4 to 12 in. d.b.h.	12 + in. d.b.h.	4 + in. d.b.h.		12 + in. d.b.h.	4 + in. d.b.h.	12 + in. d.b.h.
	– – Number – –		*Cu. ft.*	*Standard cords*	*Bd. ft. (Doyle)*	*Cu. ft.*	*Bd. ft. (Doyle)*
1937	68	17	976	11.5	2,341		. . .
1941	71	21	1,214	14.3	3,135	86	231
1946	68	19	1,179	13.9	3,701	57	251
1951	105	25	1,501	17.7	4,583	121	391
1956	131	24	1,480	17.5	4,339	75	264
1960	163	29	1,863	22.0	5,304	174	514
1965	173	30	1,952	23.0	4,982	144	404

SOUTHERN FOREST EXPERIMENT STATION

1966

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FOREST TAX TRENDS IN LOUISIANA

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SOUTHERN FOREST EXPERIMENT STATION

Average assessments of forest land are declining, severance receipts are rising rapidly. Although reclassification of woodlands under the 1954 Forest Tax Law is virtually complete, widespread discrepancies still exist in assessments.

Two principal taxes affect timber growers in Louisiana—the property or ad valorem tax on forest lands, and the severance tax. Both levies were delineated in the Forest Tax Law of 1954, which took effect January 1, 1955. Previously, timberlands were on a severance tax basis—land and growing timber were taxed together and the timber was taxed again when cut. Now taxes on timber are postponed until time of harvest under the yield tax principle, though the term "severance tax" is still used. Only ad valorem taxes on the land are collected annually.

This paper describes recent trends in each tax, updating information published in 1961 *(4)*, 1962 *(2)*, and 1964 *(3)*. It also discusses other significant fiscal measures affecting Louisiana woodland owners and timber dealers.

PROPERTY TAXES

In Louisiana property taxes account for only 23 percent of total State and local tax revenues. This is half the national average. However, such revenue from timberlands is important to the State and parishes. Commercial woodland is found in 63 of the 64 parishes and constitutes a significant portion of the property tax assessment base. In 1959 property taxes on timberland totaled $4 million; today the yield is probably much greater.

Louisiana presently has 26 million acres of rural land. Since passage of the 1954 law land classified as forest by assessors has varied between a low of 13.2 and a high of 14.7 million acres, without discernible trend. In the same time, woodland assessments have become a more significant part of the rural land assessment base. In the years immediately following passage of the law, woodlands accounted for about 28 percent of total rural land valuations. By 1962 the proportion had risen to 33 percent, where it has since remained.

Classification virtually complete.—The 1954 act required assessors to classify all timberland, except that under reforestation contract, into one of four types—tidewater cypress, longleaf pine, other pine, or hardwood. Decisions previously had been left up to the individual assessors, and the result was a multiplicity of categories that created much confusion. The requirement was largely met by 1963. The 1965 tax rolls list 7.8 million acres of other pine land, 4.0 million of hardwood, 1.5 million of cypress, and 0.5 million of longleaf pine.

The only discrepancy continues to be the large amount of forest acreage classed as miscellaneous land, which is defined by the State Tax Commission as "land not permitting of more specific classification." Such acreage has steadily increased since 1955. A particularly big rise—18 percent—occurred between 1963 and 1965. This was primarily because assessors in three parishes—Ascension, Richland, and St. Tammany—reclassified much of the woodland on their rolls from the forest categories to miscellaneous. Reasons for the change are unclear. About two-thirds of the forest acreage listed as miscellaneous in 1965 lies in 8 of the 34 parishes reporting such land. Two parishes—Acadia and Richland—assess all their large acreages of woodland as miscellaneous.

Assessments are falling.—The 1954 law limited future increases in forest ad valorem assessment to bare land but permitted previous assessments of timber to be continued. Between 1955 and 1961, almost yearly increases raised the average nearly 15 percent, from $5.08 to $5.82 an acre. Beginning in 1962, however, the average assessment began to decline, and by 1965 it was $5.45 per acre. Average assessments per parish in 1965 are shown in table 1. Three parishes—Orleans, Jefferson, and Cameron—did not show woodlands on their 1965 tax rolls, though timber was commercially harvested in the last two. Generally, parishes with the lowest timberland assessments are in south Louisiana (fig. 1) and those in the middle range of valuations are in the central and northern parts of the State. Those with high assessments are scattered.

Each year since 1954 pine lands have had the highest average assessed value, with hardwood and cypress tracts next in order. Statewide valuations in 1965 averaged $5.80 per

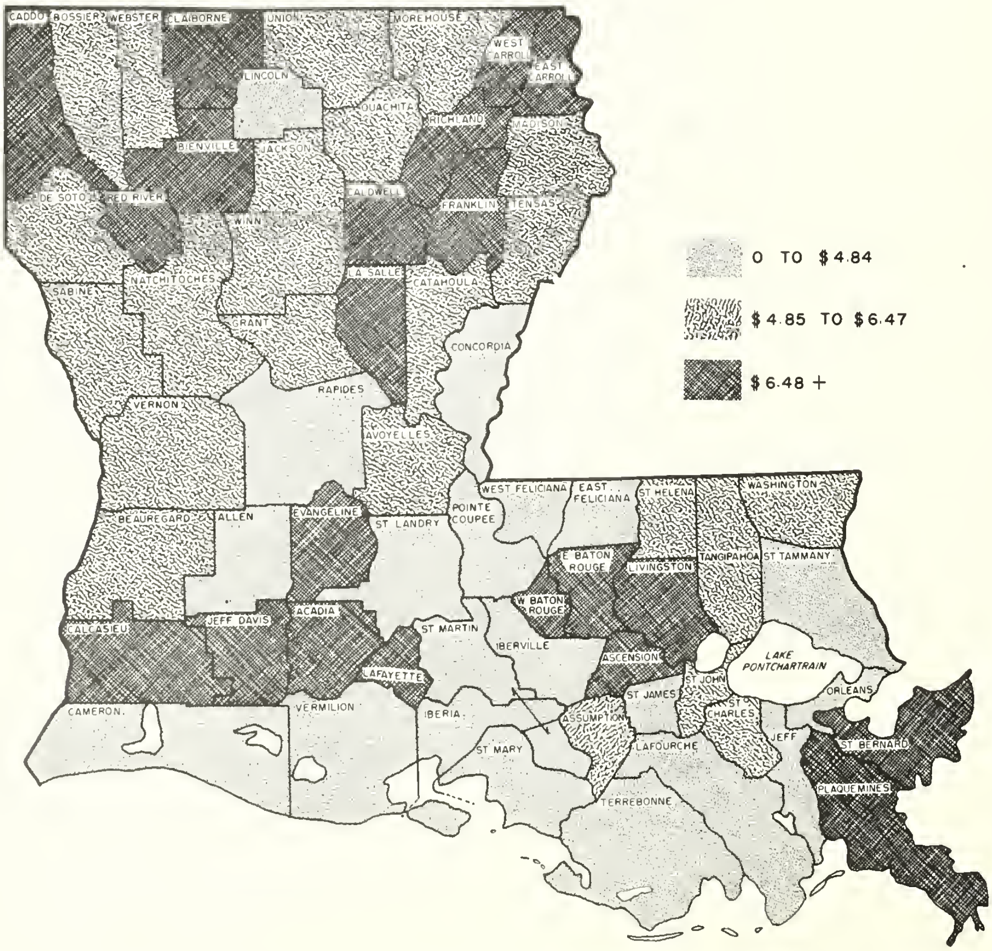


Figure 1.—*Average assessment per forest acre, by parishes, 1965.*

Table 1.—*Average assessment, proportions of woodland in various assessment categories, and total assessed forest land for Louisiana parishes in 1965*

Parish	Assessment per acre, average of all categories [1]	Assessment category						Total land, all categories
		Hardwood	Other pine	Longleaf pine	Tidewater cypress	Miscellaneous [2]	Reforestation contract	
	Dollars	*Percent*						*Acres*
Acadia	10.54	...	...	...	...	100	...	95,637
Allen	4.11	2	69	2	2	...	25	396,497
Ascension	8.74	68	...	...	...	32	...	77,430
Assumption	2.94	...	40	...	60	...	...	152,696
Avoyelles	3.23	82	...	6	3	9	...	339,150
Beauregard	5.65	1	69	27	...	...	3	676,095
Bienville	6.65	8	92	...	...	...	...	418,969
Bossier	6.35	4	93	(3)	...	...	3	319,559
Caddo [4]	15.60	...	...	...	...	...	...	361,015
Calcasieu	6.79	5	68	...	3	13	11	229,498
Caldwell	7.43	32	68	...	...	...	...	298,805
Cameron	...	...	...	...	...	...	...	...
Catahoula	5.87	75	25	...	...	...	...	377,630
Claiborne	7.06	...	100	...	...	...	...	278,282
Concordia	3.70	100	...	...	...	...	...	367,124
De Soto	5.03	1	99	...	...	...	...	416,785
E. Baton Rouge	32.43	11	4	...	7	78	...	36,250
E. Carroll	7.09	77	...	...	...	23	...	108,417
E. Feliciana	4.29	(3)	100	...	...	...	...	141,047
Evangeline	6.63	47	27	5	...	21	...	252,612
Franklin	9.25	100	...	...	...	...	...	221,753
Grant	5.77	4	96	...	...	...	...	236,061
Iberia	2.77	37	...	...	63	...	...	86,880
Iberville	1.95	4	...	...	96	...	...	297,199
Jackson	5.20	3	97	...	...	...	...	330,358
Jefferson	...	...	...	...	...	...	...	...
Jefferson Davis	11.46	100	...	...	...	...	...	63,212
Lafayette	11.43	100	...	...	...	...	...	13,114
Lafourche	4.18	(3)	...	...	78	22	...	219,414
La Salle	6.94	17	83	...	...	...	...	320,827
Lincoln	4.70	...	...	...	...	...	100	152,862
Livingston	7.09	30	55	...	13	...	2	372,660
Madison	5.24	100	...	...	...	...	...	267,025
Morehouse	5.42	51	37	...	1	11	...	358,597
Natchitoches	6.23	17	83	...	(3)	...	...	470,865
Orleans	...	...	...	...	...	...	...	...
Ouachita	6.47	34	66	...	(3)	...	...	252,140
Plaquemines	18.54	100	...	...	...	...	...	2,483
Pointe Coupee	3.73	58	...	...	14	28	...	241,219
Rapides	4.73	33	50	17	...	...	...	545,941
Red River	6.77	24	76	...	(3)	...	...	130,711
Richland	7.43	...	...	...	...	100	...	200,818
Sabine	5.00	14	86	...	...	...	...	515,078
St. Bernard	11.70	80	...	...	20	...	...	13,596
St. Charles	5.34	...	...	...	100	...	...	44,398
St. Helena	5.42	23	77	...	...	...	...	216,034
St. James	4.00	...	...	...	100	...	...	85,121
St. John	5.11	2	...	...	98	...	...	106,367

[1] Does not include reforestation contract lands.
[2] Estimated.
[3] Less than 0.5 percent.
[4] Caddo Parish assesses all its timberlands as class C agricultural lands.

Table 1.—*Average assessment, proportions of woodland in various assessment categories, and total assessed forest land for Louisiana parishes in 1965* (Continued)

Parish	Assessment per acre, average of all categories [1]	Assessment category						Total land, all categories
		Hardwood	Other pine	Longleaf pine	Tidewater cypress	Miscellaneous [2]	Reforestation contract	
	Dollars	*Percent*						*Acres*
St. Landry	4.84	100	...	...	...	...	...	315,079
St. Martin	1.66	1	...	...	99	...	...	321,352
St. Mary	3.31	...	...	...	100	...	...	62,849
St. Tammany	4.35	16	58	...	...	20	6	447,857
Tangipahoa	6.15	2	78	...	14	...	6	385,555
Tensas	5.30	100	...	...	...	...	...	261,789
Terrebonne	2.12	...	...	...	100	...	...	101,363
Union	5.03	13	87	...	...	...	...	453,015
Vermilion	3.97	21	...	...	...	79		66,438
Vernon	6.10	2	75	23	([3])	...	...	617,892
Washington	5.75	20	70	...	...	...	10	323,554
Webster	6.44	4	96	...	...	...	...	178,071
W. Baton Rouge	6.50	100	...	...	...	...	...	67,566
W. Carroll	9.26	2	...	...	...	98	...	90,044
W. Feliciana	4.62	82	14	...	4	...	...	139,009
Winn	5.51	3	87	...	...	...	10	473,376

acre for other pine, \$5.76 for longleaf pine, \$5.43 for hardwood and \$2.90 for cypress lands. The range of parish averages for each category is shown in table 2.

Table 2.—*Range of average parish assessments per acre, 1965*

Land class	High	Low
	Dollars	
Tidewater cypress	9.22	1.50
Hardwood	18.54	3.03
Longleaf pine	6.24	3.23
Other pine	8.81	2.82

The valuation decline that began in 1962 has not been shared by other pine and hardwood lands. During the last 4 years average assessments for these two categories rose about 1 percent, while those for cypress and longleaf pine acreage dropped 5 and 2 percent respectively. The principal reason for the overall decline has been decreased assessments and reclassification of woodlands in the miscellaneous category.

Pine lands lead in acreage.—Since 1954 about half of Louisiana's taxed woodlands have been assessed as other pine. Hardwood, cypress, and longleaf pine have consistently followed in that order with proportions of about 27, 10, and 3 percent respectively. The remaining 10 percent consists of acreage in the miscellaneous and reforestation contract classes.

Half of the State's 64 parishes reported other pine land in 1965—2 less than in 1964. Ten parishes—eight in north Louisiana—contain more than half the acreage in this class. Of the 51 assessing hardwood land in 1965 (1 less than in 1964 and 2 less than in 1963), 8 Delta parishes contain more than half the total. Generally, hardwood tracts are assessed higher in south Louisiana than elsewhere in the State.

Five southern parishes contain almost two-thirds of the State's cypress acreage; the remainder is distributed among 19 parishes. Seven parishes had longleaf pine land on their tax rolls in 1964 and 1965—three less than in 1963. Two in west-central Louisiana—Beauregard and Vernon—had more than 70 percent of the longleaf acreage, and also assessed longleaf lands the highest.

Allen and Vernon Parishes reported forest land in all four assessment categories in 1964 and 1965. No parishes had done so previously. Two years ago, 19 parishes assessed three classes of woodland, but the number dropped to 13 in 1965. Most of the others classify two types.

Timber acreage down in urban parishes.—Parishes with large populations, or high per capita income, or both, tend to assess their

timber acreage highest. East Baton Rouge, Calcasieu, Lafayette, St. Bernard, Jefferson, Plaquemines, Caddo, Bossier, and Ouachita Parishes value woodland considerably above the average. Each had higher tax millage, on the average, in 1965 than in 1963. Each also had less timber acreage on the tax rolls in 1965 than in 1963.

This trend probably reflects actual and potential value of forest land for suburban residential development and industrial parks. Timberlands are generally less able to absorb tax increases than are most other types of property. Thus, in parishes experiencing metropolitan growth, commercial timber acreage probably will continue to dwindle.

SEVERANCE TAXES

Before 1955 all severance taxes collected on timber went to the Louisiana Forestry Commission. Now three-fourths of this revenue is returned to the parish of origin and the remainder goes into the State's general fund.

At time of harvest, sawtimber is taxed at 2¼ percent and pulpwood at 5 percent of current average stumpage market value by species. These values are determined annually by the Louisiana Forestry Commission and the Louisiana Tax Commission. In 1965 taxes ranged from 10 cents per cord for hardwood pulpwood to 65¼ cents per thousand board feet for pine sawtimber.

Timber severance collections have been rising sharply in recent years because harvests of both sawtimber and pulpwood have been increasing. The yield in 1965 was $925,000 as compared to $803,000 in 1963 and $565,000 in 1955.

Petroleum products account for the bulk of the severance taxes collected by the State. Eight other resources—including timber—provide the remainder. Since passage of the Forest Tax Law, income from timber has gradually become more important and now ranks second only to sulfur receipts in the nonpetroleum group. In this group the proportion attributable to timber has recently been about 20 percent, as compared to about 16 percent before the law took effect.

The increase in timber severance revenue seems certain to continue as Louisiana's forest industries keep expanding. It has perhaps convinced some assessors that the Forest Tax Law provides for adequate parish revenues from timberland. This consideration may have influenced the lower assessments since 1962.

OTHER REVENUE MEASURES

Reforestation contract taxes.—A reforestation contract law passed in 1922 and a reforestation contract severance tax enacted in 1926 were not supplanted by the 1954 law. These acts as amended permit landowners who reforest denuded land to contract with the State and parish for a low fixed assessment—$3 to $8 per acre—on the land and none on the planted timber. However, a severance tax—6 percent of market value—is paid on products when cut. Three-fourths of this revenue goes to the parish of origin and one-fourth to the State general fund. After a maximum of 40 years from the date of contract for land, and after 50 years for timber remaining thereon, regular ad valorem taxation becomes effective.

Contract acreage peaked in 1953, at 670,000 acres. Then the total steadily declined, until by 1964 only 312,000 acres remained. In 1965, however, new contracts in Beauregard and Lincoln Parishes raised the total to 451,000 acres—a gain of 44 percent.

Receipts from the reforestation severance tax have steadily declined in the last decade. Only $64,000 was collected in fiscal year 1964-65. The contract law will probably be of limited importance in future years, as its most advantageous features were incorporated in the Forest Tax Law.

Taxes on virgin timber.—Prior to the new law a general severance tax was levied on timber. It ranged from 25 cents to $1.50 per thousand board feet for sawtimber, depending on species, and was 15 cents per cord for pulpwood. The entire revenue was allocated to the State Forestry Commission.

Because of a 1955 opinion by Louisiana's Attorney General, virgin timber is still subject to these old rates as well as to ad valorem taxation. But there are few virgin woodlands remaining, and in practice the Department of Revenue never applies the old severance taxes but only the new ones. However, ad valorem levies are still collected on virgin timber in some parishes.

Forest acreage tax.—A Forest Acreage Tax, not to exceed 2 cents per acre, has been authorized in Louisiana since 1944. Revenues from the tax—which is paid by woodland owners and collected by the parishes—are placed in a Forestry Fund administered by the State for protecting woodlands from fire and other damage. The State and Federal governments contribute at least twice the amount deposited each year by the participating parishes. Allocations from the fund are then prorated to each of these parishes, of which there were 31 in 1965.

The maximum tax of 2 cents per acre is collected in 28 parishes. In the other three the rate is ½ cent. Most of the parishes without this tax are in southern Louisiana.

Taxes on yard lumber.—In 1965 ad valorem taxes on lumber in the yards of sawmills and wholesalers were collected in 34 parishes—virtually all in central and northern Louisiana. Five species categories are assessed—oak, gum, cypress, pine, and miscellaneous. Miscellaneous lumber was valued the highest in 1965, on the average, and cypress, pine, oak, and gum followed in order (table 3).

Table 3.—*Range of average parish assessments of yard lumber per M bd. ft., 1965*

Species group	High	Low	Average
		– – – – Dollars – – – –	
Gum	18.00	12.00	15.63
Oak	23.13	6.15	17.13
Pine	53.54	12.00	20.45
Cypress	60.79	19.99	27.02
Miscellaneous	272.60	8.22	45.55

Lumber in retail yards, if taxed, is usually assessed on the basis of retail value and classed with other retail goods as merchandise.

TOWARD EQUITABLE TAXATION

Three factors that commonly cause taxes to affect timber growing adversely are the high cost of local government, faulty administration of the property tax, and substantial acreages of forest lands that offer little prospect of early income from which to meet annual taxes *(5)*. All three are found in Louisiana. State and parish officials have had a difficult task in bringing about tax reforms while faced with a need for increased revenue with which to finance rising expenditures.

The 1954 law was designed to give relief to woodland owners who have little prospect of timber income for many years. It has created a generally favorable forest tax climate. Many inequities still exist, however, as shown by the wide range of assessments both within classifications and parishes, and between parishes.

The most significant improvement from the viewpoint of the forest owner and other taxpayers can be achieved through more accurate and equitable assessments of woodland within provisions of the present law. With such a statute in force, other modifications of the property tax appear unnecessary and perhaps would prove disadvantageous. The Advisory Committee on Intergovernmental Relations *(1)* states that, although preferential property taxes appear to operate without cost to State and local governments, they do, in fact, impose a forced expense on the taxpayers to whom the burden has been shifted, complicate tax administration, and progressively weaken the entire property tax system.

Two things are basic to improving the quality and uniformity of assessment practice in Louisiana: standardization of assessment procedures among parishes, and instruction of parish assessors in valuation techniques applicable to timber land. Because of its investigative and regulatory powers, the Louisiana State Tax Commission is in an ideal position to provide leadership for accomplishing both tasks.

LITERATURE CITED

1. Advisory Commission on Intergovernmental Relations.
   1963. The role of the States in strengthening the property tax. Vol. 1 (A-17): 1-187.
2. Siegel, W. C.
   1962. Forest land assessments rising in Louisiana. U. S. Forest Serv. Southern Forest Exp. Sta. Southern Forest. Notes 142.
3. ——————
   1964. Forest tax law at work. Forest Farmer 24(3): 14-16.
4. —————— and Perry, J. D.
   1961. Forest taxation in Louisiana. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 187, 14 pp., illus.
5. Williams, E. T.
   1961. Trends in forest taxation. Nat. Tax J. 14(2): 113-144.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-49

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

RANDOM INTEGER DISPENSER

Clement Mesavage
SOUTHERN FOREST EXPERIMENT STATION

The random integer dispenser described herein[1] was designed to accommodate lists of random numbers printed by Grosenbaugh's THRP computer program.[2] The dispenser provides convenient sequential reference to the numbers without disclosing them prematurely. Such an arrangement is necessary to prevent sampling biases, because foreknowledge of the next random number may influence the sequence in which samples are selected.

The dispenser consists of a cast aluminum case with a hinged lid. The case measures $1\frac{1}{4}$ by $3\frac{1}{8}$ by $5\frac{5}{8}$ inches and contains two metal spools on which a printout tape is wound. External knobs are used to advance the tape so that rows of numbers may be viewed through a longitudinal slot in the lid (fig. 1). Printouts must be trimmed and joined to form a continuous tape. The spools are loaded into the dispenser in about the way film is placed in a box camera. The tape is held near the slot by a metal spanner that also serves as a support if it is desired to jot notes on the tape. Tape tension is provided by rubber grommets that bear against the inner surfaces of the knobs, and is easily adjusted by loosening or tightening the knobs.

The dispenser holds five columns of random numbers (a computer half-page), and about 20 half pages can be spliced into a tape having about 5,000 random numbers. Since five columns of numbers are simultaneously exposed in the dispenser slot, up to five independent samplings can be made for each tree that is visited. When only one is needed per tree, a new number is rotated into view for each tree until a column has been exhausted.

Each printout sheet consists of two lines of heading that identify the job and input parameters, followed by 50 rows of numbers in 10 columns. A four-character identifier is printed below each column. As shown in figure 2, the pages are cut on a line that connects a point between Z and = on successive sheets, then trimmed to a width of 3.6 inches. Excessive heading space should be snipped from each strip, but the four-character identifier should be retained. An even spool wind is assured if strips are positioned against a straight edge before they are joined. A 3/16-inch strip over-

[1] The instrument was developed primarily while the author was on the staff of the Southern Forest Experiment Station, at Harrison, Arkansas. He is now Forester, Division of Timber Management, National Forest System, U. S. Forest Service.

[2] Grosenbaugh, L. R. Three-Pee sampling theory and program 'THRP' for computer generation of selection criteria. U. S. Forest Serv. Res. Pap. PSW-21, 53 pp., illus. Pacific Southwest Forest and Range Exp. Sta., Berkeley, Calif. 1965.

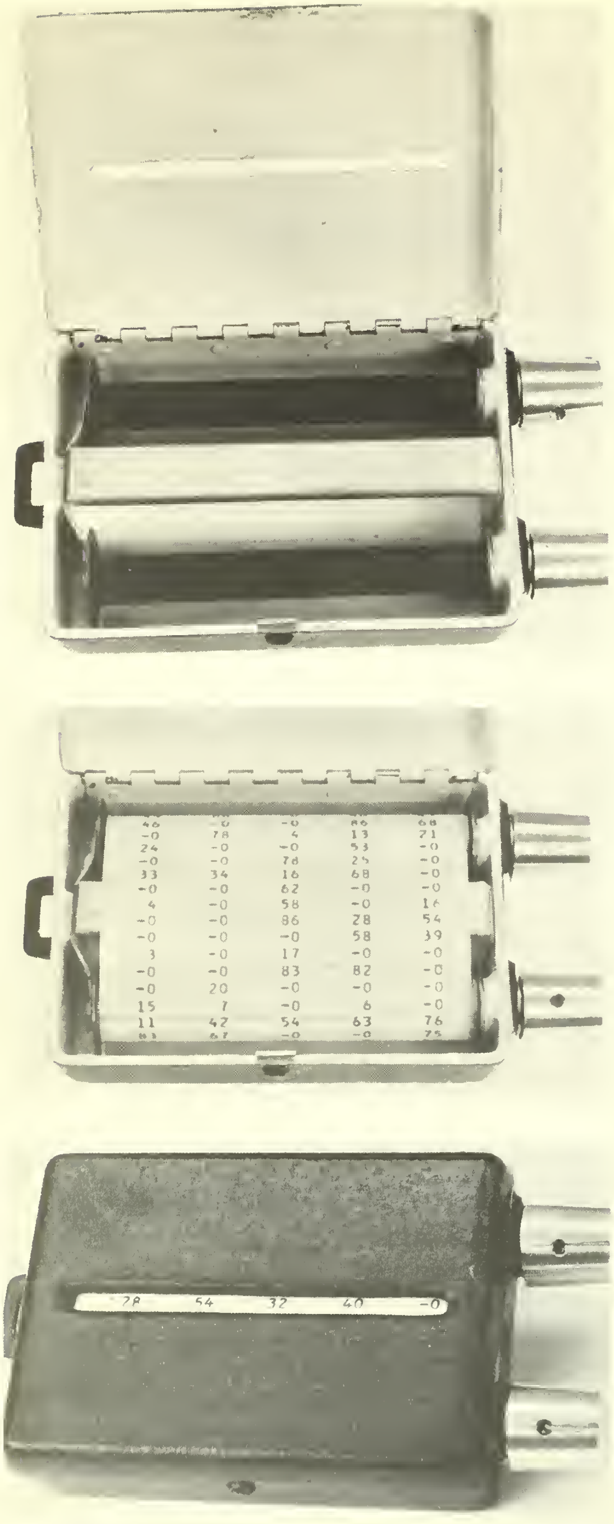
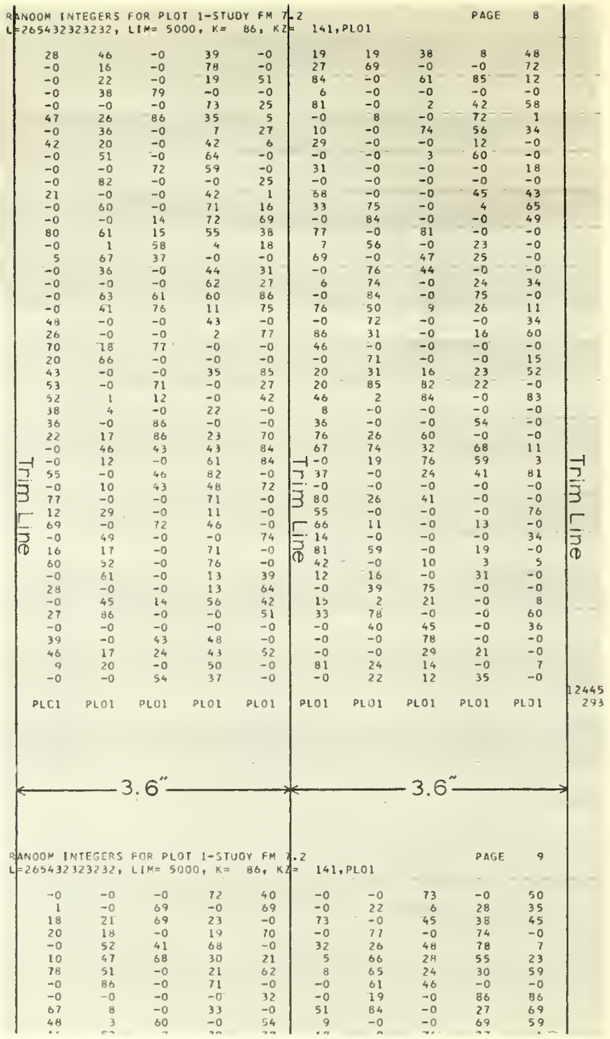


Figure 1.—*The random integer dispenser. Above: Ready for loading with tape. Middle: With tape on spools. Below: Cover closed, instrument ready for use. The dispenser is manufactured by the Bruce Company, P. O. Box 3031, Springfield, Missouri 65804.*



RANOOM INTEGERS FOR PLOT 1-STUDY FM 7.2 PAGE 8
L=265432323232, LIM= 5000, K= 86, KZ= 141,PLO1

28	46	-0	39	-0	19	19	38	8	48
-0	16	-0	78	-0	27	69	-0	-0	72
-0	22	-0	19	51	84	-0	61	85	12
-0	38	79	-0	-0	6	-0	-0	-0	-0
-0	-0	-0	73	25	81	-0	2	42	58
47	26	86	35	5	-0	8	-0	72	1
-0	36	-0	7	27	10	-0	74	56	34
42	20	-0	42	6	29	-0	-0	12	-0
-0	51	-0	64	-0	-0	-0	3	60	-0
-0	-0	72	59	-0	31	-0	-0	-0	18
-0	82	-0	-0	25	-0	-0	-0	-0	-0
21	-0	-0	42	1	68	-0	-0	45	43
-0	60	-0	71	16	33	75	-0	4	65
-0	-0	14	72	69	-0	84	-0	-0	49
80	61	15	55	38	77	-0	81	-0	-0
-0	1	58	4	18	7	56	-0	23	-0
5	67	37	-0	-0	69	-0	47	25	-0
-0	36	-0	44	31	-0	76	44	-0	-0
-0	-0	-0	62	27	6	74	-0	24	34
-0	63	61	60	86	-0	84	-0	75	-0
-0	41	76	11	75	76	50	9	26	11
48	-0	-0	43	-0	-0	72	-0	-0	34
26	-0	-0	2	77	86	31	-0	16	60
70	18	77	-0	-0	46	-0	-0	-0	-0
20	66	-0	-0	-0	-0	71	-0	-0	15
43	-0	-0	35	85	20	31	16	23	52
53	-0	71	-0	27	20	85	82	22	-0
52	1	12	-0	42	46	2	84	-0	83
38	4	-0	22	-0	8	-0	-0	-0	-0
36	-0	86	-0	-0	36	-0	-0	54	-0
22	17	86	23	70	76	26	60	-0	-0
-0	46	43	43	84	67	74	32	68	11
-0	12	-0	61	84	-0	19	76	59	3
55	-0	46	82	-0	37	-0	24	41	81
-0	10	43	48	72	-0	-0	-0	-0	-0
77	-0	-0	71	-0	80	26	41	-0	-0
12	29	-0	11	-0	55	-0	-0	-0	76
69	-0	72	46	-0	66	11	-0	13	-0
-0	49	-0	-0	74	14	-0	-0	-0	34
16	17	-0	71	-0	81	59	-0	19	-0
60	52	-0	76	-0	42	-0	10	3	5
-0	61	-0	13	39	12	16	-0	31	-0
28	-0	-0	13	64	-0	39	75	-0	-0
-0	45	14	56	42	15	2	21	-0	8
27	86	-0	-0	51	33	78	-0	-0	60
-0	-0	-0	-0	-0	-0	40	45	-0	36
39	-0	43	48	-0	-0	-0	78	-0	-0
46	17	24	43	52	-0	-0	29	21	-0
9	20	-0	50	-0	81	24	14	-0	7
-0	-0	54	37	-0	-0	22	12	35	-0
PLC1	PLO1	PLO1	PLO1	PLO1	PLO1	PLO1	PLO1	PLO1	PLO1

12445
293

RANOOM INTEGERS FOR PLOT 1-STUOY FM 7.2 PAGE 9
L=265432323232, LIM= 5000, K= 86, KZ= 141,PLO1

-0	-0	-0	72	40	-0	-0	73	-0	50
1	-0	69	-0	69	-0	22	6	28	35
18	21	69	23	-0	73	-0	45	38	45
20	18	-0	19	70	-0	77	-0	74	-0
-0	52	41	68	-0	32	26	48	78	7
10	47	68	30	21	5	66	28	55	23
78	51	-0	21	62	8	65	24	30	59
-0	86	-0	71	-0	-0	61	46	-0	-0
-0	-0	-0	-0	32	-0	19	-0	86	86
67	8	-0	33	-0	51	84	-0	27	69
48	3	60	-0	54	9	-0	-0	69	59

Figure 2.—*Trimming specifications for preparation of a printout tape.*

lap is sufficient for a glue joint. If rubber cement is used, the excess should be rubbed off so the tape will not stick.

A computer printout can be divided and loaded into several dispensers if more than one enumerator is being employed—for example, in an appraisal for a large timber sale, each cruiser would carry a dispenser containing a portion of the computer output. For jobs that require more than 10,000 numbers, several computer runs may be stacked, each having the same parameters. Thus if 15,000 numbers are needed, two outputs each with a limit of 7,500 can be programmed.

Although the THRP computer program was designed primarily for 3P sampling of timber sales, it is also useful for other types of sample enumeration. Figure 3, for example, shows an output in which random numbers were programmed for equal probability with K = 1, and (K+Z) = 5, following the procedure for punching the control cards explained on pages 50 and 51 of Grosenbaugh's publication. An output of rectangular arrangements of random numbers, as shown by figure 4, is similarly obtained. Here, the value for K is made ((K+Z) —1). By making (K+Z) equal to 150 and K equal to 149, the spread of numbers was limited from 0 to 150.

Use of the random integer dispenser with these outputs reduces selection biases, just as it does for 3P random integers.

L=571634215342, LIM= 5000, K= 1, KZ= 5,SAME

1	-0	1	-0	-0	1	1	-0	1	-0	
-0	1	-0	-0	-0	-0	-0	-0	-0	-0	
-0	-0	1	-0	1	-0	-0	1	-0	-0	
-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	
-0	-0	1	1	-0	-0	-0	-0	-0	-0	
-0	1	-0	-0	-0	-0	1	-0	1	-0	
-0	1	-0	-0	-0	-0	-0	-0	1	-0	
-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	
-0	-0	-0	-0	1	-0	1	1	-0	-0	
-0	-0	-0	-0	1	1	-0	-0	1	-0	
-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	
-0	-0	-0	-0	-0	-0	1	-0	-0	-0	
1	-0	-0	1	-0	-0	-0	-0	-0	-0	
1	1	-0	1	-0	1	-0	1	-0	-0	
-0	1	-0	1	-0	-0	-0	-0	-0	-0	
1	-0	-0	-0	-0	1	-0	-0	-0	-0	
-0	-0	-0	-0	-0	-0	-0	1	-0	-0	
-0	1	-0	1	-0	-0	-0	1	-0	-0	
-0	-0	-0	-0	1	1	-0	1	-0	-0	
-0	-0	-0	-0	-0	-0	1	1	1	-0	
										103
SAME	SAME	SAME	SAME	SAME	SAME	SAME	SAME	SAME	SAME	103

Figure 3.—*Example of random number output for equal probability.*

L=265466666666, LIM= 5000, K= 149, KZ= 150,RECT

12	127	23	49	75	93	49	105	136	129	
117	29	27	27	119	120	57	20	145	63	
39	67	149	134	38	33	127	109	-0	32	
80	120	123	5	34	119	13	21	21	20	
128	70	17	77	90	63	129	143	137	110	
11	18	54	128	33	42	86	130	17	140	
40	34	144	12	115	-0	70	117	79	29	
3	133	135	145	126	55	39	68	1	108	
130	8	136	129	50	20	17	-0	30	60	
73	80	18	102	105	149	32	83	34	66	
139	93	114	94	41	4	7	36	43	71	
105	100	59	32	117	56	103	122	67	5	
13	42	29	51	96	114	2	101	116	29	
39	119	142	86	147	149	111	2	18	129	
97	114	74	25	-0	144	101	45	45	76	
116	74	112	61	35	146	54	40	60	145	
55	41	49	140	83	24	9	84	123	5	
105	121	68	116	84	104	63	121	79	116	
142	107	109	53	95	2	13	49	28	48	
99	105	87	26	136	24	143	147	60	60	
										37757
RECT	RECT	RECT	RECT	RECT	RECT	RECT	RECT	RECT	RECT	496

Figure 4.—*Example of rectangular population of random integers.*

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-50

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

MODIFICATION OF FP12 BARR AND STROUD DENDROMETER FOR EASIER FIELD USE

Clement Mesavage [1]

SOUTHERN FOREST EXPERIMENT STATION

The modifications comprise an aiming device, a transparent lens barrel, and a tripod that adjusts to rough terrain and includes a worm gear for fine adjustment of vertical tilt.

Since the development of a computer program to process readings from a Barr and Stroud dendrometer,[2] the instrument is being adopted increasingly for timber appraisals and for the measurement of upper-stem growth. To facilitate such use, the author first suggested mounting and sighting modifications for Model FP9, the earliest commercial model available in this country.[3] Some of the modifications have been anticipated in a new model, the FP12, but design changes have created need for other types of alterations. These were worked out in collaboration with the Bruce Company, Springfield, Missouri, and are described here.

The suggested improvements, or their equivalents, are to be incorporated in new instruments made for the U. S. Forest Service. They are also available in two replacement parts assemblies from Forestry Suppliers, Inc., Jackson, Mississippi, sole U. S. importers of the Barr and Stroud dendrometer. One assembly includes a finder for aiming the instrument, and a transparent lens barrel to improve visibility of the scale. The other consists of a tripod that not only permits use of the instrument on rough terrain but also has a much-needed fine adjustment for setting a vertical line of sight to supplement the coarse adjustment supplied by the instrument itself.

[1] The modifications described in this note were developed primarily while the author was on the staff of the Southern Forest Experiment Station, at Harrison, Arkansas. He is now Forester, Division of Timber Management, National Forest System, U. S. Forest Service.

[2] Grosenbaugh, L. R. STX—FORTRAN 4 program for estimates of tree populations from 3P sample-tree-measurements. U. S. Forest Serv. Res. Pap. PSW-13, 49 pp., illus. Pacific Southwest Forest and Range Exp. Sta., Berkeley, Calif. 1964.

[3] Mesavage, Clement. Aids for using Barr and Stroud dendrometers. Soc. Amer. Forest. Proc. 1964: 238-244, illus. 1965.

Both assemblies may be readily installed by the individual user.

SCALE-READING AND AIMING

As shown by figure 1, the lens barrel of the scale-magnifier is opaque. In heavy shade, or on overcast days, the scales are in comparative darkness. Fitting the lens barrel with a clear transparent tube, as illustrated in figure 2, allows sufficient light to get to the scales.

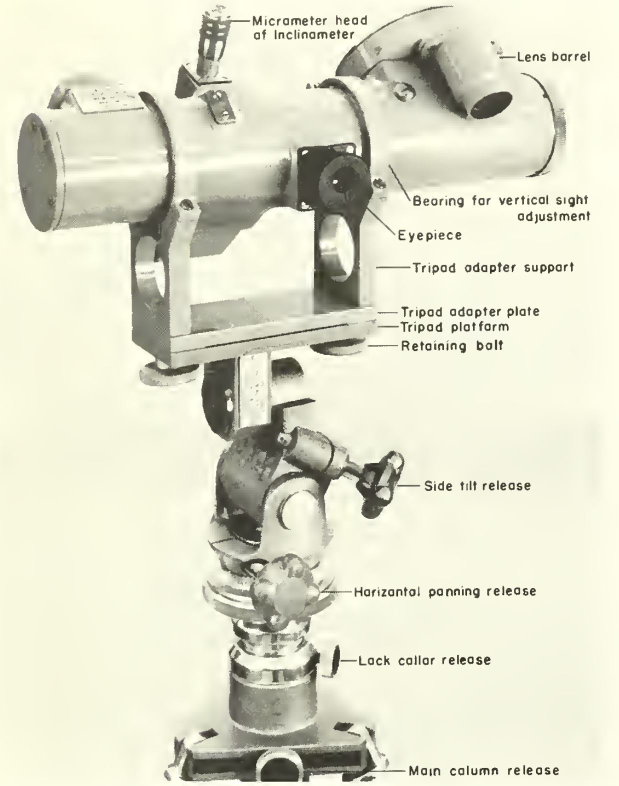


Figure 1.—*Model FP12 dendrometer and tripod head assembly as currently manufactured by Barr and Stroud.*

Extending the mounting flange of the lens barrel permits attachment of a holder for a detachable aiming device. The holder consists of a channel fastened to the flange extension with three machine screws, and a small ball bearing that provides adjustable clearance between the channel and the flange. The aiming device, a simple tube with a peep sight and a metal reticule, eliminates the confusion frequently encountered when aiming the magnifying telescope through foliage or directing the line of sight to some particular tree in a dense stand.

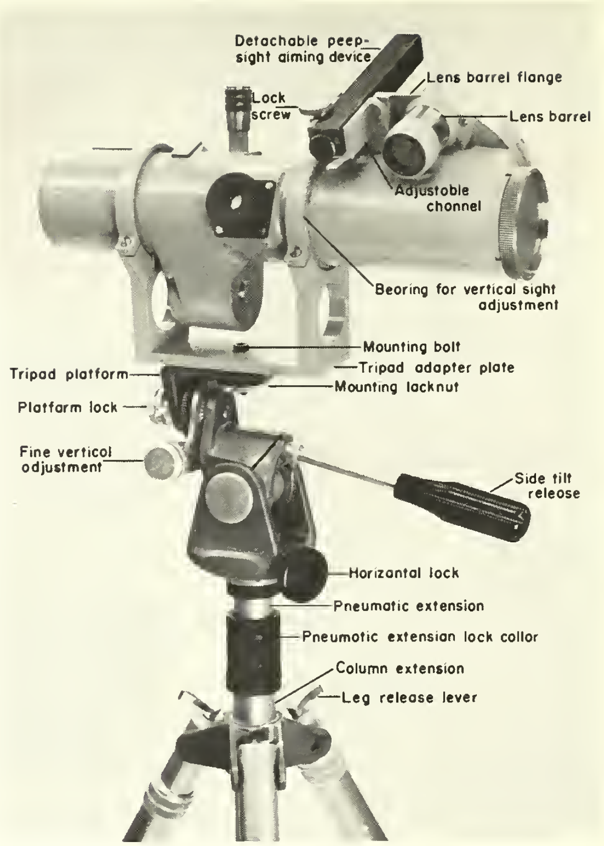


Figure 2.—*Current model FP12 after assembly of replacement parts for scale-reading, sighting, and mounting. The tripod has two-section legs tipped with cast aluminum step-on feet.*

To install the replacement lens barrel and channel support, the first step is to detach the existing magnifier. This is done by removing the four machine screws that hold it in place and prying the mount gently upwards out of the recess into which the lens barrel is fitted. The lens is seated in the forward end of the barrel and held in place by a threaded retaining ring. The ring can be turned out with a spanner wrench, and the lens and seating washers may then be pushed out from the back and transferred to the replacement lens barrel assembly.

Before the three screws on the aiming device are set up tight, the channel should be positioned so that the device sights to the same point as the magnifying telescope. Tightening the screws then makes this adjustment permanent.

TRIPOD MOUNTING

The instrument was further modified by replacing the tripod adapter plate with one that mounts on a Model PT-X tripod, made by Safelock, Inc., Hialeah, Florida, and altered for dendrometry by the Bruce Company. As shown in figure 3, the plate is fitted with a permanent adapter shoe machined to a wobble-free fit in a slot in the tripod platform. The shoe is held in the slot by a projecting bolt that slides into an open groove milled in the base of the slot. The arrangement allows the instrument to be mounted quickly and held firmly in place with a round locknut having a collar that recesses into the platform base.

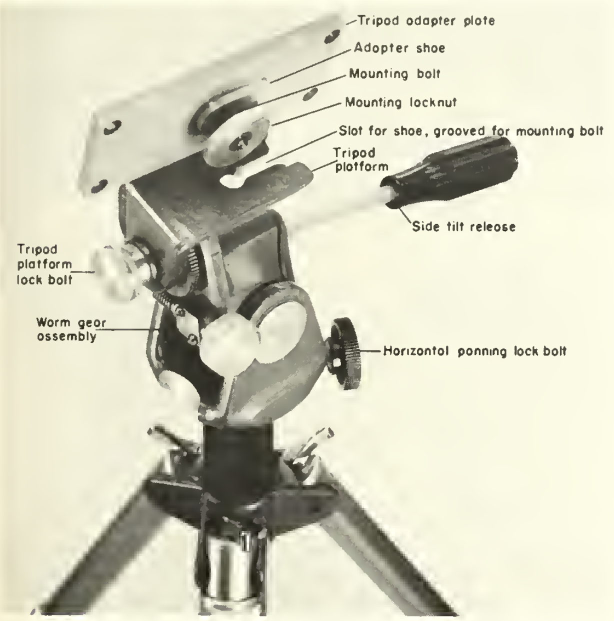


Figure 3.—*Replacement base plate and platform of replacement tripod. The round locknut has an inner shoulder that recesses into the platform for fast as well as safe mounting.*

The head of the Model PT-X tripod was also altered by the addition of a worm-gear assembly (fig. 3) for fine adjustment of vertical tilt. This adjustment makes it easy to center the level bubble for a given inclinometer reading, or to set the line of sight to a given point on a tree stem. Such an adjustment is not currently provided on the dendrometer itself. To avoid straining the gear assembly, users are cautioned not to attempt major changes in vertical tilt with this adjustment.

The tripod was modified further by fitting the legs with cast aluminum step-on feet that replace the original feet.

The tripod was otherwise not altered. As shown by figures 2 and 3, side tilt of the dendrometer is regulated with the handle that adjusts vertical tilt when the tripod functions as a camera mount. Panning is controlled by a lock knob. The tripod head is fastened to a center column that extends in two sections. The upper section, controlled by a lock collar, elevates the head 10½ inches. An air cushion under this section protects the dendrometer from accidental descent. The lower section, controlled by a knob (not pictured) may be used to elevate the instrument an additional 11 inches.

Leg extension is controlled by three levers, one in the upper end of each leg. When these levers are loosened, the legs will adjust to any kind of terrain; an instrument can be practically floated into sighting position, then quickly locked into place.

Spread of the two-section legs is stopped at an angle of approximately 30° from the center column. Fully extended, the legs touch points 42 inches apart, and on level ground the eyepiece of the dendrometer can be elevated to a height of 85 inches. This capability for extension is often important when an instrument is used on boulder-strewn terrain or on very steep slopes. For example, the eyepiece can be raised to about 66 inches for a downhill sight on a slope of 75 percent.

A smaller and lighter tripod, Safe-lock Model FL, can similarly be adapted for dendrometry and is available on special order. The eyepiece can be raised to a level-ground maximum of only 65 inches, but the tripod may prove popular on mild terrains.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-51

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

FERTILIZATION UNECONOMIC FOR FORAGE IMPROVEMENT IN LOUISIANA PINE PLANTATIONS

Vinson L. Duvall and Harold E. Grelen
SOUTHERN FOREST EXPERIMENT STATION

Applying 100 pounds per acre each of N, P, and K increased yield more than threefold and significantly improved phosphorus content of herbage. N, applied at 200 pounds per acre, significantly increased herbage protein. But these improvements, though substantial, were inadequate to justify costs.

Pine overstories severely limit grazing capacity on much of the South's cattle range. Light penetrating the canopies is inadequate for abundant growth of most native grasses, and the problem is possibly complicated because plants growing on soils of low fertility are generally lower in photosynthetic efficiency than those in fertile soils *(2)*. This paper reports trials to assess the feasibility of applying fertilizers to increase the yield and quality of forage on pine plantations in central Louisiana.

STUDY AREA

The study was made in 1964 and 1965 on two slash pine (*Pinus elliottii* Engelm.) plantations on the Palustris Experimental Forest near Alexandria, Louisiana. Trees on the 1964 and 1965 experimental sites were 25 and 30 years old, respectively. Both plantations had been thinned twice to residual basal areas of 85 square feet per acre. The areas were grazed moderately until 1963.

Soils were deep, medium textured, and slowly permeable to very slowly permeable, with pH varying from about 5.0 to 5.5. In both years, May-to-October rainfall was less than the 22-inch average: 14 inches in 1964, 20 inches in 1965.

Herbaceous cover was sparse in both plantations. Pinehill bluestem, *Andropogon divergens* (Hack.) Anderss. ex Hitchc., was the predominant grass, but several panicums, *Panicum* spp., were common. Poor-joe, *Diodia teres* Walt., and fragrant goldenrod, *Solidago odora* Ait., were the main forbs. Low shrubs, principally shining sumac, *Rhus copallina* L., and poison-oak, *R. toxicodendron* L. were fairly abundant.

PROCEDURE

On May 1, 1964, nine fertilizer treatments including control (table 1) were replicated three times on 10- by 10-foot plots. Identical treatments were applied on May 1, 1965, except that the new plots were 10 by 20 feet with half of each receiving agricultural lime (99.4 percent calcium carbonate equivalent) at the rate of 1 ton per acre. Lime was added to determine whether low pH impaired fertilizer efficiency.

Sources of nitrogen (N) and phosphorus (P) were ammonium nitrate (33 percent N) and superphosphate (20 percent P_2O_5). Fertilizer applied to plots receiving N, P, and potash (K) was an 8-8-8 commercial mixture in 1964 and a combination of ammonium nitrate, superphosphate, and muriate of potash (60 percent K_2O) in 1965.

In mid-April of both years, study sites were burned by controlled backfire to destroy litter and top-kill shrubs. To determine yield, a 9.6-square-foot quadrat centered in each treatment plot was clipped at the end of each growing period. Evaluation of yield responses to fertilization was limited to the growing season following treatment. Herbage was ovendried at 75° C. before being weighed.

In 1965, sampling was expanded to include chemical analysis of herbage. In mid-July, a 100-gram sample (green weight) was taken from a randomly selected location in a 1-foot wide strip surrounding the yield quadrat in each plot. Herbage was ovendried, ground in a Wiley mill, and analyzed for protein and phosphorus.[1] The July sampling date was chosen because, by this time, protein and phosphorus in herbage on unfertilized range are substantially less than during spring and early summer *(1)*.

RESULTS AND DISCUSSION

Lime, either alone or in combination with fertilizers, did not affect yield, protein content, or phosphorus content of herbage. In 1965, therefore, data from the two nine-plot sets per replication were combined.

Fertilization increased herbage significantly (0.05 level) both years, but only the heavily fertilized plots consistently exceeded the control. Production was unaffected by N or P alone, at either 100 or 200 pounds per acre (table 1). Plots receiving 100 pounds per acre of both N and P yielded more than unfertilized plots in 1965, but not in 1964.

In both years, range fertilized with 100 or 200 pounds per acre each of N, P, and K, or 200 pounds per acre each of N and P, produced

[1] Chemical analysis of herbage samples by the Feed and Fertilizer Laboratory, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana.

Table 1.—*Yield, protein content, and phosphorus content of herbage, by fertilizer treatments*

Fertilizer treatments N	P	K	Herbage yield 1964	Herbage yield 1965	Herbage protein, 1965	Herbage phosphorus, 1965
Pounds per acre			*Pounds (ovendry) per acre*		*Percent*	
0	0	0	418 a [1]	499 a	6.3 ab	0.085 a
100	0	0	477 a	915 abc	7.7 bcd	.108 abc
200	0	0	495 a	524 a	8.4 d	.092 ab
0	100	0	782 ab	730 ab	5.8 a	.133 abcd
0	200	0	995 ab	910 abc	5.7 a	.162 cd
100	100	0	765 ab	1,732 c	6.5 abc	.120 abcd
200	200	0	1,464 bc	1,738 c	8.1 cd	.145 abcd
100	100	100	1,459 bc	1,588 bc	7.5 bcd	.148 bcd
200	200	200	2,061 c	1,606 bc	8.5 d	.173 d

[1] Values in the same column and having the same letter in their subscripts are not statistically different at the 0.05 level (Duncan's new multiple range test).

more than unfertilized range; potash did not appreciably influence production when applied in either 100- or 200-pound-per-acre quantities in addition to the same quantities of N and P.

Fertilization significantly increased both protein and phosphorus in herbage. Plots treated with 200 pounds per acre of N, either alone or in combination with other elements, averaged significantly higher herbage protein than the control. Judged by standards recommended by the National Research Council *(3)*, however, protein in herbage from these plots was marginal for cows nursing calves. Three treatments—200 pounds per acre of P, and either 100 or 200 pounds per acre each of N, P, and K—increased phosphorus in herbage. Phosphorus levels were not statistically greater for applications containing K, however, than for those consisting of N and P, or P alone. Herbage phosphorus was inadequate for cows with calves *(3)*, irrespective of treatment.

For the lightest fertilization that consistently increased yield, each additional pound of herbage required more than a pound of fertilizer. Since unit cost of fertilizer greatly exceeded unit value of herbage, all treatments were impractical. With expenses for spreading fertilizers added, the cost-benefit ratio would be even less favorable. Quality improvement was insufficient to affect fertilizer efficiency materially.

Measurements of increased yield beyond the season of application were not made in this study, but in an earlier trial on cutover range in Louisiana *(4)*, plots receiving 300 pounds per acre of 4-12-8 yielded 603 and 50 pounds per acre more than unfertilized plots during the second and third seasons after application. Even with similar carryover effect in the present study, fertilization costs would have exceeded returns.

LITERATURE CITED

1. Campbell, R. S., Epps, E. A., Jr., Moreland, C. C., and others.
   1954. Nutritive values of native plants on forest range in central Louisiana. La. Agr. Exp. Sta. Bull. 488, 18 pp., illus.
2. Daubenmire, R. F.
   1947. Plants and environment. 424 pp., illus. New York: John Wiley and Sons, Inc.
3. National Research Council.
   1963. Nutrient requirements of beef cattle. Revised edition, Report of the committee on animal nutrition, 30 pp., illus. Wash., D. C.
4. Peevy, F. A.
   1963. Fertilizing and seeding forage on forest range in Louisiana. Agron. J. 45: 164-166.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-52

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

VARIATION IN BROWN-SPOT INFECTION OF LONGLEAF PINE FROM SEVERAL GEOGRAPHIC SOURCES

B. W. Henry and Osborn O. Wells
SOUTHERN FOREST EXPERIMENT STATION

In plantings in southern Mississippi, seedlings from seed sources near the western extremity of the range were generally more heavily infected than seedlings from the central part of the range.

Brown-spot needle blight, caused by *Scirrhia acicola* (Dearn.) Siggers, defoliates seedlings of *Pinus palustris* Mill. and delays initiation of height growth of the trees. It is a serious obstacle to reproduction of longleaf pine in the Southern United States.

This paper reports results from four plantings established in southern Mississippi between 1952 and 1957 to determine whether brown-spot infection would vary among longleaf pines from various seed sources. The seedlings were obtained from the Southwide Pine Seed Source Study *(5)*, a region-wide cooperative test sponsored by the Committee on Southern Forest Tree Improvement. The Southwide Study plantings themselves were not intended to furnish information on brown-spot infection differences among the various seed sources. High survival and rapid early height growth were considered more important, and hence the plantings were sprayed with fungicide to suppress the disease. Some infection occurred in spite of the spraying and was duly recorded, but the findings cannot be considered completely indicative. Bethune and Roth *(1)* reported significant differences in brown-spot infection in the Dooly County, Georgia, planting of the Southwide Study but acknowledged that spraying may have affected the results.

Methods and materials.—Four plantings were established: One each in Pearl River and Forrest Counties in 1953,another in Forrest County in 1954, and one in Harrison County in 1957 (fig. 1). Stock was grown in several nurseries throughout the Southern United States.

Sixteen seed-sources were represented; though widely separated, they sample practically the entire range of longleaf pine. Collections from at least 20 individual trees at each source were made in 1951 for the 1953 and 1954 plantings and in 1955 for the 1957 planting. Collection areas ranged in size from about 200 acres up to three counties. In addition, half-sib progeny from a single, resistant tree now growing on the Palustris Experimental Forest, near Alexandria, Louisiana *(3)*, were included in the 1954 Forrest County planting.

A randomized complete-block design was used in all locations. The Pearl River County

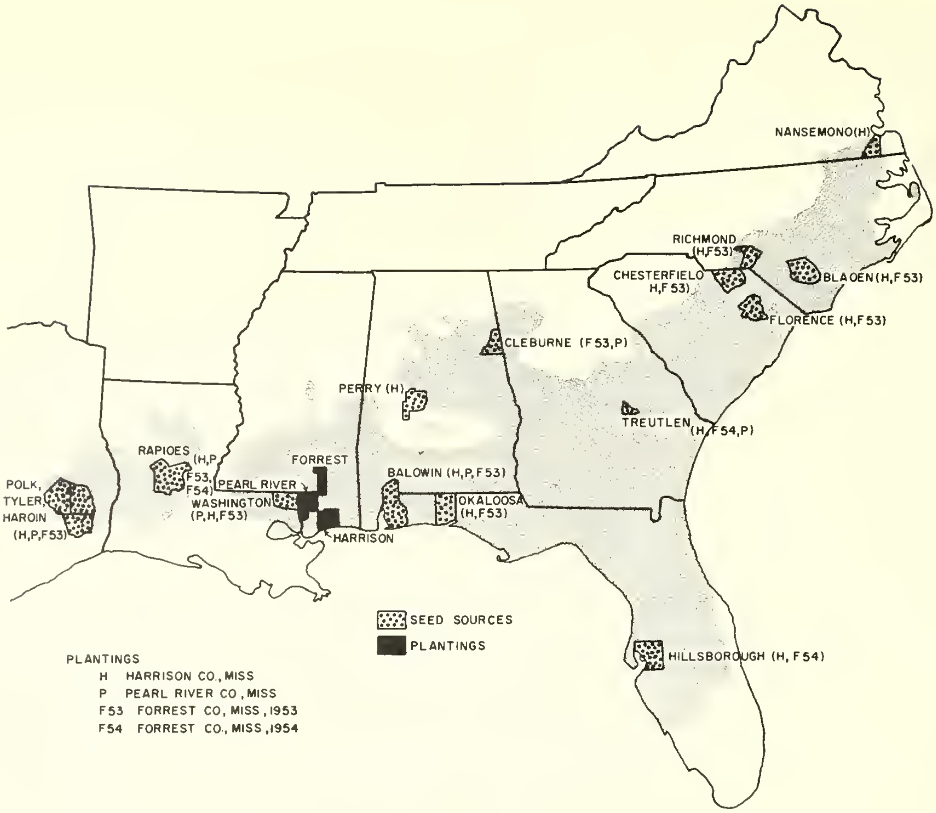


Figure 1.—*The longleaf pine seed sources and the plantings in which they were represented. Shading indicates natural distribution of longleaf pine (2).*

planting consisted of four replications of square, 49-tree, plots with trees spaced at 6 by 6 feet. The others contained either 4 or 10 replications of row-plots, each with either 10 or 25 trees per row. Trees were spaced 3 by 3 feet in Forrest County and 3 by 6 feet in Harrison County. All plantings were on well-drained, sandy soils that had originally supported natural stands of longleaf pine. Grass cover was heavy on all sites. Small spots around each tree were scalped at the time of planting in Forrest County, and the Harrison County site was burned before planting. Otherwise no cultural treatments were carried out.

In Pearl River County the number of infected seedlings per plot was tallied at the end of the first growing season, but in subsequent evaluations there, and in all evaluations in the other locations, the percentage of infected foliage on each seedling was estimated visually and the plot averages computed from these estimations. In Pearl River and Harrison County, the tallies for brown spot were made at the end of one, three, and five growing seasons, while in Forrest County they were made more frequently through the fifth year. After data expressed as percent were transformed to arc sine $\sqrt{\text{percent}}$ they were subjected to analysis of variance and, where appropriate, to Duncan's Multiple Range Test *(4)* at the 0.05 level of significance. Heights of all trees were recorded in the Pearl River and Harrison County plantings whenever the trees were scored for infection. After 5 years, scoring for infection was discontinued, as many trees were past the grass stage and growing rapidly. No further observations were made in Harrison and Forrest County, but remeasurements of height, diameter, and pest injury were made in Pearl River County after 10 years.

Results and conclusions.—Significant differences attributable to seed source appeared at the end of the first year in the plantings in Pearl River and Forrest Counties (tables 1 and 2). Such differences were still present after 3 years in the Pearl River County planting but in Forrest County they disappeared after the initial scoring.

Significant differences appeared at the end of the fourth year in the Harrison County planting. They appeared only after some trees had begun active height growth. Bias was therefore suspected, as actively growing trees invariably have a smaller proportion of foliage infected than do seedlings in the grass stage. However, an analysis restricted to trees less

Table 1.—*Brown spot infection at the end of the first growing season on longleaf pines from 15 seed sources planted in Forrest County, Mississippi, in 1953 and 1954*

1953 Seed source	1953 Infected foliage	1954 Seed source	1954 Infected foliage
	Percent		*Percent*
Baldwin County, Alabama	[1] 11.0	Resistant tree *(3)*, seed source unknown	30.5
Okaloosa County, Florida	11.0	Harrison County, Mississippi	33.2
Cleburne County, Alabama	15.5	Harrison County, Mississippi	34.1
Chesterfield County, South Carolina	14.2	Treutlen County, Georgia	34.8
Florence County, South Carolina	15.5	Rapides Parish, Louisiana	37.7
Washington Parish, Louisiana	16.0	Bladen County, North Carolina	40.3
Richmond County, North Carolina	21.0	Rapides Parish, Louisiana	41.8
Polk, Tyler, and Hardin Counties, Texas	21.2	Hillsborough County, Florida	45.0
Rapides Parish, Louisiana	21.5		

[1] Means within the same bracket are not significantly different at the 0.05 level (4).

Table 2.—*Brown spot infection and trees past the grass stage in longleaf pines from six seed sources planted in Pearl River County, Mississippi, in January 1953*

Seed source	Infection after 1 year [1]	Infection after 3 years [2]	Seed source	Survivors past grass stage after 10 years
	Percent	*Grade*		*Percent*
Treutlen County, Georgia	4.6 [3]	11.43	Treutlen County, Georgia	100.0
Cleburne County, Alabama	6.0	11.56	Baldwin County, Alabama	84.5
Baldwin County, Alabama	10.0	11.68	Cleburne County, Alabama	78.3
Washington Parish, Louisiana	26.9	12.26	Washington Parish, Louisiana	62.2
Rapides Parish, Louisiana	28.4	12.40	Polk, Tyler, and Hardin Counties, Texas	57.4
Polk, Tyler, and Hardin Counties, Texas	25.8	12.45	Rapides Parish, Louisiana	23.7

[1] Number of infected seedlings per plot.
[2] Amount of infected foliage per seedling. Grade 10.00 = 0-15 percent foliage infected; grade 11.00 = 16-35 percent; grade 12.00 = 36-65 percent; grade 13.00 = >65 percent.
[3] Means within the same bracket are not significantly different at the 0.05 level (4).

than 1.0 foot tall gave results similar to the original analysis.

In general, seedlings from the western part of the longleaf range were more heavily infected than those from the central part of the range, particularly the central Gulf Coast. Seedlings that originated east of the central Gulf Coast did not fit into any recognizable pattern. Some were infected heavily, others only lightly. For example, in the Forrest County plantings trees from the central Gulf Coast (Baldwin County, Alabama, Okaloosa County, Florida, and Harrison County, Mississippi) had relatively light infection, while trees from Rapides Parish, Louisiana, and Hillsborough County, Florida, had relatively heavy infection. The Rapides Parish seedlings were also among those most heavily infected in the Dooly County, Georgia, planting of the Southwide Study *(1)*. In the Pearl River County planting, trees from the central part of the range (Georgia and Alabama) were significantly less infected than western (Texas and Louisiana) trees. In addition there was a tendency for stocks that had relatively light infection at 1 and 3 years to have more surviving trees past the grass stage at 10 years than stocks with heavier infection at 1 and 2 years (table 2).

Data from the Harrison County planting also show the geographic trend but somewhat less conclusively (table 3).

Stocks from west of the Mississippi River had relatively heavy infection in the Harrison County planting, and, except for one of the Harrison County stocks, the central Gulf Coast stocks had relatively light infection.

Progeny of the single resistant tree in the 1954 Forrest County test had relatively light infection but were not as superior to other sources as they were in a Louisiana trial reported by Derr *(3)*.

Possibilities for environmentally induced, experimental error were great in the present tests. Competing vegetation tended to shield some seedlings from infection more than others, and the dependence upon natural sources of inoculum together with its slow rate of spread also contributed to high experimental error.

Even after these considerations are allowed for, a pattern of geographic variation was clearly evident in three plantings and weakly demonstrated in the fourth.

Table 3.—*Brown spot infection in longleaf pines from 15 seed sources planted in Harrison County, Mississippi, in February 1957*

Seed source	Infected foliage after 4 years	Infected foliage after 5 years
	-- *Percent* --	
Okaloosa County, Fla.	44.8	52.3
Harrison County, Miss.	41.3	52.6
Perry County, Ala.	41.9	53.3
Baldwin County, Ala.	50.6	55.9
Hillsborough County, Fla.	55.5	56.3
Chesterfield County, S. C.	51.8	57.1
Treutlen County, Ga.	57.3	58.7
Bladen County, N. C.	45.2	59.2
Richmond County, N. C.	55.2	62.3
Polk County, Texas	55.1	63.5
Nansemond County, Va.	49.8	63.6
Washington Parish, La.	49.5	63.8
Florence County, S. C.	52.8	66.9
Harrison County, Miss.	58.9	69.2
Rapides Parish, La.	63.4	74.3
Approximate least significant difference [1]	7.0	8.5

[1] Duncan's "significant Studentized range" for a test at the 0.05 level with a sample size of 7 (4).

LITERATURE CITED

1. Bethune, J. E., and Roth, E. R.
   1960. Source of seed affects growth of longleaf pine—fifth year results. U. S. Forest Serv. Southeastern Forest Exp. Sta., Res. Notes 146, 2 pp.
2. Critchfield, W. B., and Little, E. L., Jr.
   1966. Geographic distribution of the pines of the world. U. S. Dep. Agr. Misc. Pub. 991, 97 pp.
3. Derr, H. J.
   1963. Brown-spot resistance among F_1 progeny of a single, resistant longleaf parent. Forest Genet. Workshop Proc. 1962: 16-17. Macon, Ga.
4. Duncan, D. B.
   1955. Multiple range and multiple *F* tests. Biometrics 11: 1-42, illus.
5. Wakeley, P. C.
   1961. Results of the Southwide Pine Seed Source Study through 1960-61. Sixth Southern Forest Tree Impr. Conf. Proc. 1961: 10-24, illus.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-53

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LOSS OF TOPSOIL SLOWS SLASH PINE SEEDLING GROWTH IN FLORIDA SANDHILLS

R. H. Brendemuehl [1]

SOUTHERN FOREST EXPERIMENT STATION

Seedlings grown in pots for 9 to 18 months were significantly affected by treatments equivalent to removing 0 to 6 inches of the normal soil profile before the trees were planted. Growth differences were correlated with the nitrogen and organic-matter content of the soil.

Site preparation with machines that eradicate the native scrub oaks and wiregrass has been demonstrated to be essential for early establishment and growth of pines planted on the deep, well-drained sandy soils that collectively make up the sandhills of Florida.

Of the machines used to clear these sites, the most suitable appear to be heavy choppers having tandem drums set at an angle to the line of machine travel. These choppers give excellent control of scrub oaks and wiregrass, and growth of slash pine planted on sites prepared by them has been significantly better [2] than on comparable sites prepared by other equipment. The superiority of the choppers has been attributed to the fact that they leave the surface soil in place and mix the existing vegetation with it. Rootrakes and bulldozers remove both the vegetation and a variable amount of topsoil from the immediate planting site.

This note reports data on seedlings grown under conditions intended to represent sandhills soils with 0 to 6 inches of the normal profile removed prior to planting. In order to eliminate such field variables as competing vegetation, dissimilar soils, and microclimatic differences, the seedlings were grown in pots.

PROCEDURE

Soil was collected from three Lakeland sand profiles on the Chipola Experimental Forest, Calhoun County, Florida; the sample sites were considered to be representative of the area. At each collecting point the soil was removed in 1-inch layers to a depth of 6 inches. Each 1-inch layer was placed in a separate container.

[1] The author is in charge of the U. S. Forest Service's project, at Marianna, Florida, on establishment of pine in the Florida sandhills. When the present data were collected, the project was a responsibility of the Southern Forest Experiment Station, New Orleans, Louisiana. On July 1, 1966, it was transferred to the Southeastern Forest Experiment Station, Asheville, North Carolina.

[2] Woods, F. W. Converting scrub oak sandhills to pine forests in Florida. J. Forest. 57: 117-119, illus. 1959.

Finally a seventh layer was removed at each sample point; it was 9 inches thick and comprised that portion of the profile from 6 to 15 inches below the surface. All samples were air-dried, sieved to remove organic debris, and composited by layers.

The soil layers were then placed in 2-gallon, glazed earthenware pots in the same relation to each other as they occurred in the field. For example, pots for treatment one (no topsoil removed) were filled as follows:

Bottom layer—Three-inch layer of soil from the 6- to 15-inch composite sample.

Second layer—One-inch layer from the 5- to 6-inch composite sample.

Third layer—One-inch layer from the 4- to 5-inch composite sample.

Fourth layer—One-inch layer from the 3- to 4-inch composite sample.

Fifth layer—One-inch layer from the 2- to 3-inch composite sample.

Sixth layer—One-inch layer from the 1- to 2-inch composite sample.

Top layer—One-inch layer from the 0- to 1-inch composite sample.

Six additional treatments were developed by omitting from 1 to 6 inches of topsoil, but the total volume of soil in each pot was held constant by increasing the thickness of the bottom layer by like amounts.

Seedlings were established early in March by sowing about 25 local seeds (Calhoun County, Florida) directly into each pot. To minimize the effect of seed size on first-year seedling growth, the seeds sown were limited to those that passed through a U. S. standard number 5 (4.000 mm.) soil sieve but were too large to pass a number 8 (2.380 mm.) sieve. Eight weeks after the seeds were sown, the seedlings were thinned to eight per pot, uniformly spaced.

The seedlings were grown in two distinctly different situations. One complete set of treatments (5 replications $\times$ 7 treatments $=$ 35 pots) was placed in a greenhouse and watered frequently. These seedlings were harvested when 18 months old. A second and a third complete set (35 pots in each set) were placed out of doors in each of two successive years, each pot being buried in soil to within 1 inch of its top. These seedlings were exposed to full sunlight and received no water other than rain. The pots had drain holes near the base to prevent accumulation of moisture. Rainfall at the study site, the Chipola Experimental Forest, totaled 54 inches during the first study period (11 months) and 45 inches during the second study period (9 months). These values are about normal for this area.

At the end of each study period the seedlings were cut off at the ground line, the roots washed free of soil, and the total seedling material per pot ovendried to a constant weight in a forced-draft oven at 70° C.

Treatment effects were evaluated by procedures appropriate to a randomized block design with five replications.

RESULTS AND DISCUSSION

Slash pine seedling growth in all three installations of this study was affected significantly (0.01 level) by the treatments imposed. In each installation, total seedling growth was greatest where no surface soil had been removed (fig. 1).

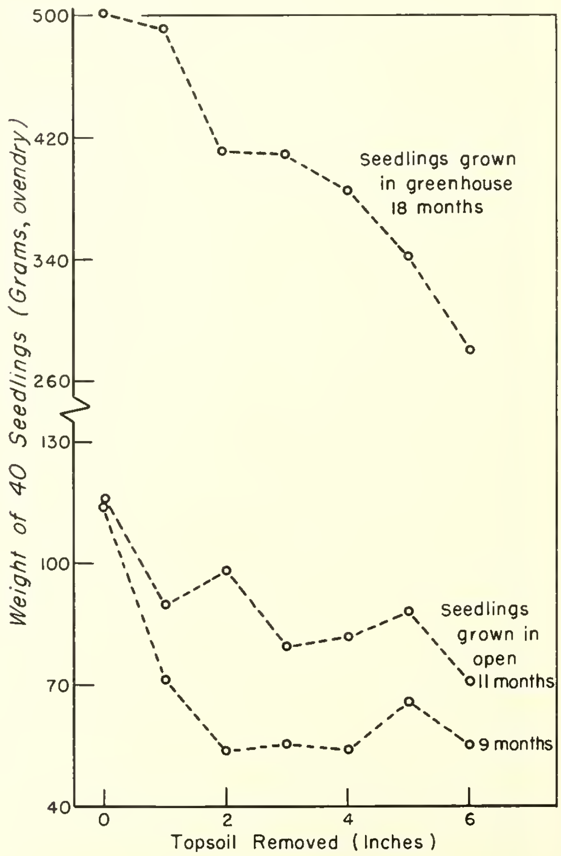


Figure 1.—*Effect of topsoil removal on slash pine seedling growth.*

Comparing treatment means by Duncan's[3] multiple range test showed no topsoil removal to be significantly better (0.05 level) than all other treatments for the two field installations; the other treatments did not differ significantly among themselves. In the greenhouse, there was no significant difference between no topsoil removal and 1 inch of topsoil removal, but both of these treatments were significantly better (0.05 level) than all other treatments.

It is unlikely that the growth differences reported are due to differences in available moisture. All soil layers combined to form the treatments were sand with almost identical wilting percentages, and thus whatever moisture was received by a given installation was equally available in all pots of that installation. Variation in the fertility level of the layers may be a factor. Data descriptive of the soil layers were obtained by standard laboratory procedures and are reported in table 1. It can readily be seen that the nutrient content of these soils, especially their organic matter, total nitrogen, available phosphorus, exchangeable potassium, and exchangeable calcium, decreased appreciably with depth. From these data, the amount of each nutrient by treatments was calculated on a per-acre basis. Of the soil characteristics tabulated, total nitrogen, available phosphorus, and exchangeable potassium were correlated with seedling growth. Simple linear regressions expressing the relationship between total ovendry weight of the 18-month-old seedlings and these soil characteristics are graphed in figure 2.

Multiple regression equations were computed with total ovendry seedling weight as the dependent variable and total soil nitrogen (X_1), exchangeable potassium (X_2), and available phosphorus (X_3) as the independent variables.

[3] Duncan, D. B. Multiple range and multiple F tests. Biometrics 11:1-42. 1955.

Table 1.—*Analysis of soil by layers*

Soil layer [1] (inches)	pH	Organic matter	Total N	Total phosphorus, P_2O_5, per acre	Available phosphorus, P_2O_5, per acre	Exchangeable potassium, K_2O, per acre	Exchangeable magnesium, MgO, per acre	Exchangeable calcium, CaO, per acre	Wilting percentage (moisture at tension of 15 atmospheres)
		– Percent –		*– – – – – –*	*– – – – –*	*Pounds*	*– – – – –*	*– – – – – –*	*Percent*
0-1	5.58	1.30	0.0297	116	14.6	56	11	500	1.11
1-2	5.32	1.14	.0256	126	10.6	51	11	468	.99
2-3	5.35	1.10	.0221	116	12.0	46	11	432	1.18
3-4	5.42	1.01	.0216	90	11.4	40	9	432	1.18
4-5	5.39	.94	.0182	116	11.4	40	11	432	1.12
5-6	5.41	.86	.0175	126	8.6	46	11	432	1.04
6-15	5.59	.66	.0108	116	10.0	36	9	432	.95

[1] Soil samples collected from previously undisturbed sites.

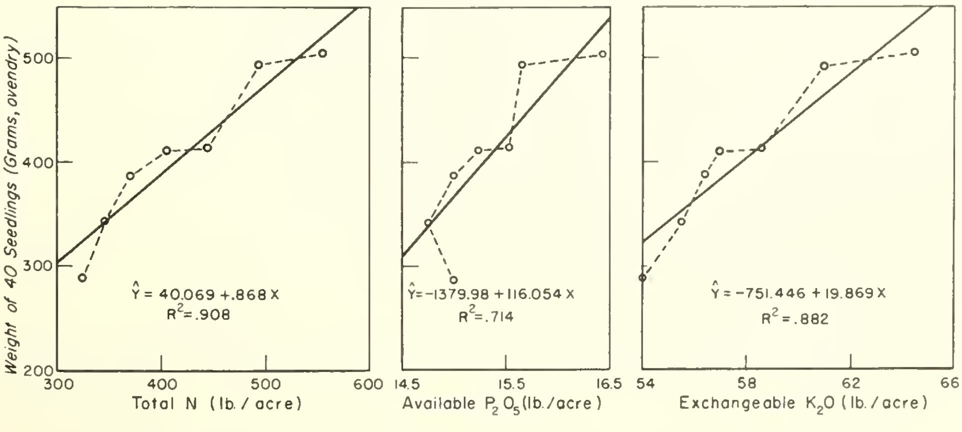


Figure 2.—*Relation of seedling growth to major soil nutrients.*

The equation $\hat{Y} = 40.069 + 0.868X_1$ is significant (0.01 level) $R^2 = 0.908$—i.e., 90.8 percent of the variation in seedling weight reported is associated with the independent variable, total soil nitrogen. Exchangeable potassium (X_2) and available phosphorus (X_3) did not make a significant contribution when used in combination with total soil nitrogen and hence were dropped from the equation.

Total nitrogen content of soil is correlated with organic matter content. In this instance the regression was significant at the 0.01 level, $R^2 = 0.9784$. Thus, the organic matter content of these soils may be a good measure of their productive capacity. This should not be construed to mean that organic matter per se has an appreciable effect on tree growth, but rather that the organic matter content is a measure of the fertility level—and hence of the productive capacity—of these infertile sandy soils.

CONCLUSIONS

On the basis of this study, one must conclude that the growth differences previously measured on comparable sandhills soils prepared by various methods are primarily due to differences in topsoil treatment. Any method of site preparation which effectively controls unwanted vegetation, leaves the topsoil in place, and incorporates the present vegetation with the surface soil can be expected to leave the site in a far more productive condition than methods that remove the existing vegetation and varying quantities of topsoil from the planting area.

SOUTHERN FOREST EXPERIMENT STATION

Forest Service, U. S. Dept. of Agriculture

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-54

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

HEAVY TIP MOTH ATTACKS REDUCE EARLY GROWTH OF LOBLOLLY AND SHORTLEAF PINE

Raymond H. Beal

SOUTHERN FOREST EXPERIMENT STATION

In loblolly and shortleaf pine plantations in the Midsouth, trees protected from Nantucket pine tip moths significantly outgrew heavily attacked trees during the first 6 years after planting.

A young southern pine plantation infested with Nantucket pine tip moths *(Rhyacionia frustrana* (Comst.)) is not pretty, but many people contend that the loss of growing tips has little effect on the plantation's growth and yield. Some studies of tip moth damage have been made *(1, 2, 3, 4)*, but the results are inconclusive. The study described here was designed to determine the long-term effects of tip moth attack on loblolly *(Pinus taeda* L.) and shortleaf *(P. echinata* Mill.) pine plantations in the Midsouth. Growth changes due to protection from the insects can now be reported for 5- and 6-year-old trees.

An analysis of results is appropriate now because attacks are most common in plantations less than 6 years old. Loblolly and shortleaf pine were chosen for study because, among commercial southern pines, they are most frequently attacked.

METHODS

Two pairs of plots were planted at each of nine locations: Crossett, Arkansas, and Oxford, Mississippi, in 1959; and Alexandria, Louisiana; Brewton, Alabama; Gulfport, Mississippi; Harrison, Arkansas; Marianna, Florida; Nacogdoches, Texas; and Sewanee, Tennessee, in 1960. Each plot was divided into two subplots. One was planted with shortleaf and the other with loblolly pine, except that at Alexandria no shortleaf was planted. Spacing was 7 by 9 feet.

One pair of plots at each location was treated with insecticide to prevent tip moth attack. The other was left unprotected. In 1959, a 5-percent water emulsion of DDT was sprayed on the study trees to the point of runoff in the spring when the first tip moth flight was observed. During the second and third growing seasons, a 2-percent water emulsion of DDT was applied at about monthly intervals. In the fourth, fifth, and sixth growing seasons, 10 grams of 10-percent granular phorate were sprinkled on the soil around each tree in early spring.

Each subplot contained 49 trees. The inner 25 trees on each were examined to determine growth and tip moth infestation.

Because the main terminals are usually attacked first, and because these growing tips are considered the most important, attacks on them were used to classify severity of infestation:

Percent of main terminals infested	Severity of attack
1- 10	very light
11- 40	light
41- 70	medium
71-100	heavy

The number of larvae in each terminal was recorded at the end of the growing season. Single attack was defined as one or two insects per tip, multiple as more than two. Trees were examined at the end of the season because it was impractical to do so after each generation of moths. There may be as many as five generations a year along the Gulf Coast.

Seedling heights were measured annually at the end of the growing season. Diameters were measured after 5 years.

Data were subjected to split-plot analysis and Duncan's test at the 5-percent protection level.

RESULTS AND DISCUSSION

Annual applications of granular phorate provided excellent protection from tip moths. For example, at Alexandria, when 71 percent of the terminals of unprotected trees were infested, only 6 percent of the protected ones were. And at Nacogdoches, while 96 percent of the terminals of unprotected trees were being attacked, all those on protected trees remained free of insects. Though effective, granular phorate is not recommended for extensive control of tip moths because it is highly toxic to mammals. The 2-percent DDT emulsion was also effective when applied monthly.

Heavy multiple attacks significantly reduced the height growth of both loblolly and shortleaf pine at Crossett. Medium multiple attacks lowered the height of loblolly and shortleaf at Nacogdoches, and loblolly at Oxford. And medium single attacks reduced the height of loblolly at Marianna (table 1). No significant differences in diameter were observed. Medium multiple and medium and very light single

Table 1.—*The effect of tip moth control*

Location	Tree height		Height difference	D.b.h.		Severity of attack on untreated trees	Type of attack
	Treated	Untreated		Treated	Untreated		
	Feet	*Feet*	*Feet*	*Inches*	*Inches*		
Loblolly pine—6th year							
Crossett, Ark.	12.0	9.9	+ 2.1*	2.1	1.5	Heavy	Multiple
Oxford, Miss.	20.0	17.3	+ 2.7*	3.5	3.2	Medium	Multiple
Loblolly pine—5th year							
Alexandria, La.	8.6	7.9	+ .7	1.4	1.3	Medium	Multiple
Brewton, Ala.	11.9	10.7	+ 1.2	1.9	1.6	Medium	Single
Gulfport, Miss.	14.8	14.3	+ .5	2.5	2.6	Very light	Single
Harrison, Ark.	10.9	10.2	+ .7	1.8	1.6	Very light	Single
Marianna, Fla.	11.4	7.5	+ 3.9*	1.7	1.3	Medium	Single
Nacogdoches, Texas	18.0	15.4	+ 2.5*	3.1	2.7	Medium	Multiple
Sewanee, Tenn.	11.2	11.3	— .1	1.8	1.8	Very light	Single
Shortleaf pine—6th year							
Crossett, Ark.	8.3	5.9	+ 2.4*	1.5	.4	Heavy	Multiple
Oxford, Miss.	15.6	13.9	+ 1.7	2.8	2.4	Medium	Multiple
Shortleaf pine—5th year							
Brewton, Ala.	11.5	10.8	+ .7	2.1	1.9	Medium	Single
Gulfport, Miss.	12.4	12.4	.0	2.4	2.4	Very light	Single
Harrison, Ark.	6.6	5.8	+ .8	1.3	1.1	Very light	Single
Marianna, Fla.	7.5	6.5	+ 1.0	1.4	1.3	Medium	Single
Nacogdoches, Texas	13.6	11.4	+ 2.2*	2.4	2.3	Medium	Multiple
Sewanee, Tenn.	8.9	9.9	— 1.0	1.5	1.6	Very light	Single

* Significant at the 5-percent protection level.

attacks at several locations did not significantly affect height growth. Thus, damage appeared to be related to geographic location as well as severity of attack.

Where heights were significantly reduced, protected trees averaged more than 2 feet taller than unprotected ones. However, it is too early to relate height differences to yield or length of rotation. An economic evaluation of damage will not be possible until the first commercial thinnings are made.

LITERATURE CITED

1. Foil, R. R., Merrifield, R. G., and Hansbrough, Thomas.
   1961. Results of tip moth control on height growth of loblolly pine. La. State Univ., Hill Farm Facts, Forest. 2, 5 pp., illus.
2. Somes, H. A., and McIntyre, T.
   1963. Tip-moth control fails to improve height of planted loblolly pines in a Maryland study. U. S. Forest Serv. Res. Note NE-16, 3 pp. Northeastern Forest Exp. Sta., Upper Darby, Pa.
3. Thor, E., and Beavers, J. T.
   1964. Nantucket pine moth damage on loblolly and shortleaf pine in west Tennessee. Tenn. Farm and Home Sci. Progr. Rep. 49, pp. 14-15, illus.
4. Warren, L. O.
   1964. Growth of pine trees protected from attack by Nantucket pine-tip moth. Ark. Farm Res. 13(1): 11.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-55

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

CONVERTING A PIN OAK FLAT TO PINE[1]

David M. Moehring
SOUTHERN FOREST EXPERIMENT STATION

Planted loblolly pines survived satisfactorily and grew rapidly on a drained flat in southeast Arkansas.

Scattered through the loblolly pine region of Arkansas and Louisiana are many wetland sites locally termed pin oak flats. These sites are flat to slightly depressed areas where both surface and internal soil drainage are slow. Natural vegetation consists mostly of wetsite grasses and sedges and hardwoods of very low quality. Pines sometimes are found on raised elevations (pimple mounds) where soil drainage is reasonably rapid. Individual flats range from 2 to 40 acres in size and collectively comprise a large acreage that may be suitable for growing pine.

Conversion to pine, however, frequently is difficult. Root development of planted seedlings is often impeded by prolonged periods of flooded or waterlogged soil in the spring. As a result, seedlings that survive a wet spring may succumb to summer drought because their restricted root systems cannot expand fast enough to maintain contact with the receding moisture in the subsoil.

The study reported here was established in November 1954 to measure survival and height growth of loblolly pine on a pin oak flat that was artificially drained to remove surface water. Although an undrained and planted check area was not installed for comparison, the 10-year survival and growth data may be of interest to land managers.

STUDY AREA

The area, containing 37 acres, is east of Hamburg, in southeast Arkansas, on land belonging to the Georgia-Pacific Corporation. It slopes southeast at the rate of 1 foot in 500. Within the flat are two large depressions, each of about 5 acres, and numerous small depressions of less than one-half acre. These areas lack natural surface drainage and usually retain standing water for 2 to 3 weeks following a heavy rain.

The soil is loess. The strongly mottled and silty surface overlies a pan of silty clay to

[1] In cooperation with the Crossett Division of the Georgia-Pacific Corporation and with the Ashley County, Arkansas, office of the Soil Conservation Service, U. S. Department of Agriculture.

silty clay loam. The pan is virtually at the surface in the depressed areas; elsewhere it ranges to 14 inches below the surface. Internal drainage of the soil is very slow.

When the study was established the vegetation consisted of predominantly wetsite oaks—water, willow, post, and southern red oak—mixed with elm, sweetgum, hickory, and an occasional loblolly pine (fig. 1A).

The drainage system was designed to remove surface water. Two main ditches, running from west to east, were directed from the two large depressions into a road ditch that flows south to a natural drainage (fig. 2). The fall was maintained at about 2 feet per quarter mile of length. The total ditch length was 60 chains. The rights-of-way were cleared with a bulldozer and grading was with road patrol equipment; the work was done by the company owning the land.

In November 1954 the study area was logged for the few oak and pine saw logs that were of reasonable quality. Oak and hickory chemical wood was removed, and remaining unmerchantable hardwoods were girdled. In February 1955 the area was handplanted with 1-year-old loblolly pine seedlings at the rate of 600 trees per acre.

RESULTS

First-year survival on the drained flat was 55 percent; the general average that year on better sites in the vicinity of Hamburg was 67 percent.[2] Most of the loss was attributed to a severe drought in August and September 1955. Some was due to open-range grazing.

The average stocking after 10 years was 250 trees per acre. Well stocked and understocked areas were interspersed over the flat, but stock-

[2] Personal communication with R. A. Williams, Forester for the Crossett Division, Georgia-Pacific Corporation.

Figure 1.—A. *The pin oak flat prior to treatment.*
B. *View from the drainage ditch 6 years after trees were planted. The large pine in the center background is on a mound and was present before the flat was drained.*
C. *The area in 1966, after 12 years.*

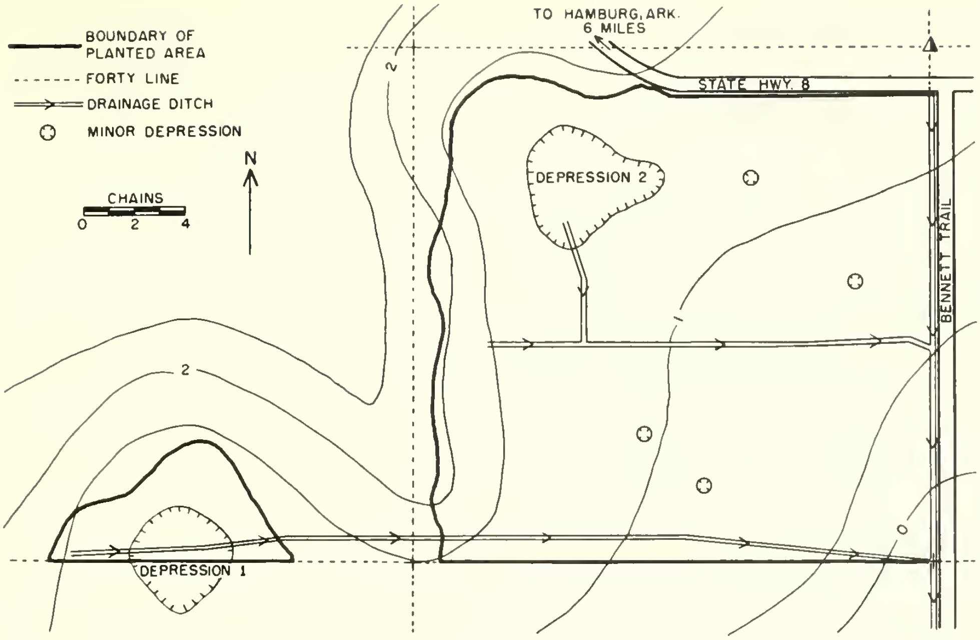


Figure 2.—*Topographic map of the flat. Contour lines are at half-foot intervals.*

ing was consistently low only in small undrained depressions. Here moisture-tolerant hardwoods are taking hold.

The average pine was 5 inches in d.b.h. after 10 years; the range in diameter was 1 to 10 inches. Basal area averaged 43 square feet per acre.

Mean tree height in 1965 was 34 feet. This averages out to more than 3 feet per year, which is excellent for any site. Heights better than average occurred most often on or around the edges of mounds, where internal soil drainage was good. Heights were generally least (23-29 feet) in the small undrained depressions. Height growth in the two large depressions varied from 28 to 38 feet, generally being least at the center of the depression and increasing toward the edge. Here shallow depth to pan may be limiting height growth, but removal of surface water has materially increased survival chance.

Expenditures for converting the flat to pine are summarized in table 1. The data are based upon company costs in 1955. Time and cost for supervisory personnel are not included. Landowners lacking a market for chemical wood would have an additional $3 to $5 per acre cost for deadening hardwoods.

Table 1.—*Expenditures per acre for converting the pin oak flat to loblolly pine*

Item	Expenditure
	Dollars
Bulldozing	1.35
Ditching	1.62
Planting	10.86
Seedlings	1.82
Cull tree deadening	2.60
Initial cost of conversion	18.25
Ditch maintenance	1.22
Total cost to date	19.47

The study was not designed for a statistical evaluation of the drainage system's effectiveness (or its need) in converting the flat to pine. However, anyone who has seen an untreated pin oak flat can appreciate the tremendous change which occurred here. This area, once supporting low-quality hardwoods and a few scattered pine, is now a productive pine site (fig. 1C). Pine growth has been outstanding and, if maintained, will soon equal in value the cost of the drainage system.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-56

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

RESPONSES OF 1-YEAR-OLD COTTONWOOD TO INCREASING SOIL MOISTURE TENSION

F. T. Bonner[1]

SOUTHERN FOREST EXPERIMENT STATION

Cottonwood cuttings potted in sandy loam and clay soils showed a sensitive control of water loss as soil moisture tensions increased. Transpiration rates began decreasing at leaf water deficits of 2.5 percent in sandy loam and 4.5 percent in clay. There were no significant differences in rates per unit of leaf area or shoot dry weight between plants grown in the two soils. Terminal growth ceased when leaf water deficits reached 4 percent in sandy loam and 5 percent in clay.

Although cottonwood (*Populus deltoides* Bartr.) seems to require a relatively large amount of water for good growth, little is known about its basic water relations. This note describes a pot study to determine the effects of increasing soil moisture tension on shoot growth, transpiration, and leaf moisture stress in 1-year-old cottonwood grown in two soils of different textures.

[1] This work was done at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

MATERIALS AND METHODS

In early January 1965, 100 cuttings 6 inches long from the "Rosedale 8" clone were taken from the Southern Hardwoods Laboratory nursery and stored at 38° F. In early April, each cutting was planted in a 6-inch clay pot; half were potted in sandy loam, half in clay. Each pot contained 1,850 g. of well-mixed soil, the moisture content of which was determined to allow for later estimates of soil moisture tension by weight.

The cuttings were placed in a covered lath house and watered daily. All plants were pruned to a single shoot when they sprouted. In late May, they were randomly placed in a controlled environment chamber and exposed to the following 24-hour regime: 12 hours light with 2,000 foot-candles at 90° F. and 60 to 70 percent relative humidity, and 12 hours darkness at 60° F. and 90 to 100 percent relative humidity. Each pot was enclosed in a polyethylene bag tied to prevent any moisture loss except by transpiration.

After a week of adjustment to chamber environment, terminal growth and transpiration were measured three times per week at the start of the light cycle. Transpiration was determined by loss of pot weight. At each weighing, distilled water was added to bring the soil to approximately 1/3 bar of moisture tension. Soil moisture retention curves developed with standard procedures (fig. 1) were used to relate moisture content by weight to moisture tension.

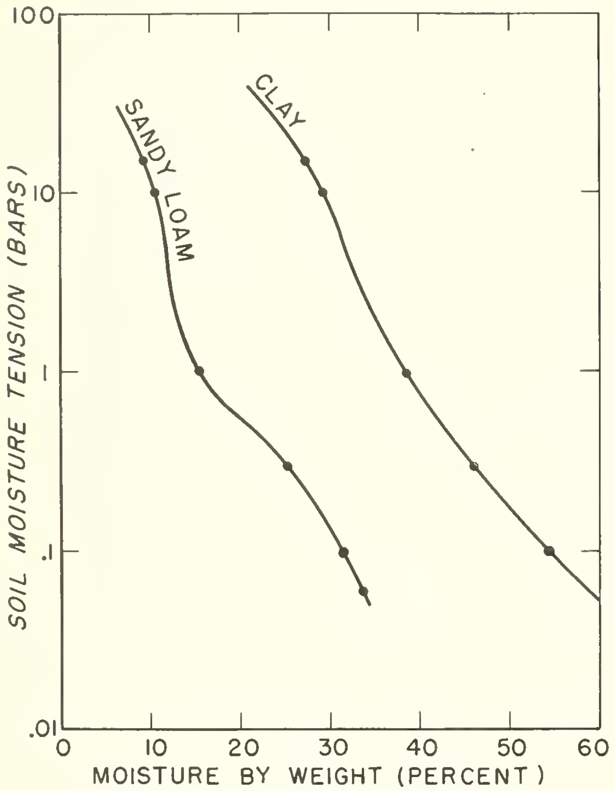


Figure 1.—*Relations of moisture tension to moisture content of the soils.*

After 3 weeks, the soil in all pots was adjusted to 1/3 bar of moisture tension during the dark cycle, and watering was discontinued. At the start of the following light cycle, five cuttings from each soil were randomly selected for measurement of: (1) transpiration, (2) terminal growth, (3) leaf water deficit, (4) leaf area, (5) shoot dry weight, (6) root dry weight, and (7) soil moisture content. The heights of all live shoots were recorded daily.

Similar measurements were made on five cuttings from each soil after 1, 2, 3, 4, and 7 days without water. In addition, five cuttings grown in clay were analyzed 10 days after watering ceased. The last cuttings were measured when they appeared to be almost dead.

Leaf water deficit was determined by a modification of Weatherley's method [2] on 10 disks, 0.8 cm. in diameter, which were cut from each of the two fully developed leaves nearest the terminal. The disks were weighed, floated in distilled water for 4 hours in 100 foot-candles of light, blotted dry between eight pieces of Whatman No. 1 filter paper under a 2,500 g. weight, and reweighed. Water deficit in percent (WD) was calculated from the formula:

$$\mathrm{WD} = \frac{\text{Turgid weight} - \text{original weight}}{\text{Turgid weight} - \text{ovendry weight}} \times 100$$

Leaf areas were estimated from dot-grid counts of leaf outlines traced on paper. Plant dry weights were taken after drying for 24 hours at 65° C. Transpiration rate was calculated per $dm.^2$ of leaf area and per g. of shoot weight.

Gravimetric soil moisture data taken from two samples per pot were converted to soil moisture tension values with figure 1.

RESULTS

Because of differences in nutrient content as well as moisture characteristics of the two soils, cuttings grown in clay had larger shoots and roots, and more and larger leaves than cuttings grown in sandy loam (table 1). Under increasing soil moisture tension, terminal growth stopped abruptly when leaf water deficits reached about 5 percent in clay and 4 per-

[2] Weatherley, P. E. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol. 49: 81-97. 1950.

Table 1.—*Growth of cottonwood cuttings in controlled environment (Each value is the mean for 30 plants)*

Measurement	Unit	In clay	In sandy loam
Shoot height	cm.	61.3	33.6
Shoot dry weight	gm.	10.46	5.42
Root dry weight	gm.	2.17	.74
Total leaf area per cutting	$dm.^2$	8.97	4.22
Leaves per cutting	No.	19.8	14.9
Mean area per leaf	$dm.^2$	.45	.28

cent in sandy loam (fig. 2). The spurts of growth 7 days after watering ceased were the result of a malfunction in the growth chamber which sent the temperature up to 118° F. for several hours about 30 hours prior to height measurement.

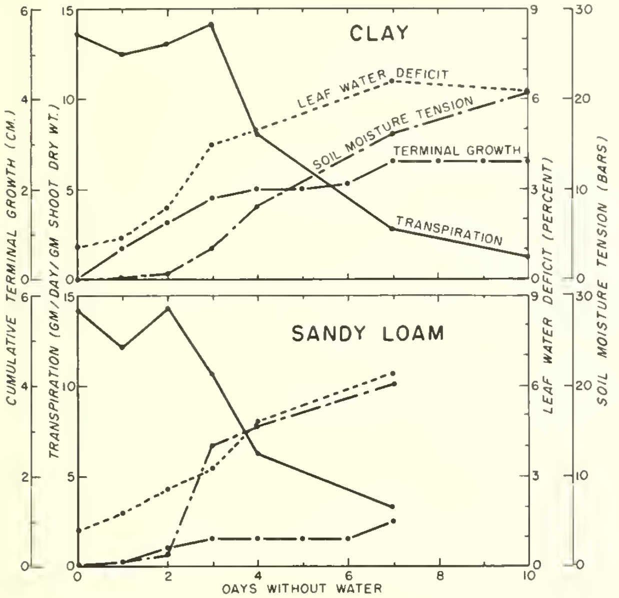


Figure 2.—*Responses of cottonwood cuttings to moisture deficiency.*

Transpiration was generally steady through the first 2 days without water for plants in sandy loam and 3 days without water for plants in clay (fig. 2). Soil moisture tensions during this period reached 2.2 bars in sandy loam and 3.5 bars in clay. Transpiration decreased with further increases in soil moisture tension. The larger plants in the clay transpired at almost double the rate of the plants in the sandy loam, but when transpiration was expressed on a leaf area or shoot weight basis, the rates did not differ significantly by soil type (table 2).

When transpiration rates began declining, leaf water deficits in the plants were 4.5 percent in clay and 2.5 percent in sandy loam. Plants were still transpiring when the last measurements were taken. Leaf water deficits averaged 6.3 percent, and soil moisture tension averaged 20 bars at this time.

Table 2.—*Transpiration rates of cottonwood cuttings expressed by two methods*

Soil	Sampling time (No. days without water)						Soil mean
	0	1	2	3	4	7	
	– – Gm./day/gm. shoot dry weight – –						
Sandy loam	14.3	12.2	14.5	10.7	6.3	3.5	10.2
Clay	13.6	12.5	13.1	14.2	8.2	2.8	10.7
	– – – – Gm./day/dm.² leaf area – – – –						
Sandy loam	16.3	14.9	17.5	14.5	9.0	4.9	12.8
Clay	14.0	14.7	15.5	15.1	10.1	3.5	12.4

As soil moisture tension increased, the bottom leaves on all plants became chlorotic, and small necrotic spots appeared on them. Finally, they abscised. The young leaves showed a definite advantage over older ones in the competition for moisture within the plant. Pronounced wilting was rarely observed.

DISCUSSION

The cessation of terminal growth at leaf water deficits of 4 to 5 percent in cottonwood indicates a sensitive control of water loss in response to moisture stress. In comparison, values were 6.9 percent for sycamore, 6.4 for sweetgum, and 8.9 for Nuttall oak in clay, and slightly less in silt loam.[3] Put in more general terms, cottonwood uses large amounts of soil moisture, but apparently reduces its needs at relatively low levels of moisture tension.

[3] Bonner, F. T. Reaction to soil moisture deficiency by seedlings of three hardwood species. Forest Sci. (submitted)

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-57

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

EAST OKLAHOMA'S TIMBER HARVEST, 1965

Charles C. Van Sickle

SOUTHERN FOREST EXPERIMENT STATION

Pine saw logs and pine posts make up half of the total roundwood harvest.

Timber products cut from the forested counties of eastern Oklahoma totaled 30 million cubic feet in 1965. More than half of the volume was pine. McCurtain County was the major producer, followed by Pushmataha and Le Flore. These counties accounted for virtually all of the pine timber harvested and for 40 percent of the hardwood.

Saw logs made up more than half of the 1965 output (table 1). Seventy-eight percent of the logs were pine. The remainder were primarily oak. Saw log production was notably higher than in 1955, when output was last reported. Figure 1 compares the major products in the 2 years.

Eighty percent of the logs sawn went to the region's seven large sawmills, each of which cut more than 3 million board feet. More than

Table 1.—*Output of roundwood by product, east Oklahoma*

Product	Standard units				Roundwood volume		
	Unit	All species	Softwood	Hardwood	All species	Softwood	Hardwood
					M cubic feet		
Saw logs	M bd. ft.[1]	103,937	81,417	22,520	17,147	13,393	3,754
Veneer logs	M bd. ft.	420	----	420	70	----	70
Pulpwood	Std. cords[2]	20,125	8,019	12,106	1,547	605	942
Piling	M linear ft.	144	144	----	71	71	----
Poles	M pieces	114	114	----	443	443	----
Posts	M pieces	4,191	3,411	780	2,607	2,108	499
Fuelwood	Std. cords[3]	81,630	----	81,630	6,122	----	6,122
Misc.[4]	M cubic ft.[5]	2,292	----	2,292	2,292	----	2,292
All products					30,299	16,620	13,679

[1]International ¼-inch rule.
[2]Not including 4.0 million cubic feet of wood from mill residues used for pulp.
[3]Not including 1.7 million cubic feet of wood from mill residues used for domestic and industrial fuel.
[4]Includes charcoal wood, furniture stock, handle stock, cooperage, and other miscellaneous industrial products.
[5]Not including 0.7 million cubic feet of wood from mill residues used for miscellaneous products.

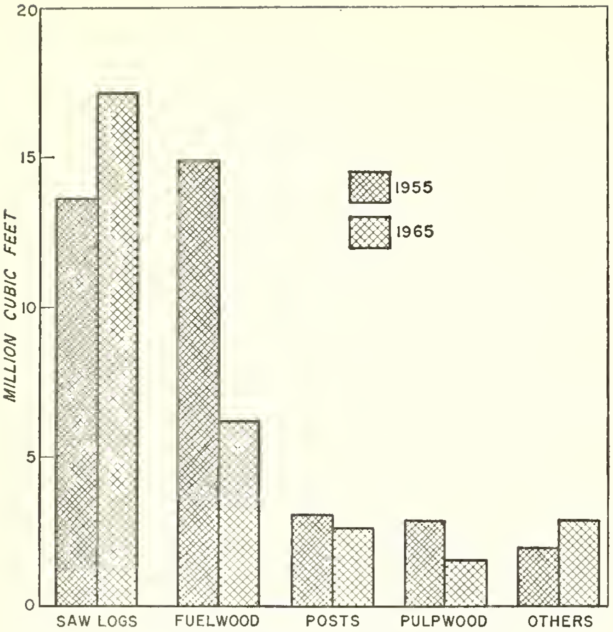


Figure 1.—*East Oklahoma's output of roundwood, 1955 and 1965.*

100 smaller sawmills were also active during the year; they received about a fifth of the saw logs.

Fuelwood was the second largest category of timber products. Hardwoods are used almost exclusively for this purpose. In the past decade estimated consumption dwindled from 200,000 cords to less than 82,000. This trend is expected to continue as per capita income and urbanization increase.

Although fewer hardwoods are now being cut for posts than in 1955, there is still a lively market for pine posts. In 1965, the region produced 4.2 million posts and imported 2.8 million more; of these, about 90 percent were pine. Additionally, one-half million cubic feet of pine was harvested for poles and pilings. The region's nine wood-preserving plants treat most of the pine volume. Cedar and hardwood posts are used untreated.

The 1965 output of pulpwood bolts in east Oklahoma was 20,000 cords, mostly hardwood. In addition, 53,000 cord equivalents of pulp chips were manufactured from pine sawmill residues. The total, which is almost double the 1955 output, reflects recent gains in the region's pulping capacity. Construction of pulpmills nearby in Arkansas is likely to further stimulate Oklahoma production in the next few years.

All other wood products made up 8 percent of the harvest. These products include logs and bolts for charcoal, furniture stock, handle stock, veneer, cooperage, and miscellaneous items.

Tables 2 through 6 constitute a directory of east Oklahoma's primary wood-using industries. Plant locations are mapped in figure 2. A canvass was made of these plants, and those that are outside the region but use east Oklahoma wood. The canvass, plus a survey of nonindustrial wood use, provided the data for this report. An effort was made to locate all active plants, but a few may have been accidentally missed. Thus, omission of a firm is no reflection upon its activities, nor does inclusion constitute a recommendation.

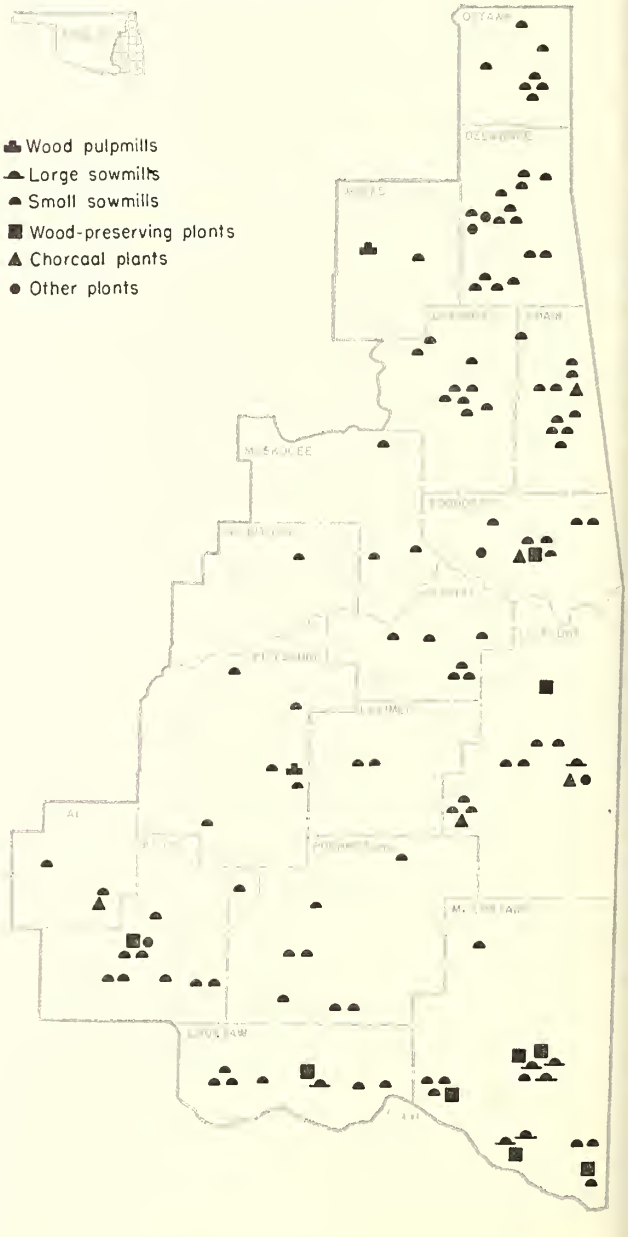


Figure 2.—*Location of primary wood-using plants in east Oklahoma, 1965.*

Table 2—*Large sawmills*[1]

County	Firm	Location	Address[2]
Choctaw	R. M. Fry Lumber Co.	Hugo	Box 458
Le Flore	Burnett Lumber Co.[3]	Heavener	Box 158
McCurtain	Burwell Lumber Co.	Idabel	Box 1067
	Dierks Forests, Inc.[3]	Broken Bow	
	Herron Lumber Co., Inc.[3]	Idabel	Box 511
	Thomason Lumber Co.[3]	Broken Bow	Box 804
	Wood Sawmill	Broken Bow	

[1]Output of 3 million board feet or more.
[2]Specified when different from plant location.
[3]Produces chips for sale to pulpmills.

Table 3.—*Wood pulpmills*

County	Firm	Location
Mayes	Georgia-Pacific, Bestwall Gypsum Div.	Pryor
Pittsburg	Dierks Forests, Inc.	Craig

Table 4.—*Small sawmills*[1]

County	Firm	Location	Address[2]
Adair	Carlis Brannan Sawmill	Stilwell	Rt. 4
	R. J. Clinton	Westville	
	E. M. Hendrex	Stilwell	Rt. 2
	Marion Howard	Westville	Rt. 2
	Kelly Sawmill	Chewey	Rt. 1, Watts
	Tom Parker[3]	Stilwell	Rt. 2
	Bill Sanders	Piney	Box 7, Rt. 2, Westville
	Henry Vaughn	Christie	Rt. 2, Westville
	Chick Walters	Christie	Rt. 2, Westville
	Lenord Wilson	Stilwell	Rt. 2
Atoka	Gene Brock Tie Mill	Stringtown	
	Claude Delay Sons	Atoka	Rt. 2
	Fugate Lumber Co.	Stringtown	
	Hass Sawmill	Daisy	816 E. Tennessee Ave. McAlester
	Jack Long Sawmill	Farris	
	Millard O. Lynn	Lane	Box 27
	Leo Smith	Tushka	Rt. 5, Atoka
	O. D. Smithart Sawmill	Tushka	Rt. 5, Atoka
	Travis Staggs	Farris	Rt. 1
Cherokee	Anderson Sawmill	Tahlequah	Rt. 3
	Applegate Sawmill	Peggs	
	Bradly Lumber Supply[3]	Park Hill	Rt. 1, Box 59
	Castille Sawmill	Tahlequah	Rt. 2
	Cowan Sawmill	Tahlequah	Rt. 4
	Goodnight Sawmill	Welling	Rt. 1
	Horne Sawmill	Moodys	
	Nuttard Sawmill[4]	Peggs	S. Star Rt., Box 58 Locust Grove
	Webster Sawmill	Tahlequah	Rt. 4

Table 4.—*Small sawmills*[1] (Continued)

County	Firm	Location	Address[2]
Choctaw	Andrew Babb	Boswell	
	Wendell David Sawmill	Ft. Towson	Rt. 1
	Marshal Davis Sawmill	Soper	
	Robert Hall	Boswell	Box 186
	John Lindamood Sawmill	Boswell	Box 144
	J. B. Simpson	Sawyer	
Coal	Marvin Brashears Sawmill	Tupelo	Box 4
	Henry Nichols Sawmill	Coalgate	
Delaware	Oscar Barnes	Jay	Rt. 1
	C. R. Botts	Dodge	308 2nd Ave. N.E., Miami
	Jess Cochran	Twin Oaks	½ E. Leack
	Fred Doughty	Colcord	
	Ed January	Colcord	Rt. 2
	K. J. Jeffries	Zena	Rt. 3, Jay
	Clyde Mattews	Jay	Rt. 2, South West City, Mo.
	J. A. McKay	Leach	Rt. 1, Box 55A, Rose
	W. L. Scott and Sons[4]	Topsy	Rt. 1, Eucha
	Coy Smith	Grove	Box 70
	George Stopp	Leach	
	Lowell W. Tipton	Grove	Rt. 2, Fairland
	Oscar Tyler	Kansas	Rt. 4, Siloam Springs, Ark.
	Tommy Wilson	Jay	Rt. 3, Gentry
Haskell	Levi Bray	Whitefield	Rt. 1, Quinton
	N. F. Brigants Sawmill	Keota	Box 232
	Mack Farmer	McCurtain	Rt. 1
	Floyd Gabbard	Stigler	
	Harvey T. Nunn Sawmill	McCurtain	Rt. 1
	Vernon Williams	McCurtain	
Latimer	T. J. Collins Mill	Wilburton	Box 696
	Enis Brothers Sawmill	Wilburton	Rt. 2
Le Flore	Sam Bennett	Wister	Rt. 1
	Noah Bethel Sawmill	Summerfield	Rt. 1, Wister
	Lee Elwood Sawmill	Summerfield	Rt. 1, Wister
	Garner Lumber Co.	Wister	Box 206
	H and R Hardwood	Talihina	Box 172
	Spruell Lumber Co.	Talihina	Rt. 2
	Walthall Lumber Co.	Talihina	Box 563
McCurtain	Altenbaumer Sawmill	Valliant	Rt. 1
	T. L. Clouse Sawmill	Broken Bow	Rt. 1, Box 209
	Coffman Brothers Lumber Co.	Bokhoma	Rt. 1, Haworth
	A. H. Honeywell Sawmill	Valliant	Star Route
	Clyde Neil Sawmill	Tom	
	Joe Smith Sawmill	Valliant	Star Route
	C. C. Standridge	Battiest	Pickens
	Swarts Timber Products	Bokhoma	
McIntosh	Lewis Brothers Sawmill[4]	Checotah	Rt. 2
Mayes	Coy Ball	Salina	Rt. 1
Muskogee	N. F. and Clifford Parker[4]	Webbers Falls	Rt. 1
	N. Thompson Sawmill	Fort Gibson	
	Raymond Woods	Warner	Sallisaw

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Table 4.—*Small sawmills*[1] (Continued)

County	Firm	Location	Address[2]
Ottawa	George B. Betts	Wyandotte	Rt. 1, Seneca, Mo.
	Dolph Burleson	Wyandotte	Rt. 1
	Elmer Mattingly	Miami	438 F St.
	Earl Prater	Wyandotte	Rt. 1, Seneca, Mo.
	Amos Rantz	Quapaw	Rt. 2, Box 225, Seneca, Mo.
	Archie St. John	Peoria	Rt. 1, Quapaw
	H. E. Wyrick	Wyandotte	Rt. 1
Pittsburg	Mike Coufal Sawmill	Pittsburg	
	Tobe Johnston Sawmill	Indianola	Rt. 2
	Cecil Pedige	Bache	Rt. 1
	Roso Lumber Co.	Haileyville	Box 62
	Newt Stoveall	Blocker	Rt. 1
Pushmataha	Birchfield and Son Lumber Co.	Rattan	Rt. 2, Antlers
	O. D. Cochran Lumber Co.	Rattan	Rt. 2, Antlers
	Gordon P. Frederick	Moyers	
	Sam Hill Sawmill	Kiamichi	Tuskahoma
	H. F. Milson	Moyers	
	Robert Musgrave	Antlers	Rt. 2
	Thomas B. Sanders Sawmill	Stanley	Box 37, Clayton
Sequoyah	Brown Sawmill[4]	Akins	Rt. 3, Muldrow
	Denny Sawmill	Nicut	Rt. 3, Muldrow
	Gardenheir Sawmill[4]	Brushy	Rt. 1, Sallisaw
	Honeycut Sawmill[4]	Marble City	Rt. 1, Bunch
	Quall Sawmill	Nicut	Rt. 3, Muldrow
	Thomas Sawmill	Brushy	Rt. 1, Sallisaw

[1]Output of less than 3 million board feet.
[2]Specified when different from plant location.
[3]Produces handle stock in addition to lumber.
[4]Produces furniture or dimension stock in addition to lumber.

Table 5.—*Wood preserving plants*[1]

County	Firm	Location	Address[2]	Type[3]
Atoka	Fugate Lumber Co.	Stringtown		P
Choctaw	R. M. Fry Creosoting Co., Inc.	Hugo	Box 458	P
Le Flore	Midwest Creosoting Products Co.	Panama	Box 575	P
McCurtain	Huffman and Kendrick Wood Preserving Co.	Broken Bow	Drawer A	P
	Mixon Wood Preserving Co.	Idabel	Box 131	P
	D. A. Moore Creosote Co.	Tom		P
	James Stewart Post Yard	Broken Bow		N
	Robert Stouter Lumber Co., Inc.	Valliant	Box 307	P
	Southwestern Wood Preserving Co.	Sallisaw	521 Commercial Bldg., Muskogee	P

[1]Only plants treating roundwood are listed.
[2]Specified when different from plant location.
[3]P indicates pressure treating.
N indicates nonpressure treating.

Table 6.—*Miscellaneous plants*

County	Firm	Location	Address[1]
Adair	Alabama Charcoal Co.[2]	Baron	Rt. 2, Westville
Atoka	Payne Handle Mill[3]	Atoka	Rt. 2
Coal	Oakheart Plant, Carter Charcoal and Carbon Co.[2]	Phillips	
Delaware	Beaver Handle Co.[3]	Topsy	
	Cotrill Brothers Gunstock Manufacturing Co.	Topsy	Box 154, Disney
Le Flore	Heavener Charcoal[2]	Heavener	Box 146
	Kerr Forest Products[4]	Heavener	Box 270, Poteau
	Talihina Charcoal Co.[2]	Talihina	Rt. 1
Sequoyah	Johnson Sawmill[3]	Vian	Sallisaw
	Western Barbecue Supply[2]	Sallisaw	Box 111

[1]Specified when different from plant location.
[2]Produces charcoal.
[3]Produces handle stock.
[4]Produces furniture stock.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE
RESEARCH NOTE

SO-58

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

POLE PRODUCTION IN NATURAL LOBLOLLY PINE STANDS NEAR CROSSETT, ARKANSAS

John R. Bassett
SOUTHERN FOREST EXPERIMENT STATION

In 35-year-old stands on sites with an index of 90, stumpage values from pulpwood and sawtimber were one-third less than from poles, pulpwood, and sawtimber, regardless of stocking during the previous 10 years. As stand density decreased from 130 to 55 square feet of basal area per acre, poles developed faster but returns per acre decreased.

The Southern Forest Experiment Station is studying how stand density affects the yield of poles, and how the integration of pole production with pulpwood and sawtimber production influences returns from even-aged stands of loblolly pine (*Pinus taeda* L.) in southeastern Arkansas. This note reports 10-year results (ages 25-35).

METHODS

In the winter of 1949-50, nine circular 0.1-acre plots surrounded by 0.5-chain isolation strips were established in 20-year-old, unthinned loblolly pine stands. Stocking on the plots varied from 120 to 160 square feet of basal area per acre. The study area is 8 miles east of Crossett, Arkansas.[1] Soils are predominantly Grenada and Calloway silt loams underlain by a fragipan at a depth of 18 to 25 inches. Drainage varies from moderately good on Grenada to somewhat poor on Calloway. The site index (at age 50) is estimated to be between 90 and 95 feet.

In 1949, three treatments were randomly replicated three times: thinning from below at 5-year intervals to basal areas of 70, 85, and 100 square feet per acre. To extend the range of densities, nine additional 0.1-acre plots were established in the winter of 1954-55 in the same stands. Their original densities ranged from 85 to 155 square feet of basal area per acre. Three plots were thinned from below to each of the densities 55, 115, and 130 square feet per acre. In thinning, the straightest, tallest trees were left; straight, limby trees were favored over crooked ones with clear boles. When each plot was established, 15 uniformly spaced superior dominants and codominants were desig-

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[1]The Crossett Division of the Georgia-Pacific Corporation makes the area available and helps to inventory the plots; R. A. Williams assisted in classifying poles.

nated as possible crop trees; in 1959, the best eight trees on each plot were selected.

Hardwoods 3.6 inches d.b.h. and larger were removed in the first thinning. In 1959, the remaining hardwoods 1.0 inch and larger at the root collar were deadened with chemicals, and submerchantable pines were cut.

Pine stems were tallied to the nearest 0.1 inch d.b.h. Merchantable height was measured with an altimeter to a point on the bole estimated to be 3.0 inches in diameter (i.b.). Form class was measured on crop trees in 1954 and on most trees in 1964; it was estimated in 1949 and 1959. Merchantable cubic and board-foot volumes in individual trees were computed from tables compiled by Mesavage and Girard *(2, 3)*. Logs at least 8.0 inches (d.i.b.) at the small end and of sufficient straightness and soundness were graded #2 if they contained fewer than 13 knots less than 2.0 inches in diameter in the best 14 feet. If they contained 13 or more such knots they were graded #3. Pole specifications are listed in table 1.

At each inventory, the merchantable volume of every tree was divided into pulpwood, poles, and sawtimber. Pulpwood included merchantable wood that would not make poles or sawtimber. A tree that qualified as a pole and as sawtimber was evaluated for both products in order to assign separate values for pulpwood and poles (P-P) and pulpwood and sawtimber (P-S). When pulpwood, poles, and sawtimber (P-P-S) were evaluated, sawtimber volume was eliminated in favor of pole volume.

Thinning treatments and management systems were compared on the basis of possible stumpage returns. The values of products removed in the 1949 and 1954 thinnings were omitted because prescribed densities were not achieved until after the 1954 thinning. The pulpwood and sawtimber stumpage values in 1959 and 1964 were assumed to be:

Pulpwood, cord (76 cu. ft.)	$ 5
Sawtimber, M bd. ft. (Int. ¼ inch)	
Grade 2	$16 (equivalent to $31 per M Doyle)
Grade 3	$11 (equivalent to $25 per M Doyle)

Pulpwood and sawtimber stumpage values were about the same in 1959 and 1964. Only 15 logs were cut in 1959. In 1964 the average sawtimber-size tree was 12 inches d.b.h., had a form class of 80, and contained 2½ logs.

Pole stumpage values increased steadily between 1959 and 1964. The few poles cut in 1959 were assigned 1959 values. Table 2 lists the values assigned to poles in 1964.

RESULTS AND DISCUSSION

Stumpage Returns

In 1964, before thinning, the average plot contained 174 trees per acre. Because of rapid growth and increases in pole prices, the value of the poles, pulpwood, and sawtimber in these

Table 1.—*Minimum d.b.h. (o.b.) of trees to meet specifications (1) for various classes of poles*

Pole length (feet)	Pole class and minimum top diameter[1] in inches						
	[2]1 8.8	2 8.1	3 7.5	4 6.9	5 6.2	6 5.6	7 5.0
	Inches						
16	------	------	------	------	------	7.2	6.8
18	------	------	------	------	------	7.7	7.2
20	------	------	------	------	------	8.0	7.5
25	------	------	------	10.8	10.0	9.0	8.2
30	------	------	------	11.4	10.6	9.7	9.0
35	------	------	13.0	12.1	11.3	10.4	9.6
40	15.6	14.6	13.6	12.8	11.9	11.0	------
45	16.4	15.3	14.2	13.4	12.4	11.5	------
50	17.1	16.0	14.8	14.0	12.9	------	------
55	17.7	16.6	15.4	14.5	13.5	------	------
60	18.2	17.2	16.0	15.0	13.9	------	------

[1]Minimum top diameter may not be exceeded by more than 3 inches.
[2]Class 1 minimum d.b.h. may not be exceeded by more than 1 inch.

Table 2.—*Stumpage value per pole, 1964*

Pole length (feet)	Pole class 1	2	3	4	5	6	7
	Dollars						
16	------	------	------	------	------	0.45	0.42
18	------	------	------	------	------	.52	.50
20	------	------	------	------	------	.56	.54
25	------	------	------	0.76	0.76	.75	.74
30	------	------	------	1.58	1.31	1.14	.96
35	------	------	4.00	3.75	3.50	2.25	1.75
40	6.00	6.00	5.50	5.00	4.50	3.50	------
45	7.50	6.50	6.00	5.50	5.25	4.75	------
50	12.00	10.20	9.00	8.40	7.50	------	------
55	17.64	16.06	15.12	10.08	8.82	------	------
60	25.08	22.44	20.46	15.84	10.89	------	------

174 trees increased nearly eightfold between 1954 and 1964. Values by thinning treatment each year were:

Basal area per acre after thinning	1954	1964
(Square feet)	*—Dollars—*	
55	48	438
70	31	356
85	53	321
100	32	371
115	76	505
130	74	440
Average	52	405

Values were also assigned to the wood removed in 1959, and they were compounded to 1964 at 4 percent. Table 3 summarizes the P-P-S values per acre of trees standing in 1964 and those cut in 1959; at all stand densities, pole management increased returns:

Basal area per acre after thinning	P-S	P-P	P-P-S
(Square feet)	*—Dollars—*		
55	260	422	443
70	258	393	411
85	281	474	485
100	272	358	365
115	309	470	482
130	314	539	547
Average	282	443	456

Pulpwood-sawtimber yield averaged 62 percent ($282/$456) of P-P-S yield. This result agrees closely with Vaughan's *(4)* estimate that, between ages 15 and 65, stands grown for pulp-

Table 3.—*Stumpage values per acre, 1954-64*

Basal area per acre after thinning (square feet)	Mean value of trees cut in 1959	Mean value of trees before 1964 cut: Pulp	Poles	Logs	Total[1]
	Dollars				
55	59	19	286	67	443
70	45	27	247	81	411
85	39	41	326	70	485
100	36	101	171	49	365
115	35	65	259	115	482
130	34	78	362	65	547
				Average	456

[1]1959 values compounded at 4 percent annually to December 1964.

wood and sawtimber yield 63 percent of the stumpage value that could be realized by integrating pole production. The differences in returns between P-P and P-P-S management were small but consistent.

Because of high variation among plots in pole-producing potential, stumpage returns were not strongly related to stand density. On 100-square-foot plots, for example, poles were numerous but shorter (table 4) and worth less (table 3) than on other plots. And among 115-square-foot plots, which were within 300 feet of each other, pole quality and quantity varied so much that stumpage returns ranged from $365 to $577 per acre. The variation is probably genetically derived, and presumably was present when the plots were established.

Pole Quality

In December 1964 (age 35), plots had an average of 96 poles per acre which ranged up to 60 feet long (table 4). Proportionately more short poles were present on heavily than lightly stocked plots because few stems on heavily stocked plots were large enough in diameter to make long poles. The merchantable length of 44 of the poles on the average plot was limited by things other than top diameter; i.e., sweep, crook, knots, fork, disease, and logging damage (table 5). As a result of thinning, the lightly stocked plots contained straighter, better formed trees than the heavily stocked plots.

From 1954 to 1959 the number of poles per acre on the average plot decreased from 168 to 82 (table 6) primarily because many trees that qualified as 16- to 20-foot poles in 1954 were too large in diameter in 1959 for these lengths and too crooked for longer poles. Changes in cruise personnel between inventories may have also contributed to changes in pole tally.

Table 5.—*Pole trees per acre whose merchantable length at age 35 was not limited by minimum top diameter*

Basal area per acre after thinning (square feet)	Poles limited by				Total poles limited
	Sweep	Crook	Knots	Other	
	Number				
55	10	0	13	0	23
70	30	0	7	0	37
85	30	10	3	0	43
100	40	7	0	0	47
115	33	3	0	3	39
130	57	13	3	3	76
Average	33	6	4	1	44

Between 1959 and 1964, the average number of poles per acre increased from 66 to 96 (table 6). Was this increase due to cruiser bias or to an improvement in pole quality? The records of numbered crop trees provide a clue. In 1959, 104 crop trees qualified as poles whereas 140 qualified in 1964. Seven tallied as poles in 1959 failed to qualify in 1964, and 43 tallied as nonpoles in 1959 were called poles in 1964. The merchantable length of 20 of the 43 trees was

Table 6.—*Changes in mean number of poles per acre, ages 25-35*

Basal area per acre after thinning (square feet)	1954, after cut	1959, before cut	1959, after cut	1964, before cut
	Number			
55	110	70	57	53
70	133	57	43	67
85	160	90	70	107
100	150	63	53	117
115	203	87	80	70
130	250	123	90	163
Average	168	82	66	96

Table 4.—*Average number of poles per acre at age 35, by length*

Basal area per acre after thinning (square feet)	Total trees	Total poles	Length (feet)									Mean length of poles
			<25	25	30	35	40	45	50	55	60	
			Number									*Feet*
55	83	53	0	3	0	7	13	20	7	0	3	43
70	113	67	0	7	3	24	17	13	0	0	3	38
85	157	103	7	10	26	7	16	30	7	0	0	36
100	247	117	21	23	40	20	13	0	0	0	0	29
115	197	70	7	10	3	27	0	10	3	7	3	37
130	250	163	27	33	30	30	17	23	0	0	3	32
Average	174	96	10	15	17	19	13	16	3	1	2	36

limited by sweep in 1964, an indication that their boles enlarged enough in 5 years to reduce a sweep that disqualified them completely in 1959. Twenty trees on 18 0.1-acre plots in 5 years are equivalent to about two trees per acre per year (20/[18 x 0.1 x 5] = 2.2). Foresters would therefore be wise to spare pole-sized trees that are marginally defective due to sweep. Cruiser bias notwithstanding, many such trees appear to have overcome moderate sweep.

Rate of Pole Development

The growth record of crop trees illustrates how stocking has affected the rate of pole development since 1954. Height growth has differed little between treatments, averaging 10 and 8 feet, respectively, for 1954-59 and 1959-64. In contrast, density has strongly affected mean 5-year d.b.h. growth:

Basal area after thinning	1949-54	1954-59	1959-64
(Square feet)		*Inches*	
55	----	2.2	2.1
70	1.8	2.1	1.8
85	1.6	1.9	1.4
100	1.4	1.6	1.3
115	----	1.6	1.2
130	----	1.4	1.1

To qualify for the next-longer merchantable length, a short pole on the average must enlarge at least 0.7 inch in d.b.h. per 5 feet of height growth. Within class 5, for example, a 10.6-inch, 30-foot pole must grow to at least 11.3 inches d.b.h. to qualify as a 35-foot pole (table 1). The slowest growing trees (those on 130-square-foot plots) grew at rates of 1.4 inches per 10 feet between 1954 and 1959, and 1.1 inches per 8 feet between 1959 and 1964. These rates equal 0.7 inch per 5 feet, or about the minimum. Thus, crop trees on the 130-square-foot plots produced the most lineal feet of poles per cubic foot of wood added. As these trees get older, their d.b.h. growth probably will exceed requirements, because height growth will decrease proportionately more than diameter growth. Moreover, to grow into most pole classes longer than 35 feet, a tree need enlarge only 0.5 to 0.6 inch in d.b.h. per 5 feet of height growth (table 1).

The boles of trees on lightly stocked plots may be enlarging too rapidly for optimum pole development. Obviously, continual excessive d.b.h. growth in relation to length growth leads to excessive taper. In trees whose merchantable length is limited by something other than minimum top diameter, excessive taper can disqualify the entire bole. In addition, as taper increases, the stumpage price per thousand board feet decreases because additional volume is given for the same price (*5*). Rapid bole growth shortens the time required to produce long poles, but widely spaced trees must be inspected relatively frequently so that they can be harvested before they grow too large for poles.

LITERATURE CITED

1. American Standards Association.
   1948. American standard specifications and dimensions for wood poles. 14 pp. Amer. Stand. Assoc., Inc., 10 East 40th St., New York.
2. Mesavage, C.
   1947. Tables for estimating cubic-foot volume of timber. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 111, 71 pp.
3. ———————— and Girard, J. W.
   1946. Tables for estimating board-foot volume of timber. U. S. Dep. Agr., Forest Serv., 94 pp.
4. Vaughan, J. A.
   1952. Problems in supply and manufacture of southern pine poles. J. Forest. 50:362-364.
5. Williston, H. L.
   1957. Pole grower's guide. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 153, 34 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-59

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

GROWTH OF SLASH AND LONGLEAF PINES AFTER CULTIVATION, FERTILIZATION, AND THINNING

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Volume growth of slash pines of pulpwood and saw-log size was decreased by disking and heavy thinning and increased by fertilization. Diameter growth was boosted by fertilization and heavy thinning but was decreased by disking. Similar but less marked results were obtained with longleaf.

In a study in central Louisiana, pines of commercial size were thinned and then fertilized and cultivated annually. Objectives of the test were to determine how seed production and growth responded to these intensive practices. This note reports effects on growth.

METHODS

The study was in a 22-year-old plantation of slash pine *(Pinus elliottii* Engelm.) and a 45-year-old natural stand of longleaf pine *(P. palustris* Mill.). Soils under both stands are fine and very fine sandy loams of the Beauregard. Bowie, and Ruston series. They have fair to good internal drainage but are low in natural fertility. Site index at 50 years averages 95 feet for slash pine and 80 for longleaf. Basal area in both stands averaged 110 square feet per acre.

In 1958, plots of 0.4 acre were freed of hardwoods and thinned to 90 and 50 square feet of basal area per acre. The longleaf plots averaged 110 trees per acre after the light thinning and 52 after the heavy. For slash pine plots, tree counts were 210 and 98.

Some heavily thinned plots received additional treatments: (1) annual disking in June with a heavy-duty offset farm disk that cut about 4 inches deep, and (2) annual disking plus annual fertilization.

Seven fertilizer treatments were tried; they comprised three rates and three times of application. The medium rate supplied 75 pounds N, 125 pounds P_2O_5, and 50 pounds K_2O per acre, and was equal to 500 pounds per acre of a 15-25-10 fertilizer. It represented an estimate of pine requirements, made partly in the light of Wenger's experience with loblolly pine *(2)*, and with allowance for the nutrients naturally present. The high rate was double this amount, and the low rate half of it. The seven treatments are listed in table 1. Two were split applications — i.e., half the total amount was applied in March and half in May. Treatments were replicated three times with each species.

Table 1.—*Thinning, cultivation, and fertilization effects on periodic annual growth per acre of slash and longleaf pine*

Treatment	Slash pine			Longleaf pine		
	Gross volume i.b.	Height[1]	Diameter[1]	Gross volume i.b.	Height[1]	Diameter[1]
	Cu. ft.	*Feet*	*Inches*	*Cu. ft.*	*Feet*	*Inches*
Light thinning	264	2.39	0.27	161	1.57	0.19
Heavy thinning	170	2.41	.37	91	1.36	.27
Heavy thinning and cultivation	111	1.43	.29	73	1.07	.25
Heavy thinning, cultivation, and						
Low NPK, March	174	2.27	.39	105	1.33	.30
Low NPK, split	146	1.67	.37	77	1.31	.33
Low NPK, May	162	2.13	.37	93	1.39	.31
Medium NPK, May	168	2.19	.41	105	1.16	.33
High NPK, March	180	2.14	.46	90	1.07	.35
High NPK, split	196	2.13	.49	110	1.43	.31
High NPK, May	182	2.16	.47	103	1.48	.29
Average	175	2.09	.39	101	1.32	.29

[1]Survivors only.

Tree volumes, diameters, and heights were measured at the beginning and end of a 5-year period on all trees in the central 0.1 acre of the plots. Volumes of individual trees were read from tables 10 and 26 of U. S. Department of Agriculture Miscellaneous Publication 50 *(1)*; values were interpolated for the nearest foot of height and nearest 0.1 inch of diameter. Five percent of the longleaf and one percent of the slash pines died during the study. In computing gross volume growth, it was assumed that the dead trees had contributed no growth.

RESULTS

Slash pine.—Heavy thinning, cultivation, and fertilization all affected volume growth of slash pine markedly (table 1). Periodic annual increment averaged 94 cubic feet per acre less on heavily thinned than on lightly thinned plots. Cultivation of heavily thinned stands depressed growth another 59 cubic feet. Both losses were statistically significant (significance was set at the 0.05 level). The loss in growth due to thinning was clearly a response to residual stocking and indicated that the heavily thinned plots, at least, were insufficiently stocked for maximum growth. The loss from cultivation probably occurred because disking disrupted root systems near the surface and thereby reduced water and nutrient uptake of the trees.

Because all fertilized plots were cultivated, they must be compared with cultivated plots of like density—and not with uncultivated plots—to assay the response to fertilization. Fertilizer boosted volume growth of heavily thinned cultivated plots in proportion to the amount applied. Gains were 50 cubic feet per acre annually for the low rate of application and 75 cubic feet for the high. The annual increase from the high rate exceeded by 16 cubic feet per acre the loss from disking. Time of application was unimportant. These conclusions were supported by orthogonal individual-degree - of - freedom comparisons of selected treatments.

Diameter growth was significantly greater with heavy than with light cutting—0.37 versus 0.27 inch yearly. Disking reduced diameter growth on heavily cut plots by 22 percent, or 0.08 inch per year. This difference, too, was significant. Fertilization at the low rate offset the loss from cultivation, and at the high rate promoted an additional 0.09 inch of growth; consequently, the stands that were cultivated and heavily fertilized grew nearly 0.5 inch in diameter annually, or 0.1 inch more than those receiving only a heavy thinning. Differences between rates of application were significant, but time of fertilization was again unimportant.

Annual height growth was significantly increased by all fertilizer treatments except one

—the low level applied half in March and half in May. The gains did not completely compensate, however, for the 1-foot loss from disking. Differences between times and rates of application were unimportant. Similarly, thinning intensity had no effect on height increment—survivors averaged 2.4 feet annually for both stocking levels.

Longleaf pine.—Only thinning intensity significantly influenced growth of longleaf pine. Heavily thinned stands grew 70 cubic feet per acre per year less in volume and 0.08 inch per year more in diameter than lightly thinned ones.

Certain other similarities existed, however, between slash and longleaf responses: (1) disked, unfertilized longleaf stands grew less in volume, diameter, and height than comparable undisked ones, and (2) fertilized stands grew more in volume and diameter than heavily thinned and disked stands, and equalled or excelled them in height growth.

LITERATURE CITED

1. U. S. Department of Agriculture.
   1929. Volume, yield, and stand tables for second-growth southern pines. U. S. Dep. Agr. Misc. Pub. 50, 202 pp.

2. Wenger, K. F.
   1953. The effect of fertilization and injury on the cone and seed production of loblolly pine trees. J. Forest. 51: 570-573.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-60

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LONGLEAF FIELD PERFORMANCE UNIMPAIRED BY NURSERY CLIPPING TO FACILITATE BROWN-SPOT CONTROL

Eugene Shoulders

SOUTHERN FOREST EXPERIMENT STATION

Neither field survival and growth nor size and grade of nursery stock were adversely affected when the needles of spring-sown seedlings were clipped to a length of 6 inches in late summer or immediately before lifting.

Nurserymen have found that they are able to control brown-spot disease (*Scirrhia acicola* (Dearn.) Siggers) of longleaf pine (*Pinus palustris* Mill.) more effectively if they shorten the needles before a dense mat forms over the nursery bed. Matting prevents uniform coverage of the foliage with a fungicidal spray. Depending on the amount of foliage present, needles are clipped in July, August, or September. They are usually sheared to about 6 inches. The research reported here was designed to learn if this drastic reduction in needle length affects survival and growth in the nursery and in the field.

METHODS

Two studies were conducted; one was started in 1960, the other in 1961. They were terminated in 1966, after trees had been in the field for 4 and 5 years.

Both studies compared no clipping with clipping of needles of spring-sown seedlings to a length of 6 inches in late August or early September. The second included an additional treatment—cutting needles back to 6 inches at lifting time—which has been recommended for improving longleaf survival on adverse sites (*1*).

Treatments were replicated five times in randomized block designs that were maintained throughout the studies. Thus, each field plot contained seedlings from only one nursery plot, and a replication in the nursery comprised a replication in the plantation.

Nursery plots were short segments of a 4-foot-wide bed. On each plot, all seedlings on a 2-square-foot area were lifted, measured, and graded. In addition, 25 seedlings of morphological grades 1 and 2 *(3)* were lifted from each plot and outplanted to observe survival and growth.

The beds were sown in early spring and were thinned to approximately 20 seedlings per square foot in May. As often as necessary, seedlings were sprayed with Bordeaux mixture to control brown-spot disease. They were fertilized and irrigated at rates that maintained good color and rapid growth.

In the first study, trees were lifted and planted on January 21. In the second, they they were lifted on February 1 and planted the next day. Because they were grown in a small experimental nursery, trees were lifted by hand. They were planted by the bar-slit method. The plantations for the two studies were adjacent to each other on a cutover longleaf pine site of good quality in central Louisiana.

In the field, trees were sprayed with Bordeaux mixture twice annually—in June and in late fall—to control needle blight.

Live seedlings in the plantations were counted annually. After 1 year in the field and at the end of the study, their diameters were measured to the nearest 1/32 inch, and their heights to the nearest 0.1 foot.

RESULTS

Reducing the length of needles did not adversely affect the size and quality of planting stock, or its field performance. At lifting time, the length of needles that had been shortened the previous September averaged 9 inches—5 to 6 inches less than unclipped needles. No other important differences in the appearances of the seedlings were noted, nor was nursery survival affected.

In the first study, 90 percent of the clipped and 86 percent of the unclipped seedlings were in morphological grades 1 and 2. Root-collar diameter of seedlings in these grades averaged 9/32 inch and was unaffected by clipping. In the second study, 85 percent of the unclipped seedlings and 75 percent of the seedlings clipped in nursery beds were in grades 1 and 2. This difference was not statistically significant (0.05 level). Clipped seedlings in these grades had an average root-collar diameter of 7/32 inch, 1/32 inch smaller than their unclipped counterparts. While the difference in diameter was statistically significant, it was unimportant because the proportion of plantable seedlings was not significantly reduced.

In the initial study, first-year field survival was improved 18 percentage points by shearing needles in the nursery (fig. 1). The difference persisted throughout the study; after 5 years, survival averaged 65 percent for clipped seedlings and 44 percent for unclipped. In the other study, neither nursery clipping nor clipping at lifting significantly affected survival. After 4 years, survival of clipped and unclipped seedlings averaged 73 percent.

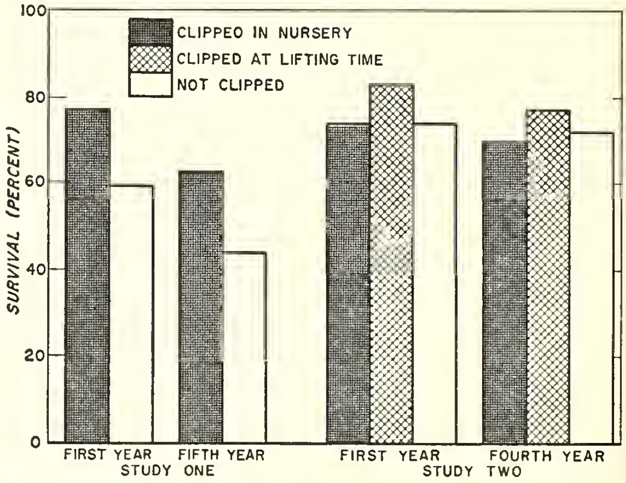

Figure 1.—*Effective of necdle clipping on field survival of seedlings.*

Cropping needles had no apparent effect on height growth. In the first study, about 60 percent of the trees in both treatments were in height growth after 5 years in the field. After 4 growing seasons in the other study, about 50 percent of the clipped and unclipped seedlings had emerged from the grass stage.

CONCLUSIONS

Advantages and limitations of clipping needles immediately before planting have been reported by Allen (*1*) and Derr (*2*). Allen showed that the treatment improved field survival on adverse sites. Derr found that growth and sometimes survival were reduced when trees were planted on favorable sites. Results from clipping at lifting in the present study are intermediate between those of the earlier studies.

Of more immediate concern are the responses to nursery clipping. It caused no important adverse effects on field survival and growth, or on size and quality of nursery stock. Therefore, the practice is recommended to nurserymen for its value in brown-spot control.

LITERATURE CITED

1. Allen, R. M.
   1955. Foliage treatments improve survival of longleaf pine plantings. J. Forest. 53: 724-727, illus.

2. Derr, H. J.
   1963. Needle clipping retards growth of planted longleaf pine. U. S. Forest Serv. Tree Planters' Notes 57, pp. 31-33, illus.

3. Wakeley, P. C.
   1954. Planting the southern pines. U. S. Dep. Agr., Agr. Monogr. 18, 233 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-61

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

THINNING DESIRABLE IN LOBLOLLY PINE PLANTATIONS IN WEST TENNESSEE

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SOUTHERN FOREST EXPERIMENT STATION

In loblolly pine plantations thinned at age 19 and at 5-year intervals thereafter, growth during the 10 years following the first thinning was independent of residual basal area within the range tested—67 to 174 square feet per acre. Thinning was economically attractive in 29-year pulpwood rotations, and appeared necessary in longer rotations.

In western Tennessee and northern Mississippi, pine has been planted on more than 600,000 acres since 1930. Loblolly (*Pinus taeda* L.) has gradually become the preferred species and is now planted almost exclusively. To manage these pine plantations efficiently and to prevent them from being prematurely clearcut, foresters need growth information and recommendations for thinning. A study was established in 19-year-old loblolly plantations on the Natchez Trace State Forest near Lexington, Tennessee, in 1955 to obtain some of the necessary information.

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Ten-year results of the study are reported here. Cubic volume growth was not significantly related to residual basal area within the range tested—67 to 174 square feet per acre. Thus, loblolly pine plantations on similar sites can be thinned to approximately 70 square feet of basal area per acre without reducing volume growth. An economic analysis shows that periodic thinning is more profitable than clearcutting in young stands.

THE STUDY AREA

The plantations studied are on the tops of two parallel ridges which were cropped prior to purchase by the Federal Government in the midthirties. The soil is in the Providence series. On most of the area, 18 to 24 inches of loess overlies an imperfectly developed claypan. Sheet erosion has reduced the thickness of the loess in spots. Site index ranges from 68 to 85 and averages 78.

Loblolly pine was planted at a 6- by 6-foot spacing. When the trees were 19 years old (fig. 1), diameters ranged from 2 to 10 inches, averaging 5.4 inches. Basal area in trees 4 inches d.b.h and larger was 142 square feet per

Figure 1.—Left: *A loblolly plot immediately before it was thinned at age 19. The crop tree (arrow) is 7.1 inches d.b.h. and 40 feet tall. Every third row was removed.*
Right: *The same crop tree at age 29 is 9.0 inches d.b.h. and 60 feet tall.*

acre, and cubic volume averaged 21 cords per acre. Dominant and codominant trees were 43 feet tall.

THE STUDY

Twenty-four ½-acre plots were established. Three plots were randomly assigned to each of eight treatments:

1. Thin to a spacing of D plus 6 feet. D is the average diameter, in inches, of trees to be kept in the stand; each increase of 1 inch in average diameter results in an increase of 1 foot in spacing. In an even-aged stand thinned on this system, basal area will increase as the average size of trees increases—e.g., from 49 square feet per acre when trees average 5 inches in diameter to 134 square feet per acre when they average 18 inches.
2. Thin to 70 to 75 square feet per acre.
3. Remove every third row in the initial cut, plus some merchantable suppressed trees. In subsequent thinnings, reduce basal area to 85 square feet per acre.
4. Remove every fourth row in the initial cut, plus some merchantable suppressed trees. In the second cut, remove the center row of the three-row strips plus some merchantable suppressed and intermediate trees. In successive selective thinnings, reduce the density to 95 square feet of basal area per acre.
5. Thin to a basal area of 120 square feet per acre, salvaging mortality and at least partially releasing saw log crop trees.
6. Thin initially to a basal area of 120 square feet per acre. Reduce the residual basal area by 5 square feet in each successive 5-year cut until 80 square feet is reached at age 59.
7. Thin with the aid of a 7-diopter prism that has a basal area factor of 53.3. This system was tried because it was thought to be easier to apply than D-plus or constant-basal-area systems. The prism pinpoint clusters, which are obscured by sparse areas in fixed-basal-area systems. Whenever more than two trees are tallied from a point, the excess trees are marked for cutting. With perfect spacing,

thinning with the aid of the 7-diopter prism should result in a residual stand of 107 square feet of basal area per acre.

8. Check—no thinning.

The basal areas before and after each treatment are shown in table 1.

On the central 1/10 acre of each plot, all pine 2 inches in d.b.h. and larger were inventoried at 5-year intervals prior to cutting. Diameters were recorded, and pole class and length of all pines in the 7-inch d.b.h. class and larger were estimated. The number of 16-foot logs in trees 9.6 inches and larger was estimated (to the nearest half log) to a minimum top d.i.b. of 6 inches.

In 1955, all hardwoods 2 inches d.b.h. and larger were cut down. To prevent sprouting, the stumps were treated with a diesel oil solution of 2,4,5-T.

On each 1/10-acre plot, the 10 dominant or codominant pines with the greatest potential for producing high quality saw logs were selected as crop trees. Information recorded on each crop tree included: (1) d.b.h. to the nearest 0.1 inch, (2) crown class, (3) total height to the nearest foot, (4) height to live crown to the nearest foot, (5) crown diameter, measured along the north-south and east-west axes to the nearest 0.5 foot, and (6) form class, measured by climbing the tree with a ladder.

A local volume table was constructed at the time of each cut. Ten or more trees in each diameter class were felled, and d.b.h., form class, merchantable length to 3 inches d.i.b., and total height were measured. Data on crop trees were also included. Cubic volumes per tree were obtained by interpolating from Mesavage's tables *(5)*. A conversion factor of 74 cubic feet of wood (inside bark) per rough cord was used.

TEN-YEAR RESULTS

During the 5 years following the first thinning, periodic annual growth per acre averaged 2.02 cords on thinned plots and 2.11 cords on check plots. Comparable statistics for the second 5-year period were 1.67 and 1.50 cords. Table 2 shows stand and stock data before the

Table 1.—*Basal areas per acre before and after thinning, 1955, 1960, and 1965*

Treatment	1955 Before thinning	1955 After thinning	1960 Before thinning	1960 After thinning	1965 Before thinning	1965 After thinning
	Square feet					
D + 6	141	67	90	77	98	83
70-75 sq. ft.	138	74	99	74	79	73
Every 3rd row	145	85	101	83	108	85
Every 4th row	138	96	114	82	97	94
120 sq. ft.	145	120	144	120	134	118
120 sq. ft. decreasing	140	120	133	115	134	110
7-diopter	145	107	128	102	124	106
Check	144	144	158	158	161	161

Table 2.—*Pine stands and stock data per acre,*[1] *1955 to 1965*

Treatment	Original stand—1955 Trees	Original stand—1955 Cubic volume inside bark		Original stand—1955 Basal area	Cut—1955, 1960, 1965 Trees	Cut—1955, 1960, 1965 Cubic volume inside bark		Cut—1955, 1960, 1965 Basal area	Residual stand—1965 Trees	Residual stand—1965 Cubic volume inside bark		Residual stand—1965 Basal area
	No.	*Cu. ft.*	*Std. cords*	*Sq. ft*	*No.*	*Cu. ft.*	*Std. cords*	*Sq. ft*	*No.*	*Cu. ft.*	*Std. cords*	*Sq. ft.*
D + 6	817	1,524	20.6	141	603	1,218	16.5	100	237	1,647	22.3	83
70-75 sq. ft.	783	1,498	20.2	138	537	1,134	15.3	94	197	1,482	20.0	73
Every 3rd row	860	1,549	20.9	145	567	1,304	17.6	100	266	1,646	22.3	85
Every 4th row	847	1,464	19.8	138	450	980	13.2	79	354	1,696	22.9	94
120 sq. ft.	793	1,605	21.7	145	383	863	11.7	65	390	2,231	30.1	118
120 sq. ft. decreasing	780	1,547	20.9	140	363	863	11.7	63	367	2,008	27.3	110
7-diopter	703	1,653	22.3	145	400	1,172	15.9	83	297	2,138	28.9	106
Check	867	1,550	20.9	144	-----	-----	-----	-----	717	2,886	39.0	161

[1] Trees 4 inches d.b.h. and larger.

first thinning and after the third thinning, and the quantity of wood removed in the three thinnings. Basal area and cubic volume growth are summarized by treatment in table 3.

The average diameter of the merchantable stand on the thinned plots before the 1960 cut was 6.5 inches—an increase of 0.6 inch in 5 years. The average diameter of the merchantable stand before the 1965 cut was 7.5 inches. It increased 0.7 inch in 5 years.

Table 3.—*Periodic annual basal area and cubic volume growth per acre*

Treatment	Annual basal area increment			Annual cubic volume increment		
	1955-1960	1960-1965	1936-1965	1955-1960	1960-1965	1936-1965
		Sq. ft.			*Std. cords*	
D + 6	4.50	4.06	6.31	1.78	1.86	1.33
70-75 sq. ft.	4.86	1.06	5.76	2.05	.98	1.22
Every 3rd row	3.18	4.90	6.38	1.77	2.02	1.37
Every 4th row	3.72	2.98	5.97	1.89	1.38	1.25
120 sq. ft.	4.80	2.90	6.31	2.40	1.62	1.44
120 sq. ft. decreasing	2.64	3.90	5.97	1.91	1.66	1.34
7-diopter	4.36	4.36	6.52	2.34	2.14	1.54
Check	2.76	.50	5.55	2.11	1.50	1.34
Average increment of thinned plots	4.01	3.49	6.17	2.02	1.67	1.36

Regression analyses were made with basal areas left following the 1955 and 1960 thinnings as independent variables and cord growth per year during the ensuing 5-year periods as dependent variables. Cubic volume growth was not significantly related (0.05 level) to residual basal area within the range of basal areas tested. Therefore, data from all thinned plots were combined for comparison with data from the check plots.

Thinning definitely increased the production of sawtimber (trees 9.6 inches d.b.h. and larger) but there was as much sawtimber on lightly thinned as on heavily thinned plots. One reason is that in all thinning treatments the crop trees, which were just entering sawtimber size, were released from competition. At age 29 before thinning, the thinned plots contained an average of 1,517 board feet per acre (International ¼-inch rule); the check plots had only 287 board feet.

Periodic annual basal area growth of the thinned plots during the first 5-year period averaged 4.01 square feet per acre; during the second 5-year period it averaged 3.49 square feet. Rainfall was greater and mortality less during the first period. The check plots appear to be reaching their maximum attainable basal area; they added only 2.5 square feet per acre during the last 5 years.

D.b.h. of the average tree removed in thinning was 5.4 inches in 1955, 5.7 inches in 1960, and 6.9 inches in 1965. Average volume increased from 1.8 to 2.5 to 4.7 cubic feet of merchantable wood. The smaller increase during the first 5 years indicates that it takes at least two thinnings to remove most of the small trees from a stand that is thinned primarily from below.

Mortality on the study plots is undoubtedly one reason for the lack of correlation between basal area and cubic volume growth. On the thinned plots, an average of 24 trees per acre 4 inches d.b.h. and larger died between 1955 and 1965. Corresponding mortality on the check plots was 154 trees per acre. The black turpentine beetle *(Dendroctonus terebrans* Oliv.) killed many trees during the last 5 years on two plots thinned to 70-75 square feet of basal area and on two plots with every fourth row removed.

A comparison of crop tree development on thinned and unthinned plots is given in table 4. Trunks of all crop trees are free of live limbs to a height of two log lengths. Maintenance of a larger live-crown ratio on thinned than on check plots has resulted in a 40 percent increase in rate of diameter growth.

Table 4.—*Crop tree development, 1955-1965*

Characteristic	On thinned plots	On check plots
Average d.b.h.	*Inches*	
1955	6.9	6.7
1960	8.0	7.4
1965	9.0	8.2
Form class	*Percent*	
1955	66	67
1960	73	73
1965	75	74
Total height	*Feet*	
1955	43	44
1960	50	53
1965	59	61
Height to live crown	*Feet*	
1955	22	23
1960	30	24
1965	33	39
Live-crown ratio	*Percent*	
1955	50	48
1960	41	35
1965	44	36
Average crown diameter	*Feet*	
1955	10.7	10.7
1960	12.7	9.9
1965	13.3	10.6

Pine poles are a very lucrative product from stands of pulpwood size. Prior to the thinning in 1965, there were 213 pole-sized trees per acre on thinned plots. Ninety of the trees contained poles. The remainder were disqualified by crook, sweep, or fork. Two-thirds of the poles were 16, 18, or 20 feet long; only 12 were 30 feet or longer. On the check plots there were 280 pole-sized trees per acre; only 77 of them would make poles.

ECONOMIC EVALUATION

Some loblolly pine plantations under 25 years old have been clearcut in northern Mississippi and western Tennessee, and more will be in the future. It is not enough to tell a landowner that he is harvesting just prior to the time of most rapid volume growth. He is more interested in dollars and cents.

I believe that a 60-year rotation in which poles, saw logs, and plywood bolts as well as pulpwood are sold will yield greater returns than a shorter rotation for pulpwood alone. An estimate of returns from growing loblolly pine to age 70 in Louisiana supports this thesis *(2)*.

Although the data from the present study are insufficient to justify long rotations, a simple economic analysis shows that periodic thinning and clearcutting when the stand is at least 29 years old is preferable to clearcutting without thinning.

The cost of establishing a plantation was assumed to be $15 per acre, and pulpwood stumpage was valued at $5 per cord. Both figures vary with location and stand conditions, but they are little affected by the length of rotation. A standard 6- by 8-foot planting spacing also was assumed. Taxes and management and fire protection costs were excluded from the analysis because they would not vary with rotation. Since density of the residual stands did not influence growth, returns on the most heavily thinned plots were compared with those on unthinned plots. Returns were converted to equivalent annual annuities (dollars per acre per year) with the formula:

$$a = \frac{Vn(p)}{(1+p)^n - 1}$$

where

a = equivalent mean annual income, dollars

Vn = net future value or income, dollars

p = alternative rate of return, decimal

n = years before final harvest, number

With interest rates of 4, 6, or 8 percent, the equivalent mean annual invested income was highest from thinning at ages 19 and 24 and clearcutting at age 29 (table 5). At 4 percent interest, the equivalent mean annual income from this treatment combination was $3.21 per acre. Comparable figures from clearcutting without thinning were $2.63 at age 19, $3.05 at age 24, and $2.80 at age 29.

Despite unusually dry weather in 1960-65, annual growth on plots thinned to less than 85 square feet per acre of basal area averaged 1.62 cords. In 1960 these plots had a residual volume of 17.07 cords. Thus, heavily thinned plots were producing at a rate of 7.7 percent per year on the average wood capital investment during the last growth period. With this rate of production, it is doubtful if clearcutting at age 29 can be justified.

Table 5.—*Estimated equivalent mean annual income per acre of planted loblolly when planting costs $15 per acre and pulpwood stumpage is $5 per cord*

Interest rate	Treatment	Pulpwood returns compounded and cumulative	Costs compounded	Equivalent mean annual income
4 percent	Thin at 19 yrs.	$ 46.50	--------	--------
	Thin at 24 yrs.	74.59	--------	--------
	Clearcut at 29 yrs.	216.78	$ 46.79	$3.21
	Clearcut at 19 yrs.	104.50	31.60	2.63
	Clearcut at 24 yrs.	157.50	38.45	3.05
	Clearcut at 29 yrs.	195.00	46.79	2.80
6 percent	Thin at 19 yrs.	46.50	--------	--------
	Thin at 24 yrs.	80.22	--------	--------
	Clearcut at 29 yrs.	233.33	81.26	2.07
	Clearcut at 19 yrs.	104.50	45.39	1.75
	Clearcut at 24 yrs.	157.50	60.73	1.90
	Clearcut at 29 yrs.	195.00	81.26	1.54
8 percent	Thin at 19 yrs.	46.50	--------	--------
	Thin at 24 yrs.	86.31	--------	--------
	Clearcut at 29 yrs.	252.79	139.76	1.09
	Clearcut at 19 yrs.	104.50	64.74	.96
	Clearcut at 24 yrs.	157.50	95.12	.93
	Clearcut at 29 yrs.	195.00	139.76	.53

DISCUSSION

Thinning has many advantages in addition to increasing the rate of return on investment. It:

1. Provides early returns to liquidate establishment costs promptly
2. Provides periodic regular income
3. Salvages trees that will soon die
4. Concentrates growth on the best trees
5. Provides the farmer with profitable work during the off season
6. Reduces the frequency of the risk and investment in planting
7. Helps develop large trees that bring high stumpage prices
8. Stimulates seed production for natural regeneration

The absence of significant differences in total growth between thinning treatments indicates that the landowner can choose the most convenient treatment that will maximize yield of the products he hopes to sell.

Probably the most convenient method, and certainly the one favored by timber cutters, was row thinning. Removal of approximately one row in six is required for adequate access anyway. And in the plantations studied, the decrease in the number of crop-tree candidates did not appear to be important, even when every third row was removed. In a stand of poorer quality, the loss in selection might be important. Even so, we can expect use of row thinning to increase as mechanical pulpwood harvesters become popular.

If the purpose of management is to grow large trees for plywood bolts, thinning to no more than 70-75 square feet of basal area per acre is a logical choice. Crop trees grew best with this treatment—2.5 inches in d.b.h. in 10 years.

The stands appeared to be too dense at 120 square feet of basal area. Growth of pulpwood was satisfactory, but diameter growth of crop trees was only 1.8 inches in 10 years. Stands might be thinned initially to 120 square feet, then to lower densities in subsequent thinnings. This procedure would provide a continuing large cut of pulpwood and a steadily increasing area for crop-tree development.

Growth was satisfactory on plots thinned by the D plus 6 technique or with the aid of a 7-diopter prism. Tree markers, however, considered neither system convenient. They much preferred to thin to a specified basal area.

On all thinned plots, the average rate of diameter growth of crop trees during the first 19 years was 3.6 inches in 10 years; from age 19 to 29, it was only 2.1 inches. To maintain a growth rate of 3 inches every 10 years, as has been suggested by many foresters, thinnings would have to be heavier than those of the present study. Diameter growth started decreasing at age 11 or 12, an indication that an early thinning for posts was needed.

When they were 29 years old, the trees on thinned plots had produced at the rate of 1.36 cords per acre per year for the life of the stand; those on the check plots had produced 1.34 cords. On the Maxwell plots at Urania, Louisiana, thinned plots did not outproduce unthinned check plots until trees were from 33 to 35 years old *(4)*. The Maxwell plots had an average site index of 93, whereas the average site index on the present plots was 78.

Some 22-year-old plots with a site index of 70 on the Natchez Trace State Forest in Tennessee grew as much wood per acre on the thinned plots as on the unthinned plots right from the start.[2] Some potential early mortality may have been salvaged at age 12 when the stands were thinned for posts. Subsequent thinnings may also have salvaged more potential mortality than usual, since posts were removed as well as pulpwood.

Horn *(3)* has advanced the thesis that thinning causes a decline in form class of residual trees and that separate volume tables should therefore be used to compute volumes on thinned and unthinned plots. Working with red pine *(Pinus resinosa* Ait.) in Ontario, Berry *(1)* found that from ages 13 to 42 the form class was lower in a thinned stand than in the unthinned check. In the present study, the form class of crop trees on thinned plots increased 9 percentage points during the last 10 years; that of the crop trees on the check plots increased 7 percentage points.

[2] Personal communication from John Lehman, Tennessee Valley Authority.

LITERATURE CITED

1. Berry, A. B.
   1965. Effect of heavy thinning on the stem form of plantation-grown red pine. Dep. Forest. Pub. 1126, 16 pp., illus. Ottawa, Can.

2. Corty, F. L., and Stevens, J. J.
   1959. Pine planting and profits in north Louisiana. La. State Univ. and Agr. and Mech. Coll. Bull. 525, 28 pp., illus.

3. Horn, A. F.
   1961. Changes in form class in a red pine plantation. J. Forest. 59: 181-183, illus.

4. Mann, W. F., Jr.
   1952. Thirty-six years of thinning research with loblolly pine. La. State Univ. First Annu. Forest. Symp. Proc. 1952: 1-7.

5. Mesavage, Clement.
   1947. Tables for estimating cubic-foot volume of timber. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 111, 71 pp.

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SOIL MOISTURE AND TEXTURE AFFECT ROOT AND SHOOT WEIGHTS OF TRANSPLANTED PINE SEEDLINGS

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SOUTHERN FOREST EXPERIMENT STATION

In a greenhouse test, increasing clay content of soils and repeated droughts inhibited shoot and root development of loblolly and shortleaf pine seedlings. Regardless of soil or watering regime, shortleaf developed greater root mass than loblolly pine after comparable treatment.

The study described here was designed to determine how the nursery-acquired shoot and root habits of 1-0 loblolly (*Pinus taeda* L.) and shortleaf (*P. echinata* Mill.) pine seedlings are modified by soil texture and moisture after transplanting. Though plant-part weights and their ratios are determined mainly by heredity and age, their modification by the environment is of silvicultural importance, especially during the seedling stage when plants are particularly sensitive to site characteristics *(5)*.

MATERIALS AND METHODS

One hundred 9-month-old seedlings of loblolly and 100 of shortleaf pine were lifted from the nursery in mid-January, and transplanted to 1-gallon cans. The plants were grown from a local seed source (Nacogdoches, Texas). They were dormant, about 1 foot tall, and had uniformly developed terminal buds, shoots, and roots.

Three mixtures of potting soil were prepared and sifted. Their components were determined by the hydrometer method *(1)*:

	Components		
Soil type	Sand	Silt	Clay
	– – – – *Percent* – – – –		
Loamy sand	84.0	7.6	8.4
Sandy loam	61.3	20.3	18.4
Clay	24.0	19.7	56.3

These soils were selected to represent a range of wilting points (moisture contents at 15 atmospheres of tension). The 15-atmosphere moisture content (in percent) was estimated from the clay content *(3)*. The wilting percent by weight was between 2 and 2.5 for

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the loamy sand, about 4.5 for the sandy loam, and about 20 for the clay soil.

To determine how soil texture modifies shoots and roots, 20 seedlings of each species were transplanted in each soil type. The plants were placed in five randomized blocks in a lath house, and rotated monthly to insure equal illumination of plants and containers. Watering was scheduled to keep the soil moisture near field capacity.

The height of all seedlings was measured immediately after planting and 1 year later, when the test was terminated. At that time, seedlings were severed at the root collar, and the separate fresh and dry weights of shoots and roots were determined.

To measure the influence of recurrent droughts on nursery-acquired shoot and root habits, 40 seedlings of each species were potted in the sandy loam soil, and arranged in the greenhouse in five blocks. The seedlings were watered as needed for 1 month after transplanting. Then, selected plants were watered only at 3-day, 1-week, 2-week, and 3-week intervals, allowing their soils to dry to 70, 51, 15, and 8 percent of field capacity, respectively.

The cans were weighed immediately before and 24 hours after watering to obtain data for computing periodic soil moisture contents. The seedlings were measured, and their shoot and root weights were determined after 1 year, as in the test of soil texture effects.

The data were analyzed by standard statistical procedures. All testing was at the 0.01 level of significance.

INITIAL SPECIES DIFFERENCES

Initial height, and initial shoot and root dry weights (after 24 hours at 105° C.) were determined from a sample of 50 plants of each species:

	Loblolly	Shortleaf
Seedling height (feet)	1.03	1.04
Shoot dry weight (grams)	3.0	3.3
Root dry weight (grams)	0.8	1.7
Shoot-root ratio	3.82	2.05

Neither seedling heights nor shoot dry weights differed significantly within or among species. However, root dry weight of shortleaf was twice as great as that of loblolly pine seedlings. Thus, shortleaf had a lower shoot-root ratio (2.05) than loblolly pine (3.82). Though the shoot-root ratios of both species were higher than those regarded as normal by Huberman *(2)*, the relative differences between the two species were maintained throughout the tests.

SOIL TEXTURE EFFECTS

After growing for 1 year in their respective soils, the height differences between the two species remained nonsignificant. Seedlings grown in clay were somewhat smaller than those in other soils. Table 1 summarizes the effects of soil texture.

Texture produced significant differences in shoot weight within each species. The heaviest shoots developed in loamy sand, and the lightest, in clay. The decrease in shoot weight with increasing clay content of the soils was probably caused by restriction of root extension.

Root dry weights differed significantly both by species and soil. As initially, shortleaf pine's root mass was nearly twice that of loblolly. The biggest roots developed in loamy sand, followed by sandy loam and clay.

Though shoot-root ratios of both species decreased during the test, shortleaf maintained its lower ratio in all soils. The ratios which developed under the influence of the various soils were significantly different. Generally, ratios increased with increasing clay content of the soils, i. e., proportionately smaller roots than shoots developed under the influence of tight soil.

Table 1.—*Average growth response of seedlings to soil texture*

Soils	Shoot height		Shoot dry weight		Root dry weight		Shoot-root ratio	
	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf
	– Feet –		*– Grams –*		*– Grams –*			
Loamy sand	1.55	1.41	5.61	6.91	3.42	7.04	1.64	0.98
Sandy loam	1.55	1.41	5.61	5.31	2.62	5.46	2.14	.97
Clay	1.44	1.38	4.33	4.56	2.23	3.53	1.94	1.29

SOIL MOISTURE EFFECTS

Following rewatering, the average maximum soil moisture was near field capacity for all treatments. The average minimum moisture contents (percent) given in table 2 indicate the relative drought intensity to which the transplants were periodically subjected. After 3 weeks without watering, soil moisture reached the wilting point repeatedly, resulting in 65 percent seedling mortality. The losses were equally divided between loblolly and shortleaf pine, suggesting that the species are about equally drought resistant. Incipient wilting was noted on some plants watered every 2 weeks, but the seedlings recovered when watered again.

Table 2.—*Average maximum and minimum soil moisture contents, by watering interval*

Watering interval	Soil moisture	
	Maximum	Minimum
	– *Percent by weight* –	
3 days	22.8	16.9
1 week	22.2	13.0
2 weeks	20.8	6.4
3 weeks	20.2	4.4

Table 3 gives the effects of watering interval on the seedlings. Regardless of interval, shortleaf pine seedlings were slightly shorter (1.29 feet) than loblolly (1.35 feet), 1 year after transplanting. The reason may be that shortleaf pine began height growth later than loblolly and was therefore more vulnerable to drought *(4)*. Only the trees watered at 3-week intervals were significantly shorter than the others.

With both species, the shoot weights of seedlings watered every week and every 2 weeks were greater than those of seedlings watered every 3 days or 3 weeks. Apparently, watering every 3 days supplied too much water, and every 3 weeks, too little.

Total shoot weights were separated into foliage and stem weights by species and watering interval. Apparently, the increases in shoot dry weight were largely due to increases in foliage rather than stem weight. Foliage weight increased as a proportion of total shoot weight with increasing periodic moisture stress.

Loblolly pine root weight decreased noticeably with decreasing moisture supply. The root weight of shortleaf seedlings was slightly higher with 2-week than 1-week watering intervals, but was least with the 3-week interval. Regardless of moisture supply, shortleaf seedlings had heavier roots than loblolly pine seedlings.

LITERATURE CITED

1. Bouyoucos, G. J.
   1951. A recalibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43: 434-438, illus.
2. Huberman, M. A.
   1940. Normal growth and development of southern pine seedlings in the nursery. Ecology 21: 323-334, illus.
3. Nielsen, D. R., and Shaw, R. H.
   1958. Estimation of the 15-atmosphere moisture percentage from hydrometer data. Soil Sci. 86: 103-105, illus.
4. Stransky, J. J., and Wilson, D. R.
   1964. Terminal elongation of loblolly and shortleaf pine seedlings under soil moisture stress. Soil Sci. Soc. Amer. Proc. 28: 439-440, illus.
5. Wenger, K. F.
   1955. Height growth of loblolly pine seedlings in relation to seedling characteristics. Forest Sci. 1: 158-163, illus.

Table 3.—*Average growth responses of seedlings to watering intervals*

Watering interval	Shoot height		Stem dry weight		Foliage dry weight		Shoot dry weight		Root dry weight		Shoot-root ratio	
	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf	Loblolly	Shortleaf
	– *Feet* –		– *Grams* –		– *Grams* –		– *Grams* –		– *Grams* –			
3 days	1.33	1.29	2.31	2.07	2.81	3.22	5.12	5.29	6.09	8.62	0.84	0.61
1 week	1.42	1.37	2.71	2.41	3.33	4.37	6.04	6.78	5.73	8.94	1.05	.76
2 weeks	1.37	1.28	2.56	2.52	4.26	5.07	6.82	7.59	4.69	9.07	1.45	.84
3 weeks	1.30	1.22	1.84	1.71	3.56	3.58	5.40	5.29	3.27	4.73	1.65	1.12

SOUTHERN FOREST EXPERIMENT STATION

1967

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SO-63

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

EFFECTS OF SPACING AND SITE ON THE GROWTH AND YIELD OF PLANTED SLASH PINE

Lloyd F. Smith [1]

SOUTHERN FOREST EXPERIMENT STATION

Gross growth of 21-year-old slash pine in southern Mississippi averaged about 38 cords per acre on a cutover site and 58 cords per acre on an abandoned field. On both sites, yield was highest on plots with the closest tree spacings.

This note gives growth and yield of 21-year-old slash pine (*Pinus elliottii* Engelm.) planted at various spacings on cutover land and on an abandoned field in southern Mississippi. The study reported was established on the Harrison Experimental Forest in 1941. One-year-old nursery seedlings were planted at square spacings of 4.6, 5.4, 6.6, and 9.3 feet—approximately 2,000, 1,500, 1,000, and 500 trees per acre. There was also a rectangular spacing of 4.6 by 9.3 feet (about 1,000 trees per acre).

Four 5/8-acre plots were planted at each spacing. The plots were in four blocks. Three blocks were on land from which longleaf pine had recently been clearcut; the fourth was on a field that had been taken out of agricultural production several years before planting. The soils were Ruston fine sandy loam, which is regarded as highly productive in the Gulf Coastal Plain. Slash pine site indexes could not be estimated at the time of planting, but heights after 15 years indicate that the old field has a site index (at age 25) of about 77, and the cutover land, between 58 and 69 *(2)*.

STOCKING AND MORTALITY

At 15 years, survival ranged from 38 to 45 percent on the cutover site, and from 30 to 52 percent on the old field (table 1). Planting spacing did not significantly [2] influence survival percent on the cutover plots. In an unpublished study report, P. C. Wakeley attributed early mortality to poor seedling storage at the planting site and to unskilled planting crews. Losses were most serious at the wide spacings, where heavy mortality created large openings and reduced yields. On some plots, there were insufficient trees for adequate natural pruning of the lower branches of the crop trees.

[1] Stationed at the Institute of Forest Genetics, Gulfport, Mississippi.

[2] In this note, statistical tests of differences were computed at the 0.01 level of confidence.

Table 1.—*Inventory, thinnings, and growth of stands (acre basis)* [1]

Initial spacing (feet)	Inventory at 15 years				Cut in two thinnings [2]				Inventory at 21 years			Gross growth at age 21		
	Trees	Survival	Basal area	Volume	Trees	Trees	Basal area	Volume	Trees	Basal area	Volume	Basal area	Volume	Mean annual growth
	No.	*Percent*	*Sq. ft.*	*Cords*	*No.*	*Percent*	*Sq. ft.*	*Cords*	*No.*	*Sq. ft.*	*Cords*	*Sq. ft.*	*Cords*	*Cords*
						CUTOVER PLOTS [3]								
4.6	784	38	135	28.9	459	58	73	16.4	325	103	28.7	176	45.1	2.2
5.4	581	40	122	27.3	322	55	64	14.0	259	98	28.8	162	42.8	2.0
6.6	415	45	96	21.7	187	45	41	9.5	228	90	26.4	131	35.9	1.7
9.3	204	40	67	15.9	67	33	22	5.7	137	75	23.1	97	28.8	1.4
4.6 × 9.3	438	43	109	24.0	200	46	46	10.1	238	93	27.6	139	37.7	1.8
						OLD FIELD PLOTS [4]								
4.6	611	30	176	55.4	385	63	95	31.3	226	126	38.3	221	69.6	3.3
5.4	456	32	151	47.7	262	57	71	27.2	194	130	37.9	201	65.1	3.1
6.6	283	31	115	37.3	166	59	51	21.6	117	89	25.3	140	46.9	2.2
9.3	267	52	125	40.0	115	43	46	16.6	152	116	37.9	162	54.5	2.6
4.6 × 9.3	420	43	136	43.5	257	61	64	23.6	163	106	30.6	170	54.2	2.6

[1] Includes all trees 3.6 inches d.b.h. and larger.

[2] Includes mortality from 15 to 21 years.

[3] Averages of three replications at each spacing.

[4] Values for single plots at each spacing.

At age 15, all trees with fusiform rust infections on the stems were examined. Between 21 and 38 percent of the pines on cutover plots had one or more stem infections, and between 34 and 45 percent of those on the old field were infected. Most of the stem galls were less than 6 feet off the ground. Some trees were killed by fusiform rust and could not be salvaged. Others were deformed, making their stems unsuitable for saw logs or poles. Following the first thinning a few of the large pines were killed by black turpentine beetles *(Dendroctonus terebrans* (Oliv.)); however, all losses were light between ages 15 and 21.

THINNINGS

The plots were thinned at ages 15 and 18 to provide growing space for the expanding tree crowns and promote growth of the best individuals for future harvests of saw logs and poles. Slash plantations normally should be thinned at about age 15 and again at 3- to 5-year intervals.

In the first thinning in this study, pines with stem infections were removed along with other defective and inferior trees. The large, high-quality pines were left. At all spacings, about one-fourth of the trees and one-fourth of the basal area were removed from the cutover plots, and about one-third of the trees and basal area were removed from the old field.

In the second thinning (at 18 years), about 100 pines per acre were removed from all plots. The basal areas and volumes cut were similar to those of the first thinning. The cut was lightest at the wide spacings.

In the two thinnings, approximately one-half of the trees, basal areas, and cordwood volumes present at age 15 were harvested (table 1). Thinned volumes were about twice as large on the old-field plots as on the cutover plots planted at the same spacings. On both sites, pulpwood yields from the thinnings were largest on the plots with the highest initial stocking.

HEIGHT AND DIAMETER GROWTH

The 15-year heights of dominant and codominant trees averaged 46 feet on the cutover plots and 55 feet on the old field (fig. 1). In 6 years, the heights of dominant and codominant trees increased to 65 feet on the cutover site and to 69 feet on the old field. Thus, mean annual height growth at 21 years was 3.1 feet on the cutover site and 3.3 feet on the old field. Planting spacing did not influence height growth.

At 15 years, average d.b.h. by plot ranged from 5.6 to 7.8 inches on the cutover site and from 7.3 to 9.2 inches on the old field. Trees with the largest diameters were on plots planted at the widest spacings. At age 21, average d.b.h. ranged from 7.5 to 10.0 inches

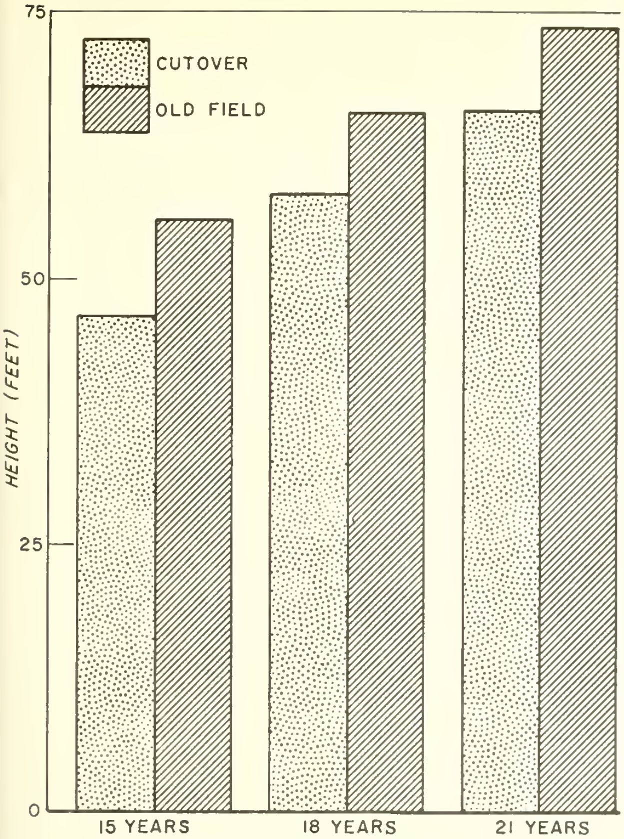

Figure 1.—*Average heights of dominant and codominant trees at 15, 18, and 21 years.*

on cutover site and from 9.7 to 11.5 inches on the old field. This rapid growth in the last 6 years reflects the thrifty condition of the plantation following thinning. The removal of many small trees in pulpwood thinnings also increased the average tree size in the reserved stand.

The diameter distribution pattern was distinctly different on the two sites (fig. 2). Clutter and Bennett *(1)* derived diameter distribution tables for slash pine plantations in Georgia which indicate changes in diameter class distribution as plantations develop on a range of sites. At age 15, the diameter distributions on the cutover plots agree more closely with Clutter and Bennett's tables than do those on the old field.

BASAL AREA GROWTH

Basal area of merchantable pines (trees 3.6 inches d.b.h. and larger) ranged from 67 to 135 square feet per acre on the cutover plots and from 115 to 176 square feet on the old-field plots at age 15 before the first thinning (table 1). Basal area was closely related to initial spacing and increased with the closer spacings

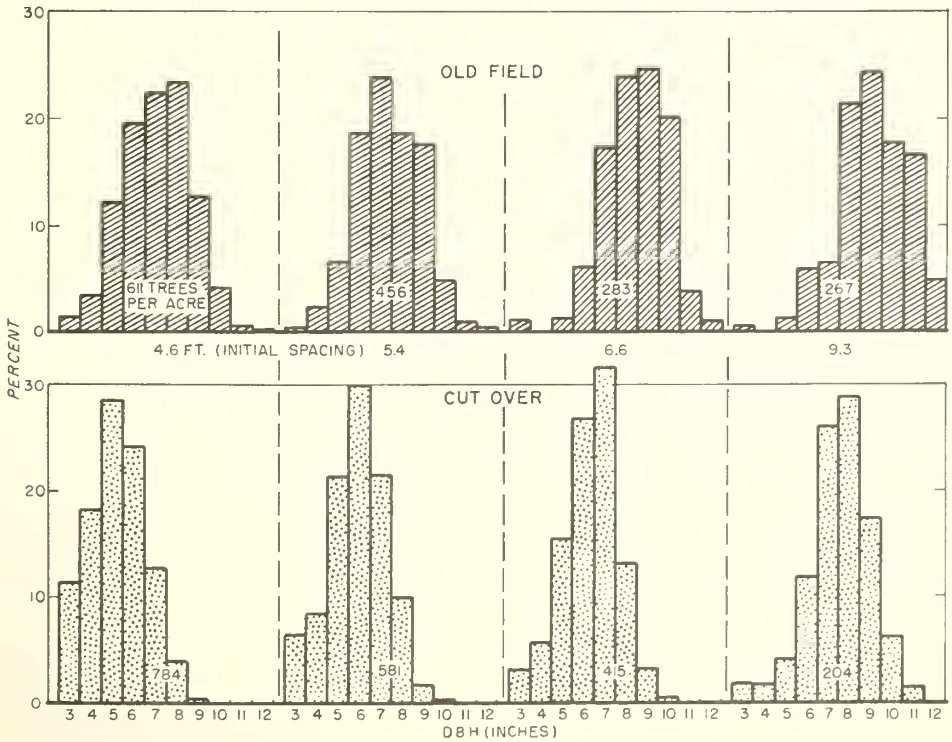

Figure 2.—*Diameter distributions at age 15 by planting spacing (3-inch class includes trees 2 and 3 inches d.b.h.).*

on the cutover site. On the old field, however, the 9.3-foot spacing had more trees and larger basal area at 15 years than the 6.6-foot spacing. On both sites the closest spacings, with 611 and 784 trees per acre, appeared to approach maximum basal area growth.

At age 21, gross basal area growth, including thinnings and mortality, ranged from 97 to 176 square feet per acre on the cutover site and from 140 to 221 square feet on the old field. In addition, an undetermined amount of basal area in merchantable pines was killed by fusiform rust before the 15-year inventory.

CUBIC VOLUME GROWTH

The merchantable volumes before the first thinning varied from 15.9 to 28.9 cords on the cutover plots and from 37.3 to 55.4 cords on the old field (table 1). Volumes were directly related to stocking except at the two widest spacings on the old field. Cordwood volumes on the cutover plots differed significantly by spacing. Data for the old-field plots were not analyzed because the treatments were not replicated. Approximately one-third to one-half of the 15-year volumes were cut in the two thinnings.

At age 21, cordwood volumes on the cutover plots were about as large as those present in the first inventory at 15 years. Thus, volume growth in the last 6 years equaled or exceeded that cut in the two thinnings. In contrast, on the old field, cordwood volumes at 21 years were considerably smaller than those in the 15-year inventory.

When the final inventory was made at 21 years, mean annual gross growth, including thinnings and mortality, ranged from 1.4 to 2.2 cords per acre on the cutover land and from 2.2 to 3.3 cords on the old field. Mortality includes only unsalvaged trees that had died between ages 15 and 21 years. In this period an average of three merchantable trees per plot died on the cutover site, and 19 per plot on the old field.

DISCUSSION

The results show the effects of five different initial spacings and two planting sites on growth and yield of planted slash at age 21 years. Poor planting practice modified the influence of initial spacing, and heavy fusiform rust infection caused considerable losses before the first thinning was made at 15 years. These losses were most serious at the wide spacings, because they increased understocking. Losses before age 15 resulted in stocking rates that were about 50 percent of those specified in the study plan.

The thinnings at 15 and 18 years substantially benefited the plantations. Thinnings removed rust-infected and other poor-quality trees, improved growing space for crop trees, and provided substantial income from the sale of pulpwood. In this study, the management objective was to cut pulpwood in early thinnings and sawtimber and poles in later harvests.

Both site and spacing treatments had a pronounced effect on the quality of the trees. A tally of trees by quality class in the first inventory indicated that 52 percent of the individuals on the cutover plots and 41 percent of those on the old field were potential sawtimber trees. There were more coarse-branched and crooked individuals on the old field. This difference in tree quality appeared to be related to the lower stocking and more rapid growth on this site. Widely spaced trees attained sawtimber size sooner than closely spaced trees.

LITERATURE CITED

1. Clutter, J. L., and Bennett, F. A.
   1965. Diameter distributions in old-field slash pine plantations. Ga. Forest Res. Counc. Rep. 13, 9 pp.
2. McGee, C. E., and Bennett, F. A.
   1959. Site index curves for old-field slash pine plantations. U. S. Forest Serv. Southeast. Forest Exp. Sta. Res. Note 127, 2 pp., illus.

SOUTHERN FOREST EXPERIMENT STATION

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SOIL-SITE RELATIONS OF UPLAND OAKS IN NORTH ALABAMA

Glendon W. Smalley [1]

SOUTHERN FOREST EXPERIMENT STATION

On 36 white oak plots on the Cumberland Plateau south of the Tennessee River, site quality was related to slope position and total length of slope. On 22 mixed red oak plots, site quality was related to aspect and slope position. No soil factors were significantly related to tree height after the effects of age and topography were taken into account.

The conventional method for estimating the quality of a site for a particular species is to measure the height and age of dominant and codominant trees and refer to site index curves. Unfortunately, this method cannot be applied in stands that have been logged or damaged by fire, grazing, ice, or snow. Neither is it applicable in poorly stocked or uneven-aged stands, or in stands where the desired species is not present. In such instances, site quality must be estimated indirectly from quantifiable features of soil and topography.

Relationships between site and soil, or topography, usually apply to a limited geographic area because of differences in parent material, soil, and climate.

The research described here is part of a comprehensive series of studies of soil-site relations of commercially important hardwoods and pines in central Tennessee and northern Alabama. This note reports results for upland oaks, including black (*Quercus velutina* Lam.), northern red (*Q. rubra* L.), scarlet (*Q. coccinea* Muenchh.), southern red (*Q. falcata* Michx. var. *falcata*), and white (*Q. alba* L.).

Results of soil-site studies have been published for black oak in southeastern Ohio *(4)*, for northern red oak in the Allegheny Mountains of West Virginia *(22)*, for white oak in southeastern Ohio *(8)* and in northern Mississippi and western Tennessee *(15)*, and for various oaks in Connecticut *(14)*, Rhode Island *(16)*, southern Michigan *(10)*, northeastern Iowa *(7)*, the Arkansas Ozarks *(1)*, western Tennessee *(11)*, the Allegheny Mountains of West Virginia and Maryland *(18, 19)*, the southern Appalachians *(6)*, and the Virginia-Carolina Piedmont *(5)*.

[1] Stationed at the Silviculture Laboratory maintained at Sewanee, Tenn., in cooperation with The University of the South. The author thanks Kenneth Pierce, Forestry Research Technician, for assistance in the field and laboratory.

METHODS

The study was conducted on the William B. Bankhead National Forest in Lawrence and Winston Counties, Alabama (fig. 1). The area is at the southern end of the Cumberland Plateau; it is strongly dissected into narrow ridgetops and valleys, extensive hills, and steep slopes. Soils are derived from conglomerate, sandstone, and shale of the Pottsville formation of the Pennsylvanian system. Most of the soils are coarse to medium textured, well to excessively drained, and strongly acid *(21)*.

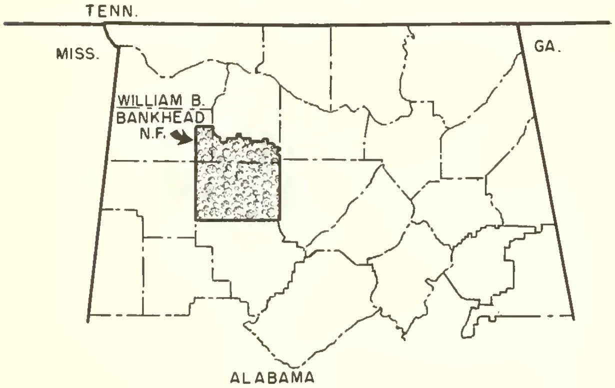

Figure 1.—*Study area.*

The climate is humid and temperate. Winters are cool, but include frequent short periods that are cold or moderately warm. Precipitation is distributed fairly evenly throughout the year, and averages about 56 inches. Light snow is common, but seldom remains on the ground for more than 3 or 4 days. Excessively dry weather is most common from August through October. The growing season is approximately 199 days. The average January temperature is 44° F., average July temperature is about 78° F. *(20)*.

On the study area, upland oak stands were located that contained no evidence of fire, erosion, or recent cutting. Plots at least 1/5 acre in size with uniform soil and topography were established in the stands. No single plot size was specified because yield on an area basis was not computed. Among a total of 58 plots, 36 contained mainly white oak, and 22 contained mainly mixed red oaks.

On each plot, tree height and total age (number of annual rings at breast height plus three) were determined for two to six dominant or codominant trees of each oak species present. Only sound, single-stemmed trees of similar crown size, bole form, and diameter were chosen. Tree age ranged from 40 to 127 years (table 1). Variations in age on any one plot were limited to 10 years. Site indices at age 50, estimated from Schnur's curves *(17)*, ranged from 48 to 81 feet.

Table 1.—*Distribution of white and mixed red oak site plots by age and site index classes (in number of plots)*

Age class (years)	Site index class (feet) 45-54	55-64	65-74	75-84	Total plots
		WHITE OAK			
40-49	...	...	1	...	1
50-59	1	2	4	...	7
60-69	2	3	1	1	7
70-79	2	5	...	1	8
80-89	2	5	2	2	11
90+	1	...	1	...	2
Total	8	15	9	4	36
		MIXED RED OAKS			
40-49	...	1	3	2	6
50-59	...	4	2	1	7
60-69	...	1	3	...	4
70-79	...	5	...	...	5
Total	...	11	8	3	22

Three pits were dug on each plot. The soil series and type were identified, and the thickness of all genetic horizons was measured down to bedrock or to a maximum depth of 48 inches. Core samples were taken at the middle of the A2 and B2 horizons in zonal soils, and at 6- and 18-inch depths in azonal soils. Composite bulk samples were taken at the same depths.

The contents of sand, silt, and clay in bulk samples were determined by Bouyoucos' method *(3)*. Core samples were also analyzed using standard procedures *(13)*, and soil constants were defined as by Broadfoot and Burke *(2)*. Bulk density, stone content, total pore volume, big-pore volume, and 60-cm. moisture were measured in the core samples.

Slope percent, aspect, slope position, and total slope length were recorded for each plot.

A total of 68 possible independent variables were compiled from the laboratory and field measurements. By plotting each possible variable against apparent site index, and by single-variable regression analysis, the 25 most promising were screened out:

	White oak	Mixed red oaks
X_1	1/age	same
X_2	$(X_1)^2$	
X_3	Aspect, sine of azimuth from East + 1	same
X_4	Slope position, percent of distance from ridge to stream (ridge = 0; stream = 100)	same
X_5	$(X_4)^2$	
X_6	Total slope length + distance to ridge (chains)	same
X_7	Slope percent	same
X_8	Aspect × slope position	
X_9	Slope position × slope percent	
X_{10}	Depth to bedrock	
X_{11}	Thickness of A horizon	
X_{12}	Total pore volume of A horizon (inches)	
X_{13}	Percent big pores of A horizon	
X_{14}	$(X_{13})^2$	
X_{15}	60-cm. moisture of A horizon (inches)	
X_{16}		Bulk density of A horizon including stones (g./cc.)
X_{17}		Bulk density of A horizon, excluding stones (g./cc.)
X_{18}	Slope position/thickness of A horizon	
X_{19}	$(X_{18})^2$	
X_{20}	60-cm. moisture of B horizon (inches)	
X_{21}	60-cm. moisture of solum (inches)	
X_{22}	Percent stones in solum	
X_{23}		Bulk density of solum, including stones (g./cc.)
X_{24}		Bulk density of solum, excluding stones (g./cc.)
X_{25}	Percent silt in A horizon + percent silt in B horizon	

In a multiple regression analysis, these variables were related to tree height rather than apparent site index because stand ages ranged widely. This procedure also avoided the assumption that the form of the height over age curves was constant for all combinations of soil and topography. Three full nine-variable solutions were tested for white oak, and one full solution was tested for red oaks.

The form of the regression equations was:

Logarithm of tree height $= b_0 + b_1x_1 + b_2x_2 + \ldots\ldots + b_nx_n$

where

$$b_0 = \text{Regression constant}$$
$$b_{1 \ldots\ldots n} = \text{Regression coefficients}$$
$$x_{1 \ldots\ldots n} = \text{Independent variables}$$

Equations were computed with the multiple-regression program described by Grosenbaugh *(9)*. Each species group was analyzed separately. Tree age was entered first in the regression, and fitting was stopped when addition of another variable did not significantly reduce the residual sum of squared deviations (0.05 level).

RESULTS AND DISCUSSION

Both white oak and red oak tree heights were related to age (X_1) and to two expressions of topography. In the presence of these variables, soil factors did not significantly improve the equations.

The topographic factors associated with white oak tree height were slope position (X_4) and total slope length plus distance from plot center to ridge (X_6):

$$Y = 1.796 - 2.296X_1 + 0.000598X_4 + 0.00523X_6$$
$$(R^2 = 66.3 \text{ percent})$$

Red oak tree height was best accounted for by aspect (X_3) and slope position, along with tree age:

$$Y = 1.932 - 8.584X_1 + 0.0382X_3 + 0.000444X_4$$
$$(R^2 = 74.6 \text{ percent})$$

An age of 50 was substituted in the equations to calculate the curves in figures 2 and 3, which show the relations between site index and topographic factors.

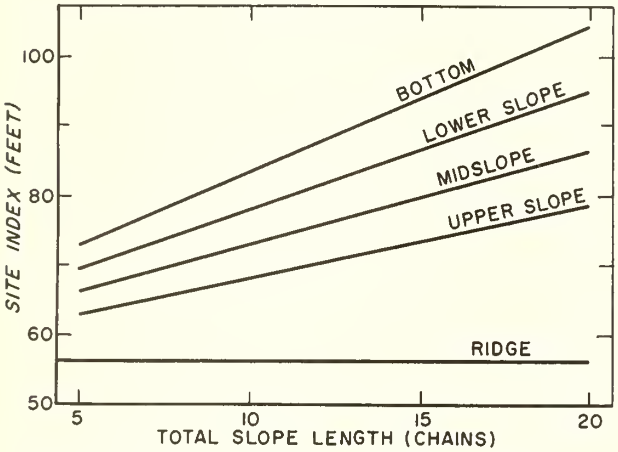

Figure 2.—*Effect of slope length and slope position on white oak site index.*

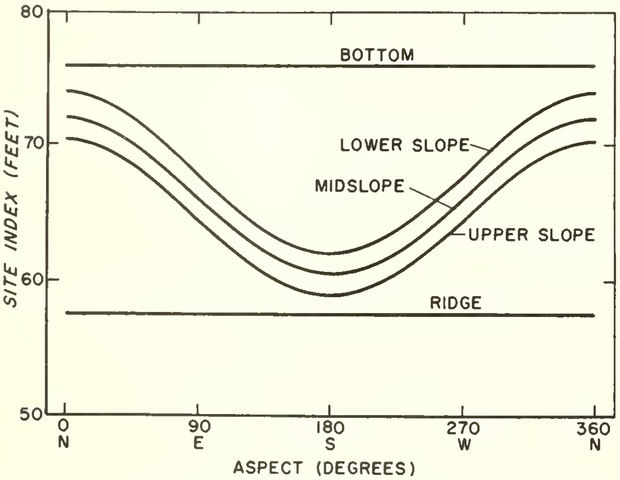

Figure 3.—*Effect of aspect and slope position on red oak site index.*

For white oak, about one-third of the height variation was attributable to age; for red oaks, one-half was a function of age. Topographic factors accounted for the remaining percents of height growth variation (R^2) explained by the equations.

Site quality for red oaks is best on north, intermediate on east and west, and poorest on south slopes. Site index of white and red oaks is lowest on dry ridges and increases downslope as the site becomes cooler and more moist. Contributions of topographic position and/or aspect to site quality for oaks have been reported in 11 Eastern States *(4, 5, 6, 7, 8, 10, 11, 14, 15, 18, 19,* and *22).*

Total length of slope plus distance from plot center to ridge influenced white oak height growth. Probably, this variable affects moisture supply, i. e., the longer the slope, the greater the soil mass, and the greater the quantity of soil moisture available for subsurface flow *(12).*

Slope percent was directly correlated with height growth of both white and red oaks, but its effect was negligible after age and other topographic factors were taken into account. The direct relation of slope steepness with tree growth agrees with Della-Bianca and Olson's *(5)* observations with scarlet and black oak in the Piedmont, and those of Carmean *(4)* with black oak on fine-textured soils with restricted internal drainage in southeastern Ohio.

Several soil factors influenced tree height. Surprisingly, 60-cm. moisture of the A horizon was inversely correlated with height of white oak. One would expect a positive relation since, in general, an increase in the amount of moisture that is held at 60 cm. of tension should mean an increase in available water.

Bulk density was inversely correlated with height growth of red oaks. Since bulk density is an indirect measure of structure, pore volume decreases as it increases. Thus, internal drainage and aeration decrease and tree growth is reduced. Weighted bulk density of the solum, excluding fragments greater than 2 mm. in diameter, was better correlated than bulk density including coarse fragments.

Soil thickness variables (total depth, surface, subsurface, and solum) did not affect the height of oaks.

Obviously, the effect on tree growth of topographic variables, which overshadowed soil variables, is indirect. Topography is an integrator of the primary causes of site variation —soil moisture and structure, nutrients, and microclimate.

LITERATURE CITED

1. Arend, J. L., and Julander, O.
   1948. Oak sites in the Arkansas Ozarks. Ark. Agr. Exp. Sta. Bull. 484, 42 pp., illus.

2. Broadfoot, W. M., and Burke, H. D.
   1958. Soil-moisture constants and their variation. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 166, 27 pp., illus.

3. Bouyoucos, G. J.
   1951. A recalibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43: 434-438, illus.

4. Carmean, W. H.
   1965. Black oak site quality in relation to soil and topography in southeastern Ohio. Soil Sci. Soc. Amer. Proc. 29: 308-312, illus.

5. Della-Bianca, L., and Olson, D. F., Jr.
   1961. Soil-site studies in Piedmont hardwood and pine-hardwood upland forests. Forest Sci. 7: 320-329, illus.

6. Doolittle, W. T.
   1957. Site index of scarlet and black oak in relation to southern Appalachian soil and topography. Forest Sci. 3: 114-124, illus.

7. Einspahr, D., and McComb, A. L.
   1951. Site index of oaks in relation to soil and topography in northeastern Iowa. J. Forest. 49: 719-723, illus.

8. Gaiser, R. N.
   1951. Relation between topography, soil characteristics, and the site index of white oak in southeastern Ohio. U. S. Forest Serv. Central States Forest Exp. Sta. Tech. Pap. 121, 12 pp., illus.

9. Grosenbaugh, L. R.
   1958. The elusive formula of best fit: a comprehensive new machine program. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 158, 9 pp., illus.

10. Gysel, L. W., and Arend, J. L.
    1953. Oak sites in southern Michigan: their classification and evaluation. Mich. Agr. Exp. Sta. Tech. Bull. 236, 57 pp.

11. Hebb, E. A.
    1962. Relation of tree growth to site factors. Tenn. Agr. Exp. Sta. Bull. 349, 18 pp., illus.

12. Hewlett, J. D., and Hibbert, A. R.
    1963. Moisture and energy conditions within a sloping soil mass during drainage. J. Geophys. Res. 68: 1081-1087, illus.

13. Hoover, M. D., Olson, D. F., Jr., and Metz, L. J.
    1954. Soil sampling for pore space and percolation. U. S. Forest Serv. Southeast. Forest Exp. Sta., Sta. Pap. 42, 28 pp., illus.

14. Lunt, H. A.
    1939. Soil characteristics, topography, and lesser vegetation in relation to site quality of second-growth oak stands in Connecticut. J. Agr. Res. 59: 407-428.

15. McClurkin, D. C.
    1963. Soil-site index predictions for white oak in north Mississippi and west Tennessee. Forest Sci. 9: 108-113, illus.

16. McGahan, M. W., Brown, J. H., Jr., Gould, W. P., and others.
    1961. Site conditions and tree growth analyses in Rhode Island forests. R. I. Agr. Exp. Sta. Bull. 357, 32 pp., illus.

17. Schnur, G. L.
    1937. Yield, stand, and volume tables for even-aged upland oak forests. U. S. Dep. Agr. Tech. Bull. 560, 87 pp., illus.

18. Trimble, G. R., Jr.
    1964. An equation for predicting oak site index without measuring soil depth. J. Forest. 62: 325-327, illus.

19. ———— and Weitzman, S.
1956. Site index studies of upland oaks in the northern Appalachians. Forest Sci. 2: 162-173, illus.

20. U. S. Department of Agriculture.
1941. Climate of Alabama. *In* Climate and Man, pp. 751-760. U. S. Dep. Agr. Yearbook 1941. Washington, D. C.

21. U. S. Soil Conservation Service.
1959. Lawrence County, Alabama. Soil Surv. Ser. 1949, No. 10, 83 pp. U. S. Government Printing Office, Washington, D. C.

22. Yawney, H. W.
1964. Oak site index of Belmont limestone soils in the Allegheny Mountains of West Virginia. U. S. Forest Serv. Res. Pap. NE-30, 16 pp., illus. Northeast. Forest Exp. Sta., Upper Darby, Pa.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-65

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

GROWTH RESPONSE OF EASTERN COTTONWOOD TO NUTRIENTS IN SAND CULTURE

F. T. Bonner and W. M. Broadfoot [1]

SOUTHERN FOREST EXPERIMENT STATION

In a greenhouse test, seedlings grew best when nutrient solutions contained 100 p.p.m. N, 75 p.p.m. P, and 100 p.p.m. K. The foliage from the largest seedlings contained 3.5 to 4.5 percent N, 0.5 to 0.7 percent P, and 3.0 to 4.0 percent K.

The prospect of rapid returns from growing eastern cottonwood *(Populus deltoides* Bartr.) makes plantation fertilization a distinct possibility on appropriate sites. A prerequisite for the economical use of fertilizers is a basic understanding of the nutrient requirements of cottonwood. Information contributing to such an understanding is presented in this note.

METHODS

Seedlings were grown from locally collected seed in sixty-three 5-gallon glazed stone crocks of sized quartz sand in a greenhouse at the Southern Hardwoods Laboratory. The sand in each crock was leached with distilled water until the specific electrical conductance of the leachate fell below 5×10^{-5} mhos per cm.—about 30 p.p.m. total soluble salts *(5)*.

A randomized block design with three replications of 21 crocks each was used to test seven levels each of nitrogen (N), phosphorus (P), and potassium (K). Nutrient solution levels were:

N—0, 10, 25, 50, 100, 200, and 300 p.p.m.

P—0, 5, 10, 25, 50, 75, and 100 p.p.m.

K—0, 25, 50, 100, 200, 300, and 400 p.p.m.

Where one element was varied, the other two elements were supplied at constant rates (100 p.p.m. for N and K, 50 p.p.m. for P). All solutions also contained the following nutrients in p.p.m. concentrations of: calcium, 86; magnesium, 104; chelated iron, 5; boron, 0.5; manganese, 0.5; zinc, 0.05; copper, 0.20; and molybdenum, 0.01. When mixed, the solutions were adjusted to a pH of 5.5 to 6.5 with NaOH.

The sand-culture apparatus was a modified version of the one described by Gauch and

[1] The research was done at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

Wadleigh *(1)*. Automatic 90-second irrigations with the nutrient solutions were delivered at 15-minute intervals from a reservoir crock. Each crock unit contained 19 liters of nutrient solution.

The seedlings were grown from fresh seeds sown on the surface of the sand in May 1965, when only distilled water was circulating in the culture apparatus. Six days after sowing, the distilled water was siphoned out, and nutrient solutions at 1/3 the intended final strength were substituted. After 2 weeks, full-strength solutions were put in all crocks. Thereafter, the solutions were replaced with fresh ones every 3 weeks.

As the seedlings grew they were thinned by hand, eventually to one seedling per crock except in those treatments where seedling height growth was much less than the average. In such treatments, enough seedlings were left to assure sufficient plant material for nutrient analyses. Final thinning was done in late June.

It was necessary to periodically add distilled water to reservoir crocks to replace water lost by evaporation and transpiration, and to prevent concentration of the nutrient solutions. Near the end of the study, 1 to 2 gallons were added per crock every 3 days for the largest seedlings.

The seedlings were harvested in late July, approximately 9 weeks after germination. Measurements were made of: (a) seedling height; (b) foliage, stem, and root fresh weight; and (c) foliage, stem, and root dry weight. Dry weights were obtained by drying the tissues to a constant weight at 68° C. Foliage samples were then ground in a Wiley mill and stored for later analyses of N, P, and K.

Foliage analysis for total N was by the Kjeldahl method. P analyses were made on ash extracts by the chlorostannous-reduced molybdophosphoric blue method. K analyses were done on ash extracts by flame photometry.

RESULTS

Based on total seedling dry weight, the best growth occurred at nutrient solution levels of 100 p.p.m. N, 75 p.p.m. P, and 100 p.p.m. K (table 1). Other expressions of seedling growth showed trends similar to total seedling dry weight.

In the P and K series, there was little difference among high levels (table 1). Comparison of treatment means by Duncan's new multiple range test showed no significant increases (0.05 level) in total seedling dry weight for additions of more than 5 p.p.m. P and 25 p.p.m. K.

Table 1.—*Mean seedling growth and foliage contents of N, P, and K*

Nutrient treatment (p.p.m.)	Total height	Total plant dry weight	Foliage nutrients		
			N	P	K
	Cm.	*Grams*	*Percent by weight*		
0 N	7	<0.1	1.58	0.78	1.97
10 N	61	5.3	2.09	.60	2.90
25 N	135	44.9	2.35	.65	2.90
50 N	168	70.4	2.94	.64	3.25
100 N	167	80.8	4.24	.69	3.00
200 N	158	76.8	4.44	.83	3.33
300 N	127	37.3	5.23	.83	3.10
0 P[1]	2	.1	5.81	.40	1.98
5 P	149	55.8	4.38	.30	3.90
10 P	151	53.6	4.20	.53	3.63
25 P	155	60.1	4.07	.50	3.00
50 P	149	63.8	4.30	.52	2.97
75 P	155	67.5	4.26	.70	3.20
100 P	154	56.5	4.00	.71	3.47
0 K	19	1.9	4.24	.72	.57
25 K	126	62.4	3.64	.75	1.20
50 K	156	62.8	3.86	.70	1.95
100 K	179	79.2	4.01	.77	3.35
200 K	161	68.8	3.84	.67	3.77
300 K[1]	152	63.4	3.87	.66	4.42
400 K	157	78.6	3.86	.68	4.13

[1] Only two replications included.

In the N series there was a significant stunting of growth with 300 p.p.m. Comparison of level means indicates no significant differences in total seedling dry weight between 50, 100, and 200 p.p.m. N. At 300 p.p.m. N, total seedling dry weight was close to that obtained at 25 p.p.m.—about half of the dry weight at the three best levels.

The relationship of growth to foliar nutrient content is important (fig. 1). Although wide variation occurred, trends are evident for foliar N and K. The inhibitory effect of high N is especially striking. The relation of growth to foliar P was weak.

The data suggest the following foliage concentrations as indicators of the best and lowest

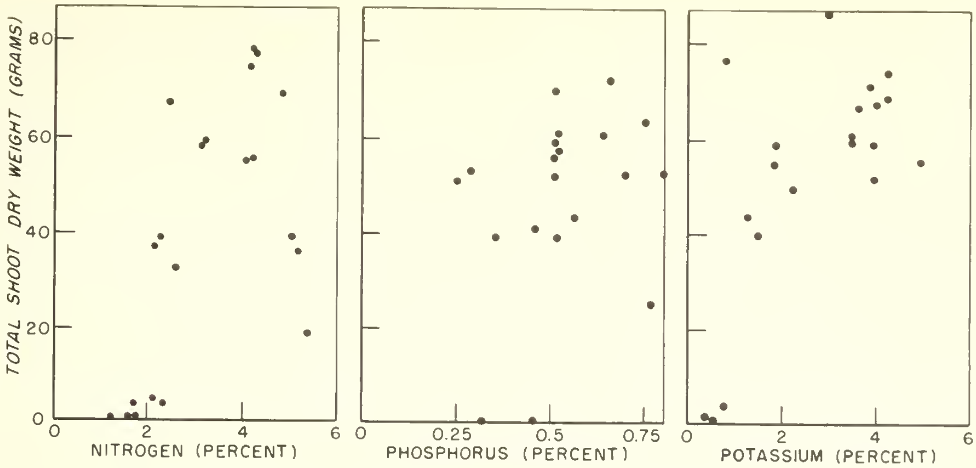

Figure 1.—*Relations between foliar nutrient contents (percent by weight) and shoot dry weights.*

acceptable growth under the conditions of the study:

	Best	Lowest acceptable
	Percent	*Percent*
N	3.5-4.5	3.0
P	.5- .7	.3
K	3.0-4.0	1.2

Seedlings grown with 0 p.p.m. of individual nutrients exhibited deficiency symptoms typical of agronomic crops. N deficiency was characterized by chlorosis, which was most pronounced between leaf veins. Some chlorosis was evident even at the 25-p.p.m. level. P-deficient shoots were small with a red pigmentation, which was strongest on the leaf margins and petioles. K deficiency was characterized by burning of leaf margins, which extended between primary veins almost to the leaf midribs. The entire leaf surfaces on K-deficient plants had a crinkled appearance.

Position in the greenhouse (blocks) had no significant effect on plant growth.

DISCUSSION

In general, the foliar nutrient contents associated with best growth were higher than those reported for most other tree species grown in nutrient culture *(4)*. However, our values compare favorably with foliage contents of N, P, and K from young *Populus* trees sampled in May-July in Europe *(7, 8)*. The lowest acceptable level of K from our study is also close to published values for K deficiency: 0.7 percent for *P. tremuloides (9)*, 1.0 percent for *P.* × *robusta (6)*, and 1.7 for *P.* × *'canadensis'* cv. 214 *(2)*.

The sand-culture results must be translated into nutrient relationships for seedlings grown in soil. Growth characteristics of sand-culture plants can be altered by factors independent of the relationship between yield and nutrient supply *(3)*. Aside from the atypical conditions of the greenhouse, makeup of nutrient solutions and method of irrigation can influence results. The present study, for example, would probably have been more valuable if additional low levels of P had been tested. Research with seedlings grown in soil is now under way.

LITERATURE CITED

1. Gauch, H. G., and Wadleigh, C. H.
1943. A new type of intermittently-irrigated sand culture equipment. Plant Physiol. 18: 543-547, illus.

2. Giulimondi, G.
1960. Ricerche preliminari sulla nutrizione minerale del pioppo a mezzo dell'analisi foliare. Pub. Cent. Sperim. Agr. Forest., Roma 4: 231-245. [Ital.]

3. Hewitt, E. J.
1966. Sand and water culture methods used in the study of plant nutrition. Commonwealth Bur. Hort. and Plantation Crops, Tech. Commun. 22. Ed. 2, rev., 547 pp., illus. Commonwealth Agr. Bur., Farnham Royal, Bucks, England.

4. Ingestad, T.
1962. Macro element nutrition of pine, spruce, and birch seedlings in nutrient solutions. Medd. Statens SkogsforsknInst., Stockholm 51 (7): 1-131, illus.

5. Jackson, M. L.
1958. Soil chemical analysis. 498 pp. Englewood Cliffs, N. J.: Prentice-Hall, Inc.

6. Meiden, H. A. van der
1959. Het onderzoek naar de betekenis van kalium voor de populier. Kali, Amsterdam 4(40): 371-376. [Dutch]

7. ———— and Kolster, H. W.
1964. Variaties in de samenstelling van populierenblad gedurende de vegetatieperiode en in verschillende delen van de kroon. Ned. Bosbouw Tijdschr. 36: 1-11, illus. [Dutch, Engl. sum.]

8. Schmalfuss, K., and Schulze, W.
1961. Über Nährstoffverlagerungen in Holzgewächsen. Flora 150: 353-371. [Ger.]

9. Walker, L. C.
1955. Foliar analysis as a method of indicating potassium-deficient soils for reforestation. Soil Sci. Soc. Amer. Proc. 19: 233-236, illus.

SOUTHERN FOREST EXPERIMENT STATION

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T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

IMPROVING GERMINATION OF NUTTALL OAK ACORNS

R. L. Johnson [1]

SOUTHERN FOREST EXPERIMENT STATION

Under simulated field conditions the best treatment for germination of acorns of Quercus nuttallii *Palmer was a combination of sowing 1 inch below soil surface, under litter, and in partial shade. Supplemental watering was also advantageous. The most important factor was depth of sowing.*

Nuttall oak, an important commercial species in low, wet areas in the South, and especially in the lower Mississippi Valley, has heavy seed crops every 3 or 4 years.[2] Plentiful seed does not ensure good stands of reproduction, however, for unfavorable site conditions may seriously hamper germination.

Acorns fall from early October to mid-December, with the peak usually in late November. The seeds frequently remain under water for 3 or 4 months during winter and spring. Long-term soaking at low temperatures does not decrease viability[3] and may help break dormancy. While acorns will germinate when submerged, it is doubtful that seedlings become established. Once the water leaves, lack of moisture appears to limit germination and seedling establishment. Since good seedling stands often occur in depressions beneath crowns of Nuttall oak, it appears that shade, moisture, and possibly litter accumulation are important factors. A study was accordingly undertaken to test various seedbed conditions, with a view to discovering a combination favorable to seedling establishment.

METHODS

Several hundred Nuttall oak acorns that had been under water since December were collected on April 19, 1964. On the 20th and 21st of April, 20 sound acorns (as judged by close visual examination) were sown in each of 72 blocks of Sharkey clay soil. The blocks, measuring 1 foot square and 6 inches deep, were

[1] Stationed at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

[2] Morris, R. C. Nuttall oak (Quercus nuttallii Palmer). In Silvics of Forest Trees of the United States, pp. 593-595, illus. U. S. Dep. Agr., Agr. Handbook 271. 1965.

[3] Briscoe, C. B. Germination of cherrybark and Nuttall oak acorns following flooding. Ecology 42: 430-431. 1961.

dug from the Delta Experimental Forest, near Stoneville, and enclosed with wooden slats on the sides and burlap underneath. The soil was relatively undisturbed during lifting.

Blocks were arranged in the nursery of the Southern Hardwoods Laboratory in a split-plot design, with three replications, to test all combinations of:

Two light treatments—full sunlight and partial shade from a snow fence placed about 1 foot above the soil surface. Snow fence slats were oriented east-west.

Two moisture treatments—natural rainfall and a minimum of 1 acre-inch of water per week through a combination of rain and supplemental watering.

Two seedbed conditions—mineral soil and about 1 inch of partially decomposed litter present when the blocks were dug.

Three sowing depths—on the surface of the mineral soil, with top of acorn even with surface of mineral soil, and with top of acorn 1 inch below surface of mineral soil.

The four light-moisture combinations constituted the major plots.

In the expectation that moisture and temperature would be important to germination, measurements were taken of: 1.—Moisture contents of one or two acorns per soil block weekly from May through July (but no more than 10 acorns were removed from any replication). 2.—Moisture contents in the surface inch of soil in shaded and unshaded mineral and littered soil blocks during one 7-day period. 3.—Temperatures on and 1 inch below the surface of mineral and littered soil both in full and partial sunlight throughout the summer.

RESULTS

Germination ranged from 0 to 100 percent, depending on treatment (table 1). Percentages were based on the 10 seeds per soil block left after 10 had been removed for moisture-content determinations. Germinating seeds were counted throughout the growing season. More than 95 percent of the seeds that germinated did so by June 16. A few acorns at all depths turned black and spongy during the first week. The number found in this condition increased weekly, and by July 1 few were sound at any depth.

Table 1.—*Germination of Nuttall oak acorns by treatments*

Planting depth and seedbed condition	Light		Shade	
	Rainfall	Rainfall and watering	Rainfall	Rainfall and watering
	Percent			
Surface				
Bare soil	13	0	0	0
Litter	3	13	3	0
Even with surface				
Bare soil	3	3	7	20
Litter	43	13	60	50
Inch below surface				
Bare soil	33	83	73	97
Litter	77	90	80	100

Analysis of germination percentages showed significant differences (0.05 level) among several variables.

Sowing depth affected germination more than any other factor. Germination averaged 5 percent for all surface-sown acorns, 25 percent for even-with-the-surface acorns, and 79 percent for acorns 1 inch below the surface. Most acorns had a moisture content of 50 to 70 percent when sown. Those placed on the soil surface were immediately exposed to 100° F. for several hours at a time; as a result, most seedcoats burst and the embryos dried. Acorns sown 1 inch deep maintained a high moisture content.

Germination was 39 percent in blocks given supplemental water and 33 percent in blocks receiving only rain. From April 21 through June 16 (8 weeks), watered blocks received 9.8 inches of water. Natural rainfall during this time was 6.6 inches, and was reasonably well distributed. In early May, 7 days after a supplemental watering, soil moisture in the surface inch of the blocks was 2 to 3 percentage points higher under shade than in the open and 2 or 3 percentage points higher under litter than in bare soil. Soil moisture averaged 5 to 6 percentage points higher in shaded, littered blocks than in open, unlittered blocks.

There was a significant interaction between watering and sowing depth. Where water was added, germination averaged 92 percent for deep-sown acorns, 3 percent for those on the surface, and 21 percent for those sown even with the surface. Corresponding percentages for acorns exposed only to rain were 66, 5, and 28. The additional water was of substantial benefit only to deep-sown acorns, but the data do not reveal the reason.

Shade from the snow fence cut light intensity by about 50 percent, according to readings taken on July 2 and August 16. Overall, shaded acorns had 41 percent germination, as compared to 31 percent for acorns in full sunlight. The interaction of light × planting depth was not significant.

Litter was about 1 inch thick in most boxes, but ranged from ½ to 2 inches. Germination was 44 percent with some litter and 25 percent without any litter.

From May 5 through June 16, temperatures near the acorns varied with treatment (table 2). On the surface of bare soil, temperatures of 70-90° (probably the best range for germination) prevailed only 27 percent of the time in full sunlight and 61 percent in shade, while for 13 percent of the time in the sun and 7 percent in the shade the acorns were exposed to 100-130° (too high for germination). Germination was best among acorns sown 1 inch below the soil surface, under litter, and under shade in temperatures that never exceeded 90° and ranged between 70-90° for 93 percent of the time.

DISCUSSION

One inch of soil over the acorns was the most beneficial single treatment. It probably acted as a buffer against extremely high temperatures. Soil moisture (which is closely associated with temperature) and moisture content of acorns were both higher, and thus better for germination, an inch below the soil surface. Litter, partial shade, and supplemental watering all helped create an even more desirable environment by further reducing temperature and conserving soil moisture.

In the forest, seedbed conditions like those of the best treatment can probably be obtained by plowing furrows during autumn. Acorns would either fall naturally or could be thrown into the furrows and then covered with 1 to 2 inches of soil. Leaf fall during the winter would provide litter. Records at Stoneville show that the soil an inch below the surface usually does not reach 70° under full shade until June or even later. By opening the stand somewhat, it may be possible to raise soil temperature to 70-90° in late April, May, and early June, when soil moisture is normally high. Apparently, few Nuttall acorns will germinate after July 1, even if soil moisture is adequate.

Table 2.—*Percent of total time recorded from May 5 through June 16 in each of nine temperature classes*

Location of sensing unit	Temperature class (° F.)								
	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130
	Percent								
Surface of bare, unshaded soil	4.6	28.7	19.1	16.2	11.1	7.4	8.6	3.7	0.7
Surface of bare, shaded soil	0	0	21.0	42.7	18.1	11.3	6.7	.2	0
One inch below surface of bare, unshaded soil	0	0	17.5	42.7	26.8	12.4	.7	0	0
One inch below surface of littered, unshaded soil	0	0	23.4	54.1	21.6	.9	0	0	0
One inch below surface of bare, shaded soil	0	0	10.2	56.3	28.0	5.5	0	0	0
One inch below surface of littered, shaded soil	0	0	6.6	86.0	7.3	0	0	0	0

SOUTHERN FOREST EXPERIMENT STATION

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GROWTH OF PINE PLANTED FOR EROSION CONTROL IN NORTH MISSISSIPPI

Hamlin L. Williston [1]

In plantations averaging 26 years old, annual net growth for the life of the stands was 1.08 cords per acre for loblolly and 0.77 cord for shortleaf. Growth of the same plantations up to age 21 years had been 0.89 cord for loblolly and 0.58 cord for shortleaf.

This note reports the growth, over a 5-year span, of pulpwood-size plantations established some two decades ago on eroding sites in the Yazoo-Little Tallahatchie watershed of northern Mississippi. The original purpose of the plantations was to stabilize the sites, and this objective was rather uniformly accomplished in the first 10 years. The stands then continued to develop, and today are demonstrating obvious commercial possibilities. It is hoped that the data summarized here will help forest managers and conservation agencies to formulate policies and procedures for preserving the hydrologic values of the plantations at the same time that timber is harvested for industrial purposes.

METHODS

The Yazoo-Little Tallahatchie Flood Prevention Project of the U. S. Forest Service established 199 permanent sample points during 1959 in plantations 16 to 26 years old. A wide range in sites and stand densities was represented. Ninety-nine of the plantations were loblolly pine *(Pinus taeda* L.), 88 were shortleaf *(P. echinata* Mill.), and 12 were slash pine *(P. elliottii* Engelm.). At each sample point a prism having a basal area factor of 10 was used to select trees for measurement. D.b.h., form class, merchantable height, and total height were recorded for each selected tree.

The plots—minus some that were clearcut in the interim—were remeasured in 1964 by the same procedures.

Volumes in rough cords per acre (in trees 5 inches and larger at d.b.h.) were determined from Minor's merchantable-length tables *(4)*. It was necessary to extend the tables downward to include form class groups 45 to 49, 50 to 54, 55 to 59, and 60 to 64, and merchant-

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able lengths of 10 and 15 feet. A conversion factor of 75 cubic feet = 1 cord was applied in extending the tables. Point-sample volumes were expanded to per-acre estimates by Grosenbaugh's method *(2)*. The heights of the five trees of largest d.b.h. on each plot were used in determining site index from Coile and Schumacher's curves *(1)*. Further information on the methodology appears in Research Note SO-1 of the Southern Forest Experiment Station *(7)*.

Ninety of the plots were on private land; of this number 15 were clearcut during the 5-year period, 13 of them ostensibly for pasture development. Only 87 of the loblolly and 83 of the shortleaf pine plots were found suitable for regression analysis. All the loblolly and shortleaf measured were used in the other computations. There were too few slash pine plots for a valid analysis.

RESULTS

The 5-year changes due to growth on surviving trees, and to losses from natural mortality and cutting, are summarized in table 1. The plantations have made substantial gains in mean diameter and height, and in average basal area and volume. Loblolly stands have outgrown shortleaf, but there are indications that the differences between species may lessen as time goes on.

Table 1.—*Stand data by species, trees 4 inches d.b.h. and larger*

Item	Loblolly stands		Shortleaf stands	
	1959	1964	1959	1964
Average age (years)	21.3	26.3	21.0	26.0
Mean diameter (inches)	8.6	9.9	6.3	6.8
Mean basal area per acre (square feet)	90	108	101	108
Mean total height (feet)	46	54	37	45
Mean merchantable height (feet)	27.8	34.1	19.5	24.4
Stand volume per acre (cords)	16.9	24.2	13.0	18.3
Trees per point sample (number)	9.0	...	10.1	...
Sum of diameters per point sample (inches)	79.8	.	63.1	...
Annual growth per acre, 1959-1964 (cords)				
Of survivors [1]	...	1.50	..	1.16
Net [2]	..	1.88	...	1.53
Net increase [3]	...	1.45	.	1.05

[1] Trees measured in 1959 and still present in 1964.
[2] Survivor growth plus ingrowth minus mortality.
[3] Survivor growth plus ingrowth minus mortality minus harvested volume.

Tree Development

Average diameter of loblolly pines increased by 1.3 inches, from 8.6 to 9.9 inches; shortleaf pines increased 0.5 inch, from 6.3 to 6.8 inches. The largest 20 percent of the loblolly pines grew 1.4 inches, and the corresponding shortleaf pines grew 0.8 inch in the 5-year period.

Loblolly pines increased 6.3 feet in merchantable height, shortleaf 4.9 feet. Total height growth was identical for the two species, both increasing 8 feet. In 1964 the average loblolly had a total height of 54 feet, the average shortleaf 45 feet. Since shortleaf had reached an average height of 37 feet in the 21 years before 1959, as compared with 46 feet for loblolly, the 5-year growth rates constitute a relative increase in total height growth of shortleaf.

Growth in height resulted in apparent increases in average site index after 1959. Indicated site index for loblolly increased from 70 to 75, for shortleaf from 54 to 63. While sites may have improved to some degree, the changes in index are believed due mainly to deviations of actual growth from that premised in the age-height curves *(1)*. The indices of sampled sites varied widely, loblolly plots in 1964 ranging from 30 to 105, and shortleaf from 20 to 97.

The average form class of merchantable trees (5 inches d.b.h. and larger) in 1964 was 74 for loblolly and 69 for shortleaf. These values represent an improvement in form during the 5-year period of 5 percentage points for loblolly and 7 for shortleaf. The improvement contributed substantially to growth during the period.

Volume Growth

Average annual net growth per acre for the life of the plantations has been 1.08 cords for loblolly and 0.77 cord for shortleaf. Average annual growth prior to the initial survey was 0.89 cord for loblolly and 0.58 cord for shortleaf.

Growth from 1959 to 1964 averaged 1.88 cords for loblolly and 1.53 cords for shortleaf—approximately two and three times that during the early years. Ingrowth, occurring on 114 plots, averaged 0.9 cord per acre per year. Growth, including ingrowth, was at the rate of 9.8 percent per year for loblolly, 12.8 percent for shortleaf.

Annual net growth of the best 25 percent of the plots during the last 5 years has averaged 3.04 cords per acre for loblolly and 2.46 cords for shortleaf. Annual net growth of individual loblolly and shortleaf plots has been as much as 3.09 and 2.32 cords per acre. Growth per acre per year for the best 25 percent of the plots over the life of the plantation has averaged 1.94 cords for loblolly, 1.41 cords for shortleaf. On the poorest 25 percent of the plots, it has averaged 0.45 cord for loblolly and 0.33 cord for shortleaf.

For loblolly, the best regression equations for 5-year periodic growth in cords per acre are listed below (independent variables based on 1959 point-sample trees):

$$\text{Survivor growth} = -0.39529 + 0.59650\,(T) + 0.09067\,(H) \qquad R^2 = 0.4340$$

$$\text{Net growth} = 22.44869 - 1.13923(A) + 0.97572\,(T) - 0.03668\,(\Sigma D) + 0.19006\,(H) \qquad R^2 = 0.3400$$

Where

T = Number of trees per sample point
H = Mean merchantable height, in feet
A = Stand age, in years
Σ D = Average sum of diameters of trees sampled at each point, in inches

The best regressions for shortleaf were:

$$\text{Survivor growth} = 1.71122 + 0.40517\,(T) \qquad R^2 = 0.3740$$

$$\text{Net growth} = -0.23886 + 1.39657\,(T) - 0.04911\,(T)^2 \qquad R^2 = 0.2308$$

The equation for 5-year survivor growth in loblolly stands can be applied by taking prism counts of trees and estimating the merchantable heights. In shortleaf, only the prism count is needed. The equations account for 43 and 37 percent of the variation, respectively. The standard errors of estimate are 3.38 and 2.64 cords.

Stand Condition

Thirty-one percent of the stands of both species had basal areas of 110 square feet or more by 1964, and were therefore regarded as in need of thinning. Twenty-two percent had basal areas of less than 60 square feet, which is probably too low for optimum utilization of the site. Many of the understocked plantations were on severely eroded sites where initial survival had been poor.

Thirty-two percent of the surviving stands had been thinned since 1959. The average thinning removed 39 square feet of basal area or 8.1 cords per acre. Residual loblolly stands averaged 84 square feet of basal area or 21 cords per acre. Residual shortleaf stands averaged 81 square feet or 16 cords. The average thinning prior to 1959 had removed 38 square feet of basal area or 6.2 cords per acre.

Since most of the plantations were established on bare and eroding fields, few hardwood trees were present initially. As the years passed, hardwoods invaded the understory in many plots, particularly those in the minor bottoms and on lower slopes. By 1964, 16 percent of the plots were judged to be in need of hardwood control.

Mortality, amounting to 0.86 cord per acre annually, occurred on 37 plots. Most of the loss was on 28 plots where infections of *Fomes annosus* (Fr.) Karst. were found in 1964. These 28 plots comprised 41 percent of all plots that had been thinned since 1954. The disease

Figure 1.—*This stand on a good site in Marshall County (site index 105) grew 80 cords in 26 years but is now infected by* Fomes annosus.

threatens to become a serious impediment to optimum management of erosion-control plantations.

DISCUSSION

The average loblolly plantation is approximately the same age as the average shortleaf plantation but has outproduced the shortleaf by 8 cords per acre. The average loblolly is 2.4 inches greater in diameter, is 9 feet taller, has 10 feet more merchantable length, is 5 percentage points better in form class, and grew 0.8 inch more in diameter in 5 years than the average shortleaf. A difference of 1 percent in form class means 2 percent in cubic volume. The superior early growth of loblolly over that of shortleaf is well documented throughout north Mississippi and west Tennessee *(3, 5, 6, 7)*. Both species, however, have grown at rates that are equivalent to high interest on investments in growing stock.

LITERATURE CITED

1. Coile, T. S., and Schumacher, F. X.
   1953. Site index of young stands of loblolly and shortleaf pines in the Piedmont Plateau Region. J. Forest. 51: 432-435, illus.

2. Grosenbaugh, L. R.
   1958. Point-sampling and line-sampling: probability theory, geometric implications, synthesis. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 160, 34 pp., illus.

3. Huckenpahler, B. J.
   1950. Development of nineteen-year-old southern pine plantations in Tennessee. J. Forest. 48: 722-723.

4. Minor, C. O.
   1950. Form class volume tables for use in southern pine pulpwood timber estimating. La. Agr. Exp. Sta. Bull. 445, 39 pp.

5. Williston, H. L.
   1958. Shortleaf versus loblolly pine in north Mississippi. J. Forest. 56: 761.

6. ——————
   1959. Growth of four southern pines in west Tennessee. J. Forest. 57: 661-662.

7. ——————
   1963. Early yield of erosion-control plantations in north Mississippi. U. S. Forest Serv. Res. Note SO-1, 7 pp., illus. Southern Forest Exp. Sta., New Orleans, La.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-68

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LOBLOLLY PINE SITE QUALITY OF FOUR LOESS SOILS

J. R. Bassett and J. T. Beene[1]

Within a 13-township area in northeastern Louisiana and southeastern Arkansas, latitude (expressed as township) accounted for one-half of the variation in site index on modal Loring, Grenada, Calloway, and Henry soils. Mean site index differed significantly (0.01 level) between soils but declined northward at a similar rate on all soils—1.2 site-index units per township. For each soil, mean site index can be estimated by township with reasonable accuracy but site quality of individual plots may vary greatly from estimated values.

Variation of site quality within soil series impairs the application of soil survey data for woodland conservation. This note reports a study conducted in 1963-64 to account for the variation in pine site quality on modal,[2] fragipan loess soils on uplands in southeastern Arkansas and northeastern Louisiana.

The soils—Loring, Grenada, Calloway, and Henry—are members of a catena that normally includes only silt-loam types in noneroded material. The soils differ in degree of drainage—surface drainage is affected primarily by topography, and internal drainage is affected by the depth and firmness of the fragipan. Some profile characteristics of typical soils are summarized in table 1.

METHODS

One plot was established in each of 92 even-aged, 35- to 65-year-old loblolly *(Pinus taeda* L.) or shortleaf *(P. echinata* Mill.) pine stands. Plots were on modal soils in Morehouse Parish (township 23 N.), Louisiana; and Ashley, Drew, and Lincoln Counties (townships 19 S. to 8 S.), Arkansas (fig. 1). Each plot contained at least three (usually five) dominant or codominant trees of either or both species. Heights and ages of individual trees were applied to shortleaf *(2)* or loblolly pine site index curves *(12)*, and the results were averaged by species to determine plot site indexes. Of the 92 stands, 56 were pure loblolly pine, 20 were pure shortleaf pine, and 16 contained both spe-

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[2] A modal profile is one representing the central concept, or the most usual condition of each property of all soils in a series.

Table 1.—*Some profile characteristics of soils* [1]

Characteristics	Loring	Grenada	Calloway	Henry
Slope, percent	8 (3-15)	4 (2-7)	2 (1-3)	0 (0-1)
Depth to mottling, inches	27 (16-39)	16 (12-29)	11 (5-16)	7 (5-8)
Depth to fragipan, inches	31 (27-35)	25 (18-31)	21 (18-24)	12 (10-35)
Thickness of fragipan, inches	15 (6-24)	25 (13-38)	18 (12-25)	35 (19-53)
Firmness of fragipan	Brittle, compact; becoming weaker with depth	Firm, compact; usually strongest on gentle slopes	Very firm, compact; slightly plastic when moist	Firm, compact; sticky and plastic when moist
Surface drainage	Medium to rapid	Medium to slow	Slow	Very slow
Internal drainage	Medium	Medium to slow	Slow	Very slow
Overall drainage classification	Moderately good	Moderately good	Somewhat poor	Poor

[1] Based on typical profiles described by the National Cooperative Soil Survey. Values in parentheses are ranges; others are averages.

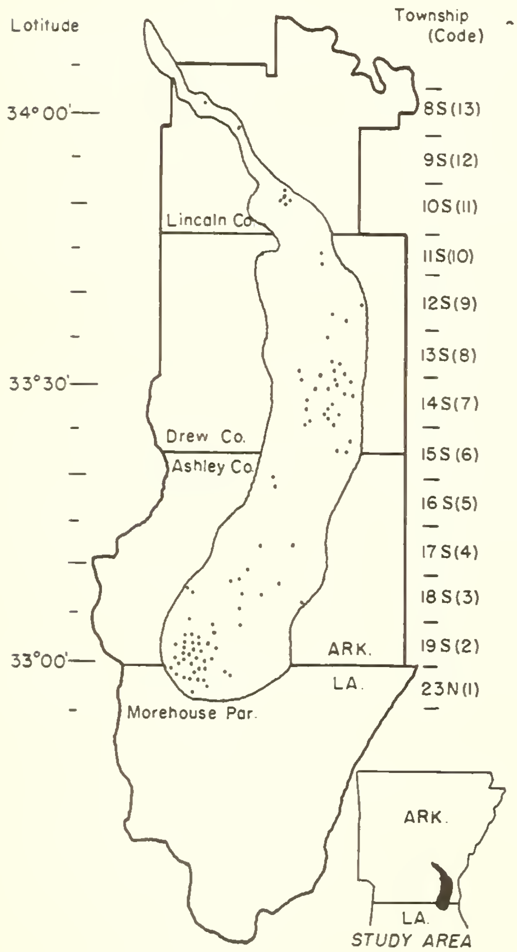

Figure 1.—*Location of study plots.*

cies. Thus, there were 72 loblolly-pine and 36 shortleaf-pine plots. There were 18 stands on Loring, 27 on Grenada, 30 on Calloway, and 17 on Henry soil.

Field records included township (expressing latitude), stand age, length and steepness of slope, depth to mottling, and depth to the fragipan. The soil profile was examined in a pit near plot center and checked with an auger near each tree. Soils were described and classified according to the methods of the National Cooperative Soil Survey and of the 7th Approximation Classification System *(10)*. At each pit, two 71-cc. cores and a bulk sample were collected from each horizon at least 3 inches thick. Water-holding capacity at tensions of 1 atmosphere (atm.) or less was determined in the cores. Chemical properties (A1 horizon only), texture, and water-holding capacity at 2-15 atm. were measured in the bulk samples.

Water-holding capacity was determined with tension table *(4)*, pressure cooker, and pressure membrane apparatus *(8)*; soil texture, by hydrometer, except that sand was sieved; total N, by the Kjeldahl procedure; P, colorimetrically in Bray-Kurtz No. 2 extract *(5)*; exchangeable cations, in ammonium acetate by flame photometry *(5)*; except Mg, colorimetrically *(3)*.

Data were insufficient to analyze site quality for shortleaf pine by individual series. However, we assumed that if shortleaf pine site index was indicative of loblolly pine site index, then shortleaf pine data could be used to augment loblolly pine data. In the 16 mixed stands, site index of loblolly pine (L) was related to site index of shortleaf pine (S): $L = 19.5 + 0.85S$. The strong relation in this equation ($S_{y \cdot x} = 1.7$, $r^2 = 0.84$) indicates that the assumption was valid. From the equation loblolly pine site index was estimated on the 20 shortleaf-only plots. Thus, a total of 92 loblolly pine site values were available for analysis. Mean ages of stands by county and soil series were:

County	Age	Series	Age
Morehouse	48	Loring	48
Ashley	47	Grenada	47
Drew	49	Calloway	47
Lincoln	39	Henry	49

The relation of site index (Y) to 18 basic variables and 21 transgenerated variables was analyzed by computing multiple linear equations in a stepwise manner with the model:

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots + b_nX_n$$

where $X_1 \ldots X_n$ are variables that account for significant (0.05 level) amounts of variation in Y, and $b_o \ldots b_n$ are coefficients determined from the data used in the final equations. The basic variables tested were:

- Latitude (coded as township: 1 = T23N, the southernmost; 2 = T19S; 3 = T18S; . . . 13 = T8S, the northernmost)
- Slope
- Length of slope above plot
- Stand age
- Depth to fragipan
- Depth to mottling
- Available water (extractable between tensions of 0.06 and 15 atm.) capable of being stored in the layer of soil between the surface and the top of the fragipan
- Macropore space (equivalent to the amount of water extractable between tensions of 0 and 0.06 atm.) in the layer of soil between the surface and the top of the fragipan
- Sand-silt-clay percentages in the A and B horizons
- Base saturation, cation-exchange capacity, phosphorus, and nitrogen in the A1 horizon

The transgenerated variables included squares of selected basic variables, combinations of selected pairs of basic variables (such as slope $\times$ length of slope, slope $\times$ macropore space, etc.), and squares of some of the combinations.

RESULTS AND DISCUSSION

Latitude (expressed as township) and stand age were the only statistically significant variables. Latitude (X) alone accounted for 51 percent of the variation in loblolly pine site index (Y): $Y = 96.9 - 1.3X$. Latitude and stand age (A) together accounted for 57 percent: $Y = 103.4 - 1.3X - 0.13A$. After their combined effect had been removed in the stepwise analysis, the contributions of other variables were not statistically significant. The data were reanalyzed, excluding latitude and stand age, to see how much variation was associated with physiography and soil properties. The square of clay percent in the A horizon accounted for a significant but negligible amount (10 percent) of variation.

There are at least two reasons why the coefficient for stand age was negative: First, as stand age increases, so does the probability that the tallest trees have been removed for poles, and that fire, insects, disease, and ice have prevented residual trees from reaching their potential height. Second, because evidence of detrimental disturbances fades with time, proportionately fewer old stands are disqualified for such disturbances than young stands. Because the contribution of age, although significant, was negligible compared to the contribution of latitude, analyses for individual series were confined to the relation of site index to latitude alone.

Why mean site index decreased northward is not clear. Mean annual growing-season rainfall and temperature differ little within the study area. Latitude is probably associated with soil changes that influence site. In all soils, for example, sand content decreased and clay content increased northward; 36 percent of the change in sand content and 19 percent of the change in clay content were associated with latitude.

Covariance analysis showed that individual-series equations differed significantly (0.01

level) in y-intercept but not in slope. In the same township, Calloway and Grenada soils averaged 3 site-index units higher than Loring and Henry soils, and all decreased in site quality northward at a mean rate of 1.2 site-index units per township (equations 2-5, table 2).

The data were analyzed by drainage groups based on the 7th Approximation Classification System *(10)*. Individual-group equations (6-8, table 2) differed significantly (0.01 level) in y-intercept but not slope. Within a township, somewhat poorly drained soils average 3 and

Table 2.—*Relation of loblolly pine site index (Y) to township (X)*[1] *by series and drainage group*[2]

Equation No.	Equation	Series or drainage group	No. of plots	$\bar{X}$	$S_{y \cdot x}$	$\sum x^2$	r^2
1	$Y = 96.9 - 1.3X$	All series	92	4.8	4.3	1,001	0.51
2	$Y = 98.2 - 1.2X$	Calloway	30	4.1	4.2	380	.57
3	$Y = 97.5 - 1.2X$	Grenada	27	4.7	3.6	277	.40
4	$Y = 94.9 - 1.2X$	Loring	18	5.1	5.2	124	.44
5	$Y = 94.4 - 1.2X$	Henry	17	5.6	3.3	190	.58
6	$Y = 96.2 - 1.2X$	Moderately good	41	4.7	4.3	362	.42
7	$Y = 99.1 - 1.2X$	Somewhat poor	30	4.1	3.8	380	.64
8	$Y = 91.9 - 1.2X$	Poor	18	5.9	3.3	192	.46

[1] Township (X) coded: 1 = T23N, La., 2 = T19S, 3 = T18S, . . . 13 = T8S (see fig. 1).

[2] Plots by drainage groups total 89 because three were rejected when profiles were reclassified according to the 7th Approximation *(10)*.

Site indexes were predicted with equations 2-5 for 21 loblolly pine plots near the study area whose site indexes had previously been measured by Zahner *(11*, p. 173). The soils were similar to those of the present study. Eighteen of Zahner's values fell within the 95 percent confidence intervals of the equations; the 21 deviations between measured and predicted values averaged 4 site-index units.

The site indexes found in Arkansas and Louisiana were compared with values measured in Mississippi by the Soil Conservation Service on soils of the same series and slope phases (0-8 percent).[3] Although there is some indication of a relation between site index and latitude in Mississippi, our results do not appear applicable there (fig. 2). There are several possible reasons: First, the soils sampled in Mississippi are not necessarily modal and are more eroded than the soils sampled in Arkansas and Louisiana. Second, growing-season rainfall is an important variable in Mississippi *(6)* because Mississippi loess spans a wider range of longitude and latitude than Arkansas-Louisiana loess. Third, Mississippi loess is more calcareous than Arkansas-Louisiana loess *(9)*.

[3] The data, collected between 1955 and 1963, were furnished by R. R. Covell, State Soil Scientist, Soil Conservation Service, Jackson, Mississippi.

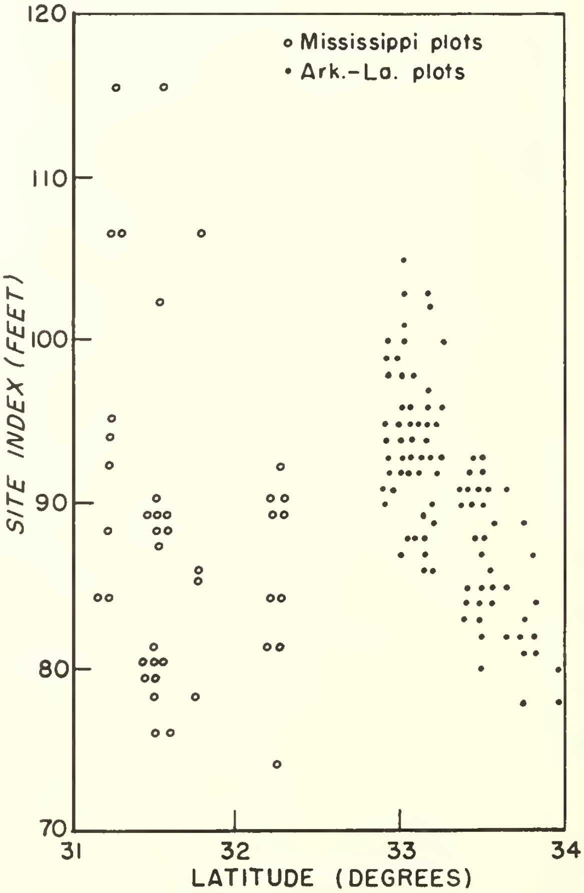

Figure 2.—*Loblolly site index for similar soils in Mississippi and Arkansas-Louisiana.*

7 site-index units higher than the moderately well drained and poorly drained soils respectively. In terms of site index these differences are small, but they represent considerable difference in productivity. For example, in 50-year-old managed stands in South Carolina, Georgia, and Virginia, stocked with 80 square feet of basal area per acre, periodic annual cubic-foot growth per acre on site 98 exceeds that on sites 95 and 91 by 8 and 18 percent, respectively *(7, p. 7)*.

Differences in site quality between drainage groups are related to differences in the availability of soil oxygen and moisture. The poorer the drainage, the greater the tendency during wet periods for soils to become saturated and deficient in oxygen—a condition that limits metabolic activities of roots. The shallow root systems in the poorly drained soils, for example, probably are too sparse to reach all available moisture during dry periods. As a result, water stress within trees may limit growth even though the supply of available moisture is far from exhausted.

Table 3 contains estimates of average site index, with 95 percent confidence limits, by township and soil series. For example, the mean loblolly pine site index of all modal Grenada soil in T23N lies between 94 and 98 (96±2). In the same township, the site indexes of individual modal Grenada plots can be expected to range between 88 and 104 (96 ±8). For Grenada, Calloway, and Henry soils, mean site index within a township can be estimated within 1 to 4 feet of its true value; site quality on individual plots in that township can be expected to range from 7 to 10 units from predicted values. For Loring soils, mean site index by townships can be estimated within 3 to 8 feet of true values, and site quality on individual plots may range from 11 to 14 feet from predicted values.

The relation of site index to soil series often can be improved by phasing and relating site to specific soil and physiographic features *(1)*. On modal Loring, Grenada, Calloway, and Henry soils in southeastern Arkansas and northeastern Louisiana, mean site quality of loblolly pine can be estimated by series with reasonable accuracy if the soils are phased, in a sense, by township. Even with phasing, however, site quality on individual plots may vary greatly from estimated values. Within the townships studied, modal profiles comprise about 75 percent of the total area occupied by the four series.[4] On nonmodal profiles, of course, the variation can be expected to exceed that reported.

[4] Estimate furnished by C. J. Finger, Soil Scientist Specialist, SCS, Little Rock, Ark.

Table 3.—*Estimates*[1] *of average loblolly pine site index (with 95 percent confidence limits) by township and soil series*

Township	Calloway			Grenada			Loring			Henry		
	Average	± Limits		Average	± Limits		Average	± Limits		Average	± Limits	
23 N	97	[2] 2	[3] 9	96	[2] 2	[3] 8	94	[2] 5	[3] 12	93	[2] 3	[3] 8
19 S	96	2	9	95	2	8	92	4	12	92	3	7
18 S	94	2	8	94	2	8	91	3	12	91	2	7
17 S	93	2	8	93	2	7	90	3	11	90	2	7
16 S	92	2	9	92	1	7	89	3	11	89	2	7
15 S	91	2	9	90	2	7	87	3	11	87	2	7
14 S	90	2	9	89	2	8	86	3	12	86	2	7
13 S	88	2	9	88	2	8	85	4	12	84	2	7
12 S	87	3	9	86	2	8	84	5	12	83	2	7
11 S	86	3	9	85	3	8	83	6	12	82	3	8
10 S	85	3	9	84	4	8	81	6	13	81	3	8
9 S	83	4	9	83	4	8	80	7	13	79	4	8
8 S	82	4	10	81	4	8	79	8	14	78	4	8

[1] Calculated using pertinent statistics in table 2.

[2] Limit for the mean site index in the township.

[3] Limit for an individual site index value predicted from the regression.

LITERATURE CITED

1. Carmean, W. H.
   1967. Soil survey refinements for classification of black oak site quality in southeastern Ohio. Soil Sci. Soc. Amer. Proc. 31: (In press).

2. Coile, T. S., and Schumacher, F. X.
   1953. Site index of young stands of loblolly and shortleaf pines in the Piedmont Plateau Region. J. Forest. 51: 432-435, illus.

3. Greweling, T., and Peech, M.
   1960. Chemical soil tests. Cornell Univ. Agr. Exp. Sta., N. Y. State Coll. Agr. Bull. 960, 54 pp., illus. Ithaca.

4. Hoover, M. D., Olson, D. F., Jr., and Metz, L. J.
   1954. Soil sampling for pore space and percolation. U. S. Forest Serv. Southeast. Forest Exp. Sta., Sta. Pap. 42, 29 pp., illus.

5. Jackson, M. L.
   1958. Soil chemical analysis. 498 pp., illus. Englewood Cliffs, N. J.: Prentice-Hall, Inc.

6. McClurkin, D. C., and Covell, R. R.
   1965. Site index predictions for pines in Mississippi. U. S. Forest Serv. Res. Pap. SO-15, 9 pp., illus. Southern Forest Exp. Sta., New Orleans, La.

7. Nelson, T. C., Lotti, T., Brender, E. V., and Trousdell, K. B.
   1961. Merchantable cubic-foot volume growth in natural loblolly pine stands. U. S. Forest Serv. Southeast. Forest Exp. Sta., Sta. Pap. 127, 12 pp., illus.

8. Richards, L. A.
   1947. Pressure-membrane apparatus construction and use. Agr. Eng. 28:451-454, 460, illus.

9. Russell, R. J.
   1944. Lower Mississippi Valley loess. Bull. Geol. Soc. Amer. 55:1-40, illus.

10. Soil Survey Staff.
    1960. Soil classification, a comprehensive system: 7th approximation. U. S. Dep. Agr. Soil Conserv. Serv., 265 pp., illus.

11. Zahner, Robert.
    1958. Site-quality relationships of pine forests in southern Arkansas and northern Louisiana. Forest Sci. 4:162-176, illus.

12. ————
    1962. Loblolly pine site curves by soil groups. Forest Sci. 8:104-110, illus.

SOUTHERN FOREST EXPERIMENT STATION

1967

U.S. FOREST SERVICE RESEARCH NOTE

SO-69

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LAND CLEARING IN THE DELTA REGION OF MISSISSIPPI, 1957-1967

Roy C. Beltz and Joe F. Christopher
SOUTHERN FOREST EXPERIMENT STATION

In the Delta region of Mississippi, more than one-fifth of the commercial forest acreage has been cleared in the last decade. Only 30 percent of the timber on this land was utilized. In 1967, soybeans were growing on two-thirds of the cleared land.

The 1967 Forest Survey of Mississippi reveals that trees have been removed from a large portion of the State's Delta region. This region's 5.5 million acres lie almost entirely in the alluvial plain of the Mississippi River in the northwestern part of the State (fig. 1). A survey in 1957 classified about 1.9 million acres in the Delta as forest land. Such land must be presently or formerly at least 10 percent stocked with forest trees, and not currently developed for nonforest use. Virtually all forest land in the Delta is commercial, that is, capable of growing crops of industrial wood and not withdrawn from timber utilization.

Between the 1957 and 1967 surveys, more than 400,000 forest acres were cleared—a loss of 22 percent of the commercial forest land area. The present forest of 1.5 million acres includes 27 percent of the land in the region.

Since the first forest survey in 1932, the proportion of Delta land in forests has declined steadily (fig. 2). The rate of decline in the last decade, however, was nearly four times that noted in earlier surveys.

During the 1967 survey, special attention was given to plots that had been cleared in the last 10 years. These plots were visited, and date of clearing, former forest type, and degree of timber utilization were determined.

Clearing of survey plots was heaviest toward the end of the 10-year period. About 70 percent of it was done in the last 4 years. Among forest types in the area, sweetgum-water oak was most heavily affected (fig. 3). This desirable type occupied more than one-third of the cleared land. The demand for farmland, however, is extending the work into less-productive timber types. For example, one-fourth of the area cleared since the 1957 survey was occupied by overcup oak-bitter pecan, one of the least desirable types for timber management.

The razed forests contained 150 million cubic feet of growing stock, including ½ billion board feet of sawtimber. Only 30 percent of this wood was sold. The rest was bulldozed into windrows and burned, or pushed into ditches. Primary reasons for not selling stumpage were: (1) landowners were unaware either of the value of the timber or of the names of prospective buyers, (2) bulldozers uproot standing trees more readily than stumps, (3) the decision to clear a tract was made too late

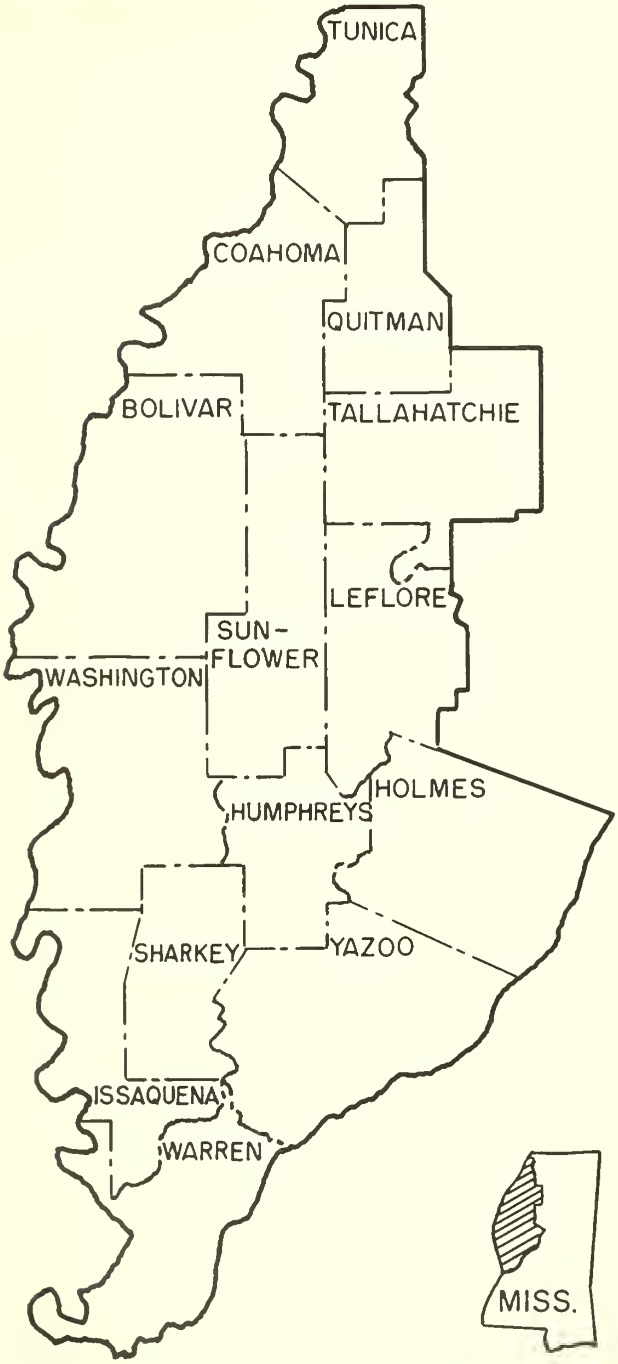

Figure 1.—*The Delta region of Mississippi.*

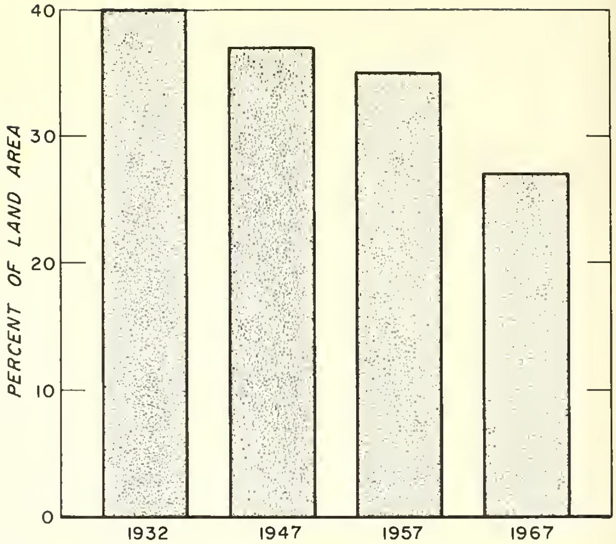

Figure 2.—*Decline in forested area in the Mississippi Delta.*

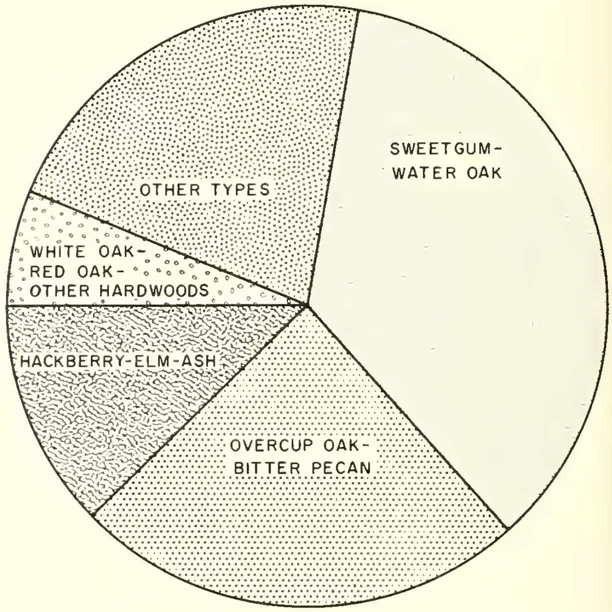

Figure 3.—*Clearing in the Delta region by forest type, 1957-1967.*

in the year to log merchantable timber and remove the stumps and slash before the forthcoming planting season, (4) or the timber was too poor or scattered to be logged profitably.

About 45 million cubic feet of cleared timber were harvested and sold, mainly as saw logs and pulpwood. An undetermined additional amount went into domestic products, such as fuel and fence posts.

In general, the largest forest acreages were cleared in counties with the greatest forest area. Yazoo County, first in forest area, was the leader in land cleared with 73,700 acres. Warren County, second in commercial forest area, was next with 40,000 acres (table 1). The third-ranked county in commercial forest area, Holmes, was an exception. It had the least land cleared of the 14 Delta counties. Washington County was third in land clearing, but seventh in forest area. More than a third of the forest in this county was razed in the last decade. Washington County is adjacent to the Mississippi River and well suited for agriculture, while Holmes County contains some upland and is less suitable for crop farming.

The upsurge in forest-land clearing is primarily the result of worldwide demand for soybeans. Soybean acreage in the United States has increased by about 50 percent since 1960. It has been reported that soybeans surpassed corn and cotton in 1966 and became the number one agricultural cash crop in the Nation.[1] In Mississippi, the acreage in soybeans has almost doubled in the last 4 years. Soybeans were planted on approximately 65 percent of the land cleared in the Delta.

[1] Simerl, L. H. Soybeans are now the No. 1 U. S. cash crop! The Soybean Dig. 27(3): 12-13, 16-17. 1967.

Table 1.—*Land area and commercial forest by county, 1957 and 1967*

County	Total land area	Commercial forest		
		1957	1967	Decrease
	Thousand acres			
Bolivar	590.5	107.7	75.6	32.1
Coahoma	363.9	94.1	67.2	26.9
Holmes	491.8	222.9	214.7	8.2
Humphreys	269.6	101.0	68.0	33.0
Issaquena	264.8	160.7	128.0	32.7
Leflore	379.0	94.3	66.0	28.3
Quitman	263.4	64.3	42.7	21.6
Sharkey	279.0	132.1	95.4	36.7
Sunflower	444.2	49.3	36.9	12.4
Tallahatchie	412.1	150.7	127.5	23.2
Tunica	293.1	91.4	72.0	19.4
Warren	371.8	233.2	193.2	40.0
Washington	469.6	108.3	69.6	38.7
Yazoo	600.1	307.1	233.4	73.7
Total	5,492.9	1,917.1	1,490.2	426.9

SOUTHERN FOREST EXPERIMENT STATION

1968

U.S. FOREST SERVICE
RESEARCH NOTE

SO-70

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

RESPONSES TO SOIL MOISTURE DEFICIENCY BY SEEDLINGS OF THREE HARDWOOD SPECIES[1]

F. T. Bonner

SOUTHERN FOREST EXPERIMENT STATION

Growth of terminal shoots of potted sycamore, sweetgum, and Nuttall oak seedlings began to decrease when leaf water deficits reached 6 to 9 percent. Growth-limiting soil moisture tensions were much lower and occurred much sooner in Commerce silt loam than in Sharkey clay. Transpiration was greatest in the fastest growing individuals; it decreased steadily as tension increased.

This note reports some responses of sweetgum (*Liquidambar styraciflua* L.), sycamore (*Platanus occidentalis* L.), and Nuttall oak (*Quercus nuttallii* Palmer) to increasing soil moisture tensions. Seedlings of the three species were planted in Sharkey clay and Commerce silt loam, two important alluvial forest soils of the Mississippi River Valley, and changes in water use, shoot growth, and leaf moisture stress were measured as soil moisture tension increased.

METHODS

Seventy 1-year-old dormant seedlings of each species were taken from the nursery at Stoneville, Mississippi, in February. Half were planted in 1-gallon cans containing clay, half in silt loam. Each can contained a single seedling. The planted seedlings were placed in a greenhouse, and in May, when shoots were growing rapidly, the tops of the cans were covered with oilcloth and sealed with tape. Spaces around stems and the drainage holes in the can bottoms were filled with cotton and coated with a paraffin-vaseline mixture to prevent all water loss except by transpiration. Examination of roots at the end of the study revealed no apparent damage from sealing the cans.

Soil moisture tensions were adjusted to an estimated 1/3 atmosphere by adding distilled water. Amounts to be added were calculated from original soil moisture content, weight of

[1] The study was conducted at the Southern Hardwoods Laboratory, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Stoneville, Mississippi. The Laboratory is maintained in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

The work was done as partial requirement for the Doctor of Forestry degree at Duke University.

SOUTHERN FOREST EXPERIMENT STATION

1968

U.S. FOREST SERVICE RESEARCH NOTE

SO-70

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

RESPONSES TO SOIL MOISTURE DEFICIENCY BY SEEDLINGS OF THREE HARDWOOD SPECIES[1]

F. T. Bonner

SOUTHERN FOREST EXPERIMENT STATION

Growth of terminal shoots of potted sycamore, sweetgum, and Nuttall oak seedlings began to decrease when leaf water deficits reached 6 to 9 percent. Growth-limiting soil moisture tensions were much lower and occurred much sooner in Commerce silt loam than in Sharkey clay. Transpiration was greatest in the fastest growing individuals; it decreased steadily as tension increased.

This note reports some responses of sweetgum (*Liquidambar styraciflua* L.), sycamore (*Platanus occidentalis* L.), and Nuttall oak (*Quercus nuttallii* Palmer) to increasing soil moisture tensions. Seedlings of the three species were planted in Sharkey clay and Commerce silt loam, two important alluvial forest soils of the Mississippi River Valley, and changes in water use, shoot growth, and leaf moisture stress were measured as soil moisture tension increased.

METHODS

Seventy 1-year-old dormant seedlings of each species were taken from the nursery at Stoneville, Mississippi, in February. Half were planted in 1-gallon cans containing clay, half in silt loam. Each can contained a single seedling. The planted seedlings were placed in a greenhouse, and in May, when shoots were growing rapidly, the tops of the cans were covered with oilcloth and sealed with tape. Spaces around stems and the drainage holes in the can bottoms were filled with cotton and coated with a paraffin-vaseline mixture to prevent all water loss except by transpiration. Examination of roots at the end of the study revealed no apparent damage from sealing the cans.

Soil moisture tensions were adjusted to an estimated 1/3 atmosphere by adding distilled water. Amounts to be added were calculated from original soil moisture content, weight of

[1] The study was conducted at the Southern Hardwoods Laboratory, Southern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Stoneville, Mississippi. The Laboratory is maintained in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

The work was done as partial requirement for the Doctor of Forestry degree at Duke University.

soil in each can, and the weight of the soils at 1/3 atmosphere of tension. Terminal growth and can weights were recorded daily at 8 p.m. All weight loss was attributed to transpiration, and distilled water was added daily to replace this loss. During the experiment, daily greenhouse temperatures fluctuated between minimums of 66 to 80° F. and maximums of 95 to 126° F.

After 1 week of these measurements, all cans were brought to 1/3 atmosphere at 8 p.m., and watering was discontinued. Five seedlings of each species in each soil were randomly selected the following morning for measurement of (1) transpiration, (2) terminal growth, (3) leaf water deficit, (4) total leaf area, (5) shoot fresh weight, (6) shoot dry weight, and (7) soil moisture tension. Six other groups were similarly analyzed as soil moisture was depleted by transpiration—the last group when the leaves had wilted and the plants appeared to be nearly dead.

Leaf water deficits were estimated by a modification of Weatherley's method [2] on 10 disks, 0.7 cm. in diameter, which were cut from the two fully expanded leaves nearest the terminal of each seedling. The disks were quickly placed in tared weighing bottles, weighed to the nearest 0.1 mg., and floated in distilled water in Petri dishes for 4 hours under 100 foot-candles of light. They were then blotted dry between eight sheets of Whatman No. 1 filter paper pressed together with a weight of 2,500 g., reweighed, and dried. Water deficit in percent (WD) was calculated from the formula:

$$WD = \frac{\text{Turgid weight} - \text{fresh weight}}{\text{Turgid weight} - \text{ovendry weight}} \times 100$$

To find dry weight, vegetation was dried for 24 hours in a forced-air oven at 65° C.; soil was dried for 48 hours at 105° C. Weights of the current year's shoots were kept separate from those of the previous year. Leaf areas were estimated from dot-grid counts of leaf-outline tracings.

Moisture percent by weight for each can was determined from two randomly selected complete vertical profile samples taken with a soil tube. These values were used to estimate soil moisture tensions with the moisture retention curves (fig. 1), which were constructed from data obtained by standard pressure plate and membrane procedures for samples from the soil lots used in the study.

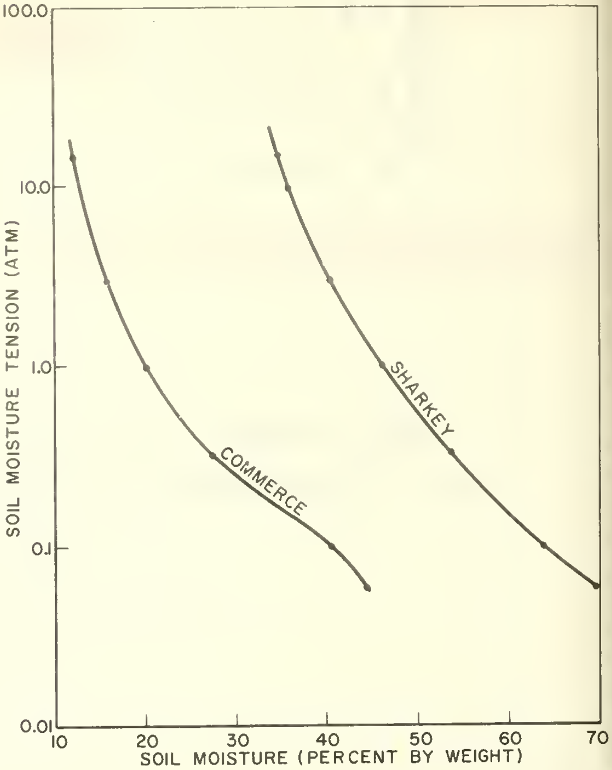

Figure 1.—*Relation of soil moisture tension to soil moisture content.*

RESULTS

In general, seedlings that grew fastest transpired most. By species, average transpiration per seedling prior to the drying cycle was proportional to the amount of terminal growth (table 1). To remove the effect of growth rate, transpiration was thereafter expressed

Table 1.—*Average dry weight of current shoots and daily transpiration prior to the drying cycle*

Species	Transpiration		Weight of current shoots	
	Clay	Silt loam	Clay	Silt loam
	Grams per day		*– Grams –*	
Sycamore	55.3	82.3	1.52	1.97
Sweetgum	31.0	36.2	.94	1.02
Nuttall oak	47.5	22.0	2.65	1.61

[2] Weatherley, P. E. Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol. 49: 81-97. 1950.

in grams per day per gram of the current year's shoot dry weight. This expression gave more consistent results than expressions based on leaf area or fresh weight of shoots, and it equalized, in general, rates on the two soil types (table 2). As expected, transpiration rates decreased as soil moisture was depleted.

Terminal growth slowed when leaf water deficits reached 6 to 9 percent, i.e., after 5 to 7 days without water in Sharkey clay and 3 to 5 days in Commerce silt loam (table 2). Estimated soil moisture tensions at this stage ranged from 12 to 17 atmospheres in clay, and from 1 to 3 atmospheres in silt loam. Terminal growth stopped completely after 13 to 15 days without water in clay, and after about 11 days in silt loam. Average leaf water deficits at these times varied widely among species, but, in both soils, they were highest in sycamore and lowest in sweetgum leaves.

As soil moisture tension increased, older leaves were the first to wilt and die on sycamore and sweetgum. On Nuttall oak, all leaves appeared to die at once, and mature leaves did not appear to wilt before they died.

DISCUSSION

Although they could not be accurately determined, the soil moisture tensions at which terminal growth slowed or ceased were surprisingly high in Sharkey clay in most cases. When seedlings appeared to be at the point of death, soil moisture percents by weight in the clay averaged 30.4 for sycamore, 29.8 for sweetgum, and 25.9 for Nuttall oak, and the seedlings were still slowly transpiring. These values are considerably below the 34.7 percent that is equivalent to 15 atmospheres of tension, the limit commonly suggested for this activity. Additional studies of soil-water relations of tree seedlings seem warranted, especially in clay soils.

Table 2.—*Seedling reactions to moisture deficiency by species and soil*

Species and days without water	Sharkey clay				Commerce silt loam			
	Leaf water deficit	Soil moisture tension	Transpiration	Cumulative terminal growth	Leaf water deficit	Soil moisture tension	Transpiration	Cumulative terminal growth
	Percent	*Atmospheres*	*G./day/g.*	*Cm.*	*Percent*	*Atmospheres*	*G./day/g.*	*Cm.*
Sweetgum								
0	4.5	<1	65.9	0.0	6.0	<1	55.0	0.0
3	5.0	1	51.1	.4	4.5	1	61.9	.4
5	5.9	10	30.5	.7	5.9	1	47.5	.6
10	8.0	11	21.2	.9	7.4	6	31.4	.7
13	8.2	20+	3.5	.9	12.9	13	3.1	.7
17	9.4	20+	10.2	1.0	14.0	15	4.6	.7
Sycamore								
0	2.7	<1	47.8	.0	3.8	<1	56.0	.0
3	6.9	14	42.7	1.2	6.9	2	40.8	1.8
5	6.9	16	41.7	1.7	8.9	5	10.1	2.1
8	7.5	17	28.6	1.9	12.9	12	14.6	2.3
11	11.7	20+	9.5	2.0	23.6	14	4.2	2.4
15	13.1	20+	4.6	2.1	41.0	20+	2.7	2.4
Nuttall oak								
0	9.7	1	31.0	.0	8.6	<1	25.8	.0
3	9.0	12	27.4	.6	7.6	1	21.2	.4
6	7.8	10	21.2	.9	...	...	...	.4
8	...	...	...	1.1	6.7	2	21.3	.4
9	11.1	20+	11.9	1.1	...	...	...	.5
11	...	...	...	1.2	10.2	3	11.3	.5
13	10.3	20+	8.2	1.3	...	...	...	.5
14	...	...	...	1.3	8.7	2	5.5	.5
20	26.4	20+	3.9	1.3	...	...	...	.5
22	...	...	...	1.3	11.3	10	3.7	.5

SOUTHERN FOREST EXPERIMENT STATION

1968

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OLEORESIN EXUDATION PRESSURE RECORDER

William G. Dodge and Henry R. Miller[1]

SOUTHERN FOREST EXPERIMENT STATION

This note describes a device by which, for the first time, reliable continuous observations of oleoresin exudation pressure may be made at any distance below the bark of a pine tree. The device comprises a probe-sensor which transmits pressure changes through oil-filled tubes to an electrically powered continuous recorder (fig. 1). In its general components, as well as in the method of sealing the connection between tree and instrument, the device differs from others that have been described.[2,3,4]

The unique component is the probe-sensor. It is made of 3/8-inch (outside diameter) Plexiglas tubing cut to a length equaling the tree diameter. Both ends are tapped with internal 10-32 threads. A hose fitting with concentric barbs is threaded and then screwed into the sensing end of the probe (fig. 2).

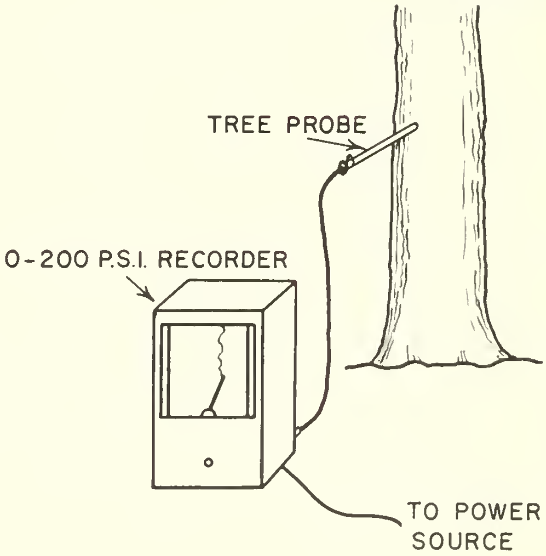

Figure 1.—*The recorder consists primarily of a probe-sensor, pressure recorder, and power supply.*

[1] When this work was done Dodge was Agricultural Engineer, Southern Forest Experiment Station, Auburn, Ala. Miller was a student in forestry (Honors Program), Auburn University.

[2] Anderson, N. H. Improved hydrostatic pressure gauge methods for measuring oleoresin exudation pressure in bark beetle research. Can. Entomol. 96: 1322-1327. 1964.

[3] Bourdeau, P. F., and Schopmeyer, C. S. Oleoresin exudation pressure in slash pine: its measurement, heritability, and relation to oleoresin yield. In The Physiology of Forest Trees, pp. 313-319. Ed. K. V. Thimann. New York: Ronald Press. 1958.

[4] Schopmeyer, C. S., Mergen, F., and Evans, T. C. Applicability of Poiseuille's Law to exudation of oleoresin from wounds on slash pine. Plant Physiol. 29: 82-87. 1954.

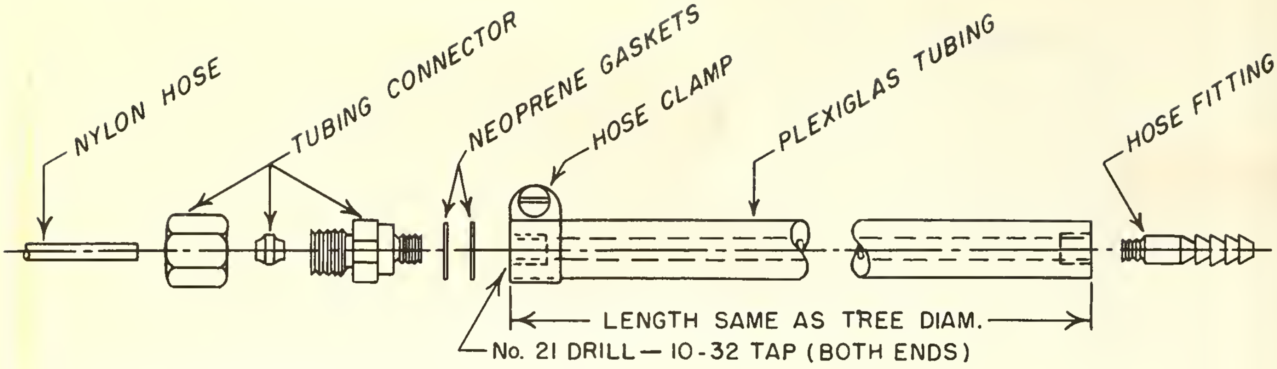

Figure 2.—*Detail of probe-sensor.*

To insert the sensor in the tree, a hole 3/8 inch in diameter is bored to within 3/4 inch of the intended pressure measurement point. This hole is then deepened 3/4 inch with a No. 21 drill on a special extension. With a mallet, the probe is driven into the 3/8-inch hole sufficiently to seat the hose fitting in the smaller hole made with the No. 21 drill. A tight seal is essential to eliminate leakage.

The protruding end of the probe is fitted with a hose clamp of worm-gear type. A compression tubing connector with two neoprene washers is carefully screwed into the threaded end. The clamp strengthens the probe tube when the connector is tightened. Nylon tubing, 1/8 inch in outside diameter, connects the probe and the pressure recorder.

The pressure system is purged of air and filled with mineral oil. Purging must be thorough. A hand-operated pump, constructed from Plexiglas and resembling a large hypodermic syringe, performed well.

Electric power for the recorder is obtained by converting 12 volts d.c. from storage batteries to 115 volts a.c. One heavy-duty battery will supply enough power for about 24 hours of operation before recharging. Several batteries, connected in parallel, will extend the operating period.

The recorder is calibrated by connecting a bourdon gauge in series with it, applying pressure to the system with the hand oil pump, and adjusting the recorder to agree with the gauge. It is advisable to check recorder calibration at several pressure levels. If a number of recorders are used, they can be temporarily connected in series and calibrated in the same manner.

The system has been used on slash pine continuously for as long as 3 days without malfunction. It is sensitive enough to measure a change in pressure of 2 p.s.i., and has a range of 0 to 200 p.s.i. The bourdon gauge comes to equilibrium in about an hour. Pressures near the bark are measured from inside the bole by inserting the probe almost all of the way through the tree.

Detailed drawings of the component parts are available at the Southern Forest Experiment Station's Forest Engineering Laboratory at Auburn, Alabama. The address is: U. S. Forest Service, Agricultural Engineering Building, Auburn University, Auburn, Alabama 36830.

SOUTHERN FOREST EXPERIMENT STATION

1968

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LOGGING DISTURBANCE ON EROSIVE SITES IN NORTH MISSISSIPPI

B. P. Dickerson [1]

SOUTHERN FOREST EXPERIMENT STATION

Sawtimber harvesting disturbed 15 percent of the logged area to some degree. Pulpwood harvesting disturbed 12 percent. About 1 year after logging was completed, soils on 3 percent of the saw log cuttings and 1 percent of the pulpwood areas showed signs of accelerated erosion.

Since 1948 more than 500,000 acres of pine have been planted in north Mississippi, primarily for erosion control. Some of the plantations have reached merchantable size and are being harvested. Many more will become merchantable in the near future, and there is concern that logging may start a new cycle of erosion. There may be comparable risk in logging extensive natural stands on similar sites. In an effort to evaluate the hazard, a survey was begun in 1963 to appraise the condition of the forest floor after various types of cutting.

STUDY AREA AND METHODS

The operations sampled in this survey were near Oxford, Mississippi. Soils varied but generally were Coastal Plain material overlain with varying depths of loess on the upper slopes and ridges. Topography ranged from moderate to hilly.

Since there are no large areas of sawtimber-size pine plantations, sampling of sawtimber cutting was limited to natural stands of upland hardwood or pine-hardwood. Size of operations varied, and volumes removed were estimated to range between 700 and 5,000 board feet per acre. The areas logged varied from 40 to more than 700 acres.

Four methods of sawtimber logging were sampled:

Tree-length skidding with rubber-tired wheeled tractors. Winch equipment facilitated skidding of up to six logs at a time, to landings on gravel roads or ridge-top truck trails (fig. 1).

Log-length skidding with a crawler tractor. Skidding on this operation was uphill to landings on a graveled country road; topography was steep.

Log-length skidding with mule teams. Skidding was mostly downhill to roads in valleys or on nearly level ground to roads

[1] Stationed at the Forest Hydrology Laboratory, Oxford, Miss. The Southern Forest Experiment Station maintains this Laboratory in cooperation with the University of Mississippi.

Figure 1.—*The wheeled logging tractors used on several operations skidded one to six logs per trip, usually straight uphill.*

on broad ridges. Landings were numerous and skidding distances short.

Log-length skidding with an A-frame cable system mounted on a truck. Skidding was uphill to ridgetop landings, which were numerous; skidding distances were usually less than 150 feet. The skidder was also used for loading.

Pulpwood operations were in young pine stands. Volumes removed varied from 3 cords per acre on some of the thinnings to more than 20 cords per acre on the clear-cut areas. In all the operations, trucks were driven to points from which the bolts were hand-loaded.

Cutting areas were visited 1 to 8 months after logging, in every case after several heavy rains had fallen. Straight-line transects were located at least 100 feet apart in each area, running generally parallel with the contours. Any disturbance intersected by the transect was classified as to cause and degree, and the length of the disturbance along the transect was recorded. These linear measurements were used to compute the percent of the area disturbed.

Degree of disturbance was classified as: (1) litter disturbed but no soil bared, (2) soil bared, (3) soil bared and compacted, (4) soil rutted to a depth of 1 inch or more, and (5) soil rutted and compacted. In addition, areas undisturbed or occupied by slash were recorded.

Cause of damage was classified as: road, primarily for trucks; skid trail, i. e., two or more logs hauled over the same route; log movement, i. e., disturbance caused by the passage of a single log; and landings or loading areas.

Observations were made of the presence and degree of erosion found on a subsample of the disturbed areas. Erosion was classed as: (1) none present, (2) light—active sheet erosion, (3) moderate—severe sheet erosion and formation of rills, and (4) severe—rills deeper than 3 inches and gullies forming. For severe erosion, specific causes were noted if discernible.

Penetrometer readings were taken on compacted and adjacent undisturbed areas. The penetrometer cone was 2.5 cm. long and 2 cm. in diameter at the base.

SAWTIMBER OPERATIONS

Of 11 areas sampled, 10 were cut selectively. The other one was a clear-cutting, logged with wheeled tractors.

The total area disturbed on the clear-cut operation was 50 percent more than that on the selectively cut areas (table 1). The more severe soil disturbances (soil bared and compacted, and soil rutted and compacted) were twice as great. These differences may reflect variation in volume removed, but the sample was too limited to be conclusive.

Landings or loading areas disturbed 1 percent of the total area sampled (table 2). In mule and A-frame logging, there were a number of roadside landings, each receiving rela-

Table 1.—*Type and extent of soil disturbance from timber harvesting operations*

Type of operation	Operations	Undisturbed	Covered by slash	Type of disturbance: Litter disturbed	Soil bared	Soil bared, compacted	Soil rutted	Soil rutted, compacted	Total area disturbed
	No.	*Percent of area*							
Sawtimber									
Selective cut	10	72	14	5	1	4	1	3	14
Clear-cut	1	44	35	7	0	8	0	6	21
Average		69	16	5	1	4	1	4	15
Pulpwood									
Selective cut	7	60	25	10	0	0	0	5	15
Clear-cut	4	46	44	2	0	2	0	6	10
Average		51	37	5	0	1	0	6	12

Table 2.—*Causes of disturbance on areas logged for sawtimber*

Logging method	Number of jobs	Cause of disturbance: Landings	Log movement	Roads	Skid trails	Total
		Percent of area				
Tree-length, skidding with rubber-tired tractor	5	2	1	4	10	17
Log-length, mule skidding	4	1	1	7	3	12
Log-length, A-frame	1	1	0	6	5	12
Log-length, crawler tractor	1	[1] 0	9	[1] 0	5	14
Average, all jobs		1	2	5	7	15

[1] Logs were skidded to main gravel road.

tively light use. Little serious disturbance was found on these landings, and it was difficult at times to distinguish between landings and road. The reverse was true where logs had been skidded with a wheeled tractor. Most operators using the tractors felt that it was more efficient to skid trees farther than to establish new landings. As a result, fewer but larger landings received heavier use and all were rutted, bared, and compacted (table 3).

Only 2 percent of the total area was disturbed by log movement, and usually the disturbance was slight. Some rutting and compacting were observed, however, especially where crawler tractors were used to skid logs to a main gravel road.

Although the majority of the roads were on ridgetops, some were on slopes up to 12 percent. The average grade at sampling points was 5 percent. Most roads were bared, rutted, and compacted, but usually little serious erosion was evident. Gullies were forming on a few steeply sloping roads where concentrated runoff was channeled down the ruts.

Skid trails accounted for nearly half of the disturbed area. Though trails were found on slopes as steep as 45 percent, the average disturbance from this cause was on a 10-percent slope. On the steeper slopes, trails were generally at right angles to the contour and shorter in length. This reduced the amount of runoff channeled down the trail, and erosion was usually light. Severe erosion occurred when skidding up or across small drains interfered with normal flow of water.

Sixty-four percent of the disturbed areas (10 percent of the total area sampled) had no, or only light, erosion. Severe erosion was observed on only 20 percent of the disturbed areas (3 percent of the total area sampled).

Table 3.—*Type and extent of soil disturbance on areas logged for sawtimber*

Logging method	Number of jobs	Undis-turbed	Covered by slash	Type of disturbance					Total area disturbed
				Litter dis-turbed	Soil bared	Soil bared, compacted	Soil rutted	Soil rutted, compacted	
	Percent of area								
Tree-length, skidding with rubber-tired tractor	5	67	16	4	. . .	6	1	6	17
Log-length, mule skidding	[1] 4	72	16	6	2	2	. .	2	12
Log-length, A-frame	1	65	23	4	. . .	6	2	. . .	12
Log-length, crawler tractor	1	70	15	6	2	2	1	3	14

[1] One job was combination of mule and cleat tractor skidding with mule the dominant method.

Annual plants were invading the majority of the disturbed areas.

The penetrometer readings on the disturbed areas showed a 115-percent increase in the resistance of the soil to penetration (table 4).

Table 4.—*Summary of penetrometer readings*

Soil class	Saw log operations		Pulpwood operations	
	Undis-turbed	Com-pacted	Undis-turbed	Com-pacted
	Pounds			
Silty-clay loam	45	99	69	128
Sandy loam	33	69	49	86
Average	39	84	61	110

PULPWOOD OPERATIONS

Roads were the only source of soil disturbance on pulpwood operations. Trucks were driven into the woods for loading, and the areas became densely laced with roads, most of which were used only once or twice. Some roads had gradients as high as 22 percent, but drivers usually avoided such steep slopes. Slightly less area was disturbed than by sawtimber harvesting, and for the most part such disturbance was minor. Less than 1 percent of the total area was classed as severely eroding at the time of the survey; 97 percent had little or no evidence of soil movement. Only when roads were used repeatedly under wet conditions was there evidence of rutting and compaction that led to excessive erosion.

Slightly more area was classed as compacted on the clear-cuts than on the selective cuttings. The clear-cuts also had greater areas occupied by logging slash, with the result that truck movement was restricted to fewer roadways. The substantial ground area covered by slash on both pulpwood and sawtimber clear-cuts (table 1) may hinder planting or direct seeding.

Penetrometer readings on disturbed, compacted soils showed an 80-percent increase in resistance to penetration over the undisturbed areas. In both pulpwood and sawtimber operations, effects of compaction were similar on the silty clay loam and sandy loam soils.

DISCUSSION

While the nature and immediate causes of disturbance varied considerably among the operations, total disturbance differed little between saw log and pulpwood cuttings. From 1 to 3 percent of the logged area displayed accelerated erosion, but it is not known whether the sites have become stabilized or will continue to erode. Sites where soil was bared, rutted, or compacted are expected to be more susceptible to continuing erosion than those where only the litter was disturbed.

Continued observation and perhaps intensive instrumentation will be needed to evaluate the ultimate effects in terms of soil loss or sediment production.

SOUTHERN FOREST EXPERIMENT STATION

1968

U.S. FOREST SERVICE RESEARCH NOTE

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TESTS OF REPELLENTS FOR DIRECT-SEEDING BLACK WALNUTS IN TENNESSEE

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Arasan-endrin has provided fair protection for direct-seeded black walnuts on forested sites of the Cumberland Plateau.

Natural regeneration of black walnut (*Juglans nigra* L.) is usually sparse, and artificial methods are required to establish the desired number of seedlings on most sites capable of growing this species. Direct seeding may be more feasible than planting, particularly on much of Tennessee's Cumberland Plateau, where steep slopes and rocky soils prohibit machine operation and make even hand planting difficult.

An effective repellent is necessary. In screening tests at Sewanee, an Arasan-endrin (AE) combination appeared to have considerable repellency. Although the formulation has not protected hardwood seeds under heavy pressure elsewhere *(2, 4)*, two studies were made near Sewanee, Tennessee, to determine effectiveness of an AE repellent.

The first study reported here evaluated a promising AE mixture with three methods of application. The second retested the best AE formulation, as well as nicotine and selenium compounds. These latter materials have been effective against seed predators in other regions, but had not been field tested with walnuts on the Cumberland Plateau *(1, 3, 5)*.

METHODS

Repellent Formulation

In the first study AE was applied as unmodified slurries, as slurries thickened by adding a fibrous filler, and as suspensions sprayed on the soil surface over untreated walnuts. The repellent was a mixture of two parts Arasan-75 to one part endrin 50-W.[2] A nonphytotoxic asphalt emulsion, Flintkote C13-HPC, was the carrier for all formulations. In addition to three levels within each application method, the asphalt-fiber base for the modified slurries and the asphalt emulsion carrier for overspray treatments were tested without chemicals. Untreated seed was included as an overall check, for a total of 12 treatments.

The sticker for slurries contained 40 percent C13-HPC in water, by weight. Blended AE, added at rates of 20 g., 40 g., or 60 g. for each 100 g. of asphalt emulsion base, constituted the three slurry levels. Various levels of slurries to be thickened with fiber were first pre-

[1] Stationed at the Sewanee Silviculture Laboratory, which is maintained at Sewanee, Tennessee, by the Southern Forest Experiment Station in cooperation with the University of the South.

[2] Mention of trade names is for information only and does not imply endorsement by the U. S. Department of Agriculture.

pared similarly, except for diluting the carrier to 25 percent asphalt emulsion to compensate for capacity of the filler to absorb moisture. Next, Turfiber[3] was beaten into these mixtures in a ratio of ½ volume of fiber per unit volume of the previously-prepared slurries. Adding this filler diluted the proportion of repellents in the final mixes, but improved adhesive qualities. Net retention of chemicals was also increased, as estimated from the total quantity of each formulation used in treatment (table 1).

Table 1.—*Retention of repellent chemicals, as percent of weight of unstratified seed*

Application method and repellent chemical	Repellent level		
	Low	Medium	High
Unmodified slurry			
Arasan-75	3.0	5.3	7.3
Endrin 50-W	1.5	2.7	3.6
Total	4.5	8.0	10.9
Slurry plus fiber			
Arasan-75	5.0	8.8	10.9
Endrin 50-W	2.3	4.4	5.5
Total	7.3	13.2	16.4

For the three levels of soil sprays, AE was added to a 15-percent asphalt emulsion at rates of 10 g., 20 g., or 30 g. in each 100 g. of carrier. A thin mixture was required so that these suspensions could be applied to the soil with a small hand sprayer.

The second study reevaluated AE slurries and tested nicotine and selenium, each at three levels. Slurries tested in 1965-66 were similar to those of the previous year, but had either 40 g., 60 g., or 80 g. of blended AE added to each 100 g. of carrier. For the nicotine repellents, Black Leaf 40 was blended into a latex sticker (Dow 512-R, 10 percent in water) at rates of 5 percent, 10 percent, and 15 percent, by volume. Sodium selenate was dissolved in a 10-percent Rhoplex-water adhesive to give 2,500 p.p.m., 5,000 p.p.m., and 7,500 p.p.m. selenium for levels of this repellent candidate. Walnuts coated only with stickers used for the three repellents, plus untreated seed, were also included, for a total of 13 treatments.

Higher levels of AE are near the practical upper limits of formulation. Because of storage conditions chemicals used in these studies were fairly moist and mixed well at all rates. If very dry, they cannot be mixed at rates of 60 to 80 g. in 100 g. of 40 percent asphalt-emulsion. In this case, small amounts of dilute asphalt-emulsion can be added until the mixtures are thin enough to apply to walnuts.

[3] A cellulose fiber material furnished by International Paper Co.

Walnuts sown in both years were stratified overwinter in cold, moist sand. After removal, they were air-dried until free of surface moisture. Application of high-level slurries and fiber-thickened slurries required rolling the nuts in a tray containing repellent mixtures. Nuts were dipped in the thinner slurries or solutions, drained, and dried on wire racks until the coating hardened.

Field Procedures

Both studies were installed on rocky, northerly-facing slopes of the Cumberland Plateau escarpment near Sewanee, Tennessee. Soil between the rocks is a friable dark loam of Jefferson series, or undifferentiated parent material originating from sandstone and shale caprocks of the Plateau. These sites originally grew fine hardwoods ranging from oak-hickory stands to mixed-mesophytic hardwoods.

Plots were spaced three chains apart to reduce chances of one repellent treatment influencing activities of small mammals on adjacent plots. This possibly favored heavier animal pressures, and a more severe test, than if seeding had been done on larger, contiguous areas. In the 1964-65 study, each plot contained 40 seed spots, spaced about 6 feet apart in a rectangular grid; each plot had 30 seed spots in the 1965-66 trial. In all, 1,920 walnuts were sown in April 1964 and 2,340 in April 1965. A single walnut was planted on each seed spot and covered with lightly-firmed soil, after raking away hardwood litter. Overspraying untreated nuts required approximately 70 cc. of the repellent suspensions to drench a 6-inch, circular area.

Treatments were replicated four times in the first study and six times in the second, in randomized, complete blocks. Seed spots that had not produced a seedling by the second summer after sowing were dug up to determine the number of walnuts taken. Differences in seed losses and total field germination, expressed as percent of seed sown, were tested by analysis of variance. Comparisons were specified in advance for testing differences in seed losses and tree percents. Only differences at the 5-percent level of significance are reported in the results section.

RESULTS

Seed Depredations

More than half the seed spots in both studies were disturbed within 1 month of sowing; heavy depredations continued into midsummer. Seed spot excavation verified that 81 percent of walnuts sown in 1964 and 82 percent of those sown in 1965 had been destroyed.

Animals carried off 79 percent of untreated walnuts in the first study. Only medium and high-level AE slurries afforded any notable protection; losses averaged 58 and 52 percent, respectively. For all other treatments, losses were as great as or greater than the untreated check. Unmodified slurries also gave better protection, on the average, than slurries containing cellulose fiber, even though this latter treatment permitted application of higher repellent levels. Spraying large amounts of AE over seed spots was less effective than applying a lesser quantity of these chemicals directly to the walnuts.

In 1965-66, pilferage of untreated seed averaged 74 percent. Selenium and nicotine were ineffective; overall, over 90 percent of walnuts treated with them were lost.

AE slurries reduced depredations more than nicotine and selenium. Seed loss was lower on plots sown with AE-treated walnuts than where walnuts were coated only with asphalt-emulsion. For low and medium AE levels, losses averaged 63 and 49 percent; 75 percent of the highly treated walnuts were destroyed, possibly indicating that loading each 100 g. of asphalt emulsion carrier with 80 g. of chemicals was too much and reduced durability.

Seedling Establishment

Results expressed as tree percents parallel those based on seed losses. However, seedling establishment integrates any effects of repellents on field germination as well as on depredations. In the 1964-65 study, the two most effective formulations yielded tree percents over four times as great as those obtained from unprotected seed. Although AE at 40 g. per 100 g. of sticker was less effective in 1965-66, the 60-g. rate application doubled seedling catches compared to the untreated check (table 2). The 80 g. per 100 rate yielded fewer seedlings than low and medium levels of application.

Considerable second-year germination has been noted with direct-seeded walnuts in other regions *(6)*. But in the studies reported here, less than 1 percent of the established seedlings resulted from delayed germination. Obviously, few walnuts that failed to produce a seedling during their first growing season survived until the next.

For walnuts sown in 1964, AE applied directly to the seed yielded more seedlings than did oversprayed seed spots. Medium and high-level slurries also proved better than the low level. Adding a cellulose fiber thickener to the slurries reduced overall seedling establishment. The filler diminished repellency and reduced field germination. In supplemental greenhouse tests, germination of walnuts coat-

Table 2.—*Proportion of direct-seeded black walnuts producing a seedling, by repellent treatments*

Years and treatments tested	Repellent level [1]			
	None	Low	Medium	High
	Tree percent			
1964-65 test				
Check—untreated nuts	8			
AE—oversprayed	[2] 6	3	10	2
AE—unmodified slurry		8	36	34
AE—slurry plus fiber	[2] 0	11	12	14
1965-66 test				
Check—untreated nuts	23			
AE	[2] 3	30	46	19
Nicotine sulfate	[2] 20	11	12	2
Sodium selenate	[2] 14	5	18	1

[1] Repellent levels are not directly comparable between the two studies. Medium and high-level AE slurries in 1964-65 are equal to the low and medium levels tested in 1965-66.

[2] Asphalt emulsion carrier for repellents sprayed over seed spots, asphalt-fiber base used in modified slurries, or carriers for slurries and solutions.

ed with modified slurries ranged from 24 to 43 percent, the lowest figure being obtained from nuts treated only with the asphalt emulsion-fiber base. Germination averaged 65 percent for the unmodified slurries and differed little between levels of application.

In 1965-66, walnuts protected with AE produced more established seedlings than those treated with nicotine or selenium, and, on the average, all levels of AE were better than asphalt emulsion. None of the repellents tested in 1965 drastically reduced germination. In the greenhouse, seedlings from selenium-treated walnuts were stunted and chlorotic, as might be expected with this very toxic element. However, these phytotoxic effects were not apparent in the field.

Since seedling growth was not investigated, residual timber and brush were not deadened on the scattered plots. First-summer seedling survival averaged 58 percent in 1964 and 46 percent in 1965, despite the shade of competing hardwoods. Survival of the intolerant black walnut seedlings should be considerably better on well-prepared sites.

DISCUSSION

These studies collectively show that AE is fairly effective against free-ranging animals on forested Cumberland Plateau sites. It worked best when applied directly to walnuts as unmodified slurries, and was less effective with two alternate methods of application. To afford any important protection these materials must be applied at rates of 40 to 60 g. per 100 g. of carrier. But 80 g. of AE in each 100 g. of carrier is evidently beyond the upper limit of practical application for asphalt emulsion-based slurries as formulated here.

Nicotine and selenium, as used in this test, showed no promise.

Neither the quantity of natural foods available nor animal numbers on the study areas were precisely determined, but squirrels were numerous following seeding during both years. That animal pressure was heavy is evident from the rapid loss of both untreated and most treated walnuts.

In the Southern Highlands, most walnut seeding will be restricted to fairly small areas, because of the discontinuous occurrence of high-quality sites. Potential for animal depredations in most operational seedings will probably be at least as great as in these studies. Repellents that can yield tree percents of 50 to 75 consistently would be desirable for seeding walnuts on the Cumberland Plateau. None tested so far at Sewanee are this effective.

Animal pressures may be lighter in other regions, and damage risks may be less where conditions permit clearing and seeding on relatively large tracts. Good results were obtained with AE treated walnuts in an old field in Wisconsin containing moderate numbers of squirrels *(6)*. In this study, repellents were applied at a lower rate than for the best slurries tested at Sewanee.

Concentrated AE slurries were effective enough on the Cumberland Plateau to warrant more tests in other regions on a variety of sites and under a wider range of animal pressures.

LITERATURE CITED

1. Burns, R. M.
   1961. Rabbit repellents in north Mississippi. U. S. Forest Serv. Tree Planters' Notes 45, pp. 19-22.
2. Engle, L. G., and Clark, F. B.
   1959. New rodent repellents fail to work on acorns and walnuts. U. S. Forest Serv. Cent. States Forest Exp. Sta., Sta. Note 138, 2 pp.
3. Hildreth, A. C., and Brown, G. B.
   1955. Repellents to protect trees and shrubs from damage by rabbits. U. S. Dep. Agr. Tech. Bull. 1134, 31 pp.
4. Klawitter, R. A., Stubbs, Jack, and Johnson, F. M.
   1963. Tests of Arasan 75-Endrin 50W rodent repellent on Shumard and swamp chestnut oak acorns. U. S. Forest Serv. Res. Note SE-4, 2 pp. Southeast. Forest Exp. Sta., Asheville, N. C.
5. Rediske, J. H., and Lawrence, W. H.
   1962. Selenium as a wildlife repellent for Douglas-fir seedlings. Forest Sci. 8: 142-148.
6. Stoeckeler, J. H.
   1964. Two-year results of direct-seeded black walnut in a cove on the Coulee Experimental Forest, La Crosse, Wis. U. S. Forest Serv. Tree Planters' Notes 67, pp. 12-13.

SOUTHERN FOREST EXPERIMENT STATION

1968

U.S. FOREST SERVICE RESEARCH NOTE

SO-74

Forest Service, U. S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

LONGLEAF PINE SITE INDEX POORLY CORRELATED WITH SOIL TYPE IN SOUTHERN ALABAMA

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SOUTHERN FOREST EXPERIMENT STATION

On a 3,000-acre area, variation of site index within nine soil types was so large that differences in the means by soil type were significant only for the two extremes.

In the study reported here, the variation of site index within and among soil types was determined in second-growth longleaf pine (*Pinus palustris* Mill.) stands on a 3,000-acre area of the Middle Coastal Plain in southern Alabama. On this limited area, site index was expected to be closely related to soil type. It was not. Variation of site index was greater within than among soil classification units, and regression equations including several measured soil and site factors accounted for only a small portion of the total variation.

PROCEDURE

The study area was on the Escambia Experimental Forest. The stands had received fairly uniform burning and cutting treatments during the 20 years before the study. All occupied virgin soils. A total of 103 plots was situated on nine soil types: Alaga, Eustis, Troup, and Wagram loamy sands, and Bowie, Cuthbert, Magnolia, Norfolk, and Ruston fine sandy loams. Plots were not equally distributed among the soil types, but the three major types —Troup loamy sand and Norfolk and Bowie fine sandy loams—were about equally sampled. The plots, 1.5 chains square, were randomly selected at a series of mechanically located points. They were uniform in soil type, aspect, and slope.

Total height and age were determined on four dominant trees on each plot. Measured trees were free of damage by fire, insects, disease, suppression, and grazing. Seven years were added to ring count at breast height to obtain age. Average age by plot ranged from 36 to 78 years. Site index was obtained for each tree (*7*), and the four values were averaged to determine site index for the plot.

A soil sample was taken from the center of each plot with a 3-inch orchard auger. Thickness and texture of the A1 horizon, texture of the B2 horizon, and depth to the horizon of greatest clay accumulation were determined. Slope, aspect, and topographic position were measured. Topographic position (expressed in percent) was defined as the distance to the nearest branch bottom divided by the total distance from the branch to the nearest upslope ridge that had immediate drainage effect on the plot. The soils were classified by Soil Conservation Service procedures and descriptions.

Mean site indexes, ranges in site index, standard deviations, standard errors, and coefficients of variation were computed for soil types and for all data combined. Mean site indexes by soil type were compared by Tukey's test for multiple comparisons. Scattergrams were plotted of site index and of the measured soil and site factors.

RESULTS AND DISCUSSION

Except for the high and low means, average site indexes by soil type were not significantly different at the 5-percent level. Mean indexes of soil types varied from 59 to 69 feet; on individual plots, they ranged from 51 to 84 feet (fig. 1). The Alaga loamy sand and Bowie fine sandy loam had the

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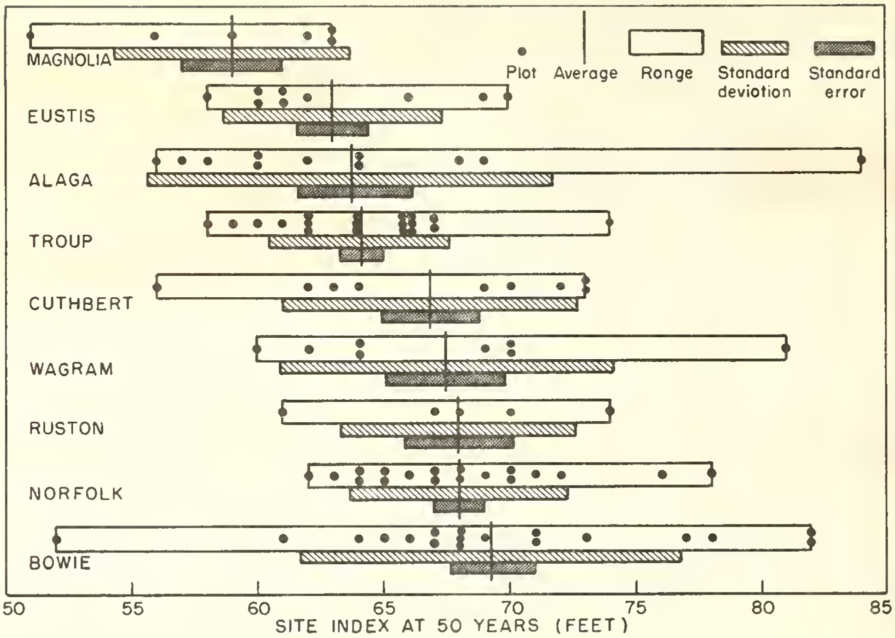
Figure 1.—
Means, ranges, standard deviations, and standard errors of site indexes by soil type.



greatest ranges and the largest coefficients of variation; the coefficients of variation on these soils exceeded that for all soil types combined.

The topographic and soil factors measured had little or no relation to site index either within soil types or for all plots combined. An apparent relation between site index and textural class of the B2 horizon for combined plots was detected, but, because of the limited number of replications, it could not be statistically analyzed. Site index appeared to increase as the clay content of the B2 horizon increased.

The reasons for the failure to account for the large variation in site index are not known. They may be environmental, genetic, or methodological. The soil and site factors analyzed may have been inappropriate, though most have been related to longleaf pine site index in other studies *(2, 3, 4, 5, 6)*. A few previous attempts elsewhere to estimate site index for soil classification units were also unsuccessful *(1, 3, 8)*.

Whatever the reasons, the approach taken does not appear to be adequate for studies of longleaf pine. A more sensitive, but more comprehensive approach, is indicated. Particular care must be taken to control nonenvironmental factors, perhaps by a procedure similar to that outlined by Young *(9)*.

LITERATURE CITED

1. Carmean, W. H.
   1961. Soil survey refinements needed for accurate classification of black oak site quality in southeastern Ohio. Soil Sci. Soc. Amer. Proc. 25: 394-397.

2. Coile T. S.
   1952. Soil productivity for southern pines. Part I: Shortleaf and loblolly pines. Part II: Longleaf, slash and pond pines. Forest Farmer 11(7): 10-11, 13; 11(8): 11-12.

3. Linnartz, N. E.
   1963. Relation of soil and topographic characteristics to site quality for southern pines in the Florida parishes of Louisiana. J. Forest. 61: 434-438.

4. McClurkin, D. C.
   1953. Soil and climatic factors related to the growth of longleaf pine. U. S. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 132, 12 pp.

5. McClurkin, D. C., and Covell, R. R.
   1965. Site index predictions for pines in Mississippi. U. S. Forest Serv. Res. Pap. SO-15, 9 pp. Southern Forest Exp. Sta., New Orleans, La.

6. Ralston, C. W.
   1951. Some factors related to the growth of longleaf pine in the Atlantic Coastal Plain. J. Forest. 49: 408-412.

7. U. S. Forest Service.
   1929. Volume, yield, and stand tables for second-growth southern pines. U. S. Dep. Agr. Misc. Pub. 50, 202 pp.

8. Van Lear, D. H., and Hosner, J. F.
   1967. Correlation of site index and soil mapping units poor for yellow-poplar in southwest Virginia. J. Forest. 65: 22-24.

9. Young, H. E.
   1967. A new method of site evaluation. J. Forest. 65: 728, 730-731.

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SWEETGUM SEED PRODUCTION ON SOILS IN CENTRAL MISSISSIPPI

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SOUTHERN FOREST EXPERIMENT STATION

During 1965 and 1966, sweetgum trees on Delta sites produced more seed than trees on loess and Coastal Plain sites. Speed and completeness of germination were about the same for seed from the three sites.

Interest in culture of sweetgum (*Liquidambar styraciflua* L.) is increasing so rapidly that seed orchards and seed production areas are being established. The study reported here was designed to determine which of three common sites in Mississippi—Delta, loess, or Coastal Plain alluvium—is best for seed production. Fruitfulness of trees, number of full seed per fruit, germinative capacity, and germinative energy of the seeds were correlated with various tree and site characteristics.

PROCEDURE

Twenty dominant and codominant seed-bearing trees between 12 and 24 inches d.b.h. were selected on each of the three sites, Delta, deep loess, and Coastal Plain alluvium, in central Mississippi during June 1965. Plots were near 33° N. latitude (fig. 1). The 60 sample trees were permanently marked, and seeds were collected from them in the summer and fall of 1965 and 1966.

Each year, three or four limbs were shot down from the upper two-thirds of each tree's crown. Productivity for a tree was defined as the percentage of fruit-bearing twigs in a random sample of 30 twigs from the removed limbs. The average number of full seeds per fruit was determined by cutting seeds extracted from 10 fruits from each tree; seeds with a firm white endosperm were considered full.

Seed quality was measured in standard laboratory germinators. After a 30-day moist stratification at 35° to 40° F., six replications of 50 seed per tree were germinated for 15 days at 85° F., a relative humidity of nearly 100 percent, and 100 foot-candles of light for 2 hours per day. Counts were made daily, and the germinated seeds were discarded. Germinative capacity (completeness) was calculated as the percentage of sound seed germinated at the end of 15 days. Germinative energy (speed) was calculated as the largest quotient obtained when the cumulative percentage of germination for each day of the test was divided by the number of days since the test began, after the method of Czabator *(3)*.

Regressions were computed to determine the influence of 10 variables on productivity and quality:

(1) Diameter at breast height
(2) Five-year radial growth
(3) Tree age

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[2] Research Forester at the Southern Hardwoods Laboratory during the study. Now at the Forest Tree Seed Laboratory, State College, Miss. The Southern Hardwoods Laboratory is maintained at Stoneville, Miss., in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

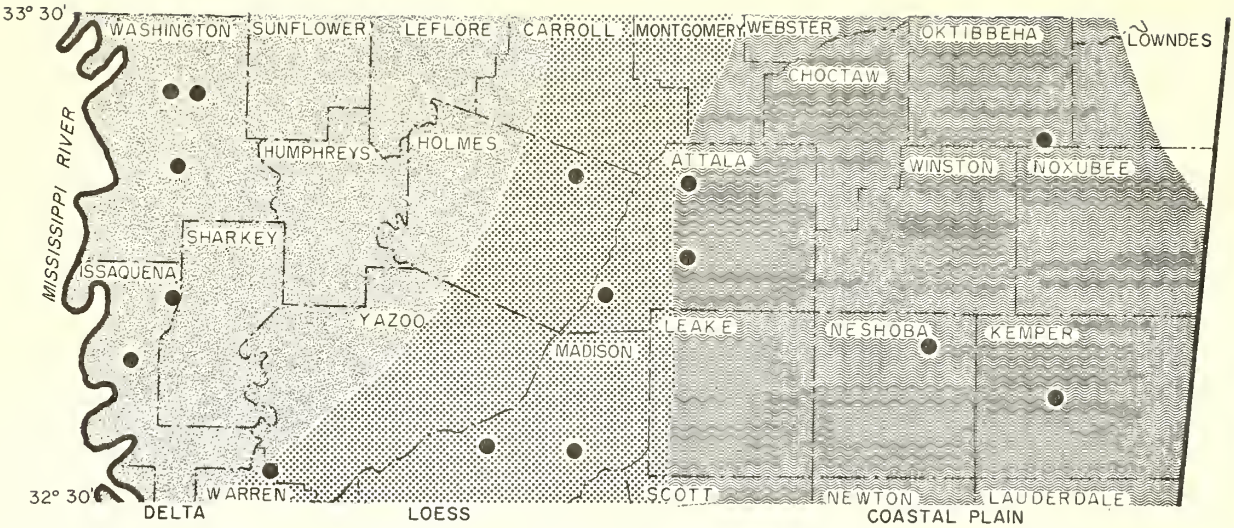

Figure 1.—*Five plots (large dots) were located on each of the three major soil areas in central Mississippi.*

(4) Current year's twig growth
(5) Previous year's twig growth
(6) Site index—by method of Broadfoot and Krinard *(2)*
(7) Crown surface area
(8) Fruit diameter
(9) Fruit weight
(10) Number of epicormic branches.

RESULTS AND DISCUSSION

Fruit production was significantly greater on trees on the Delta site than on the other two sites (table 1). The difference in fruitfulness was slight in 1965, but in 1966 trees on Delta soil were twice as prolific as those on other sites. Loess and Coastal Plain sites were about equally productive.

Fruits from Delta trees contained more than twice as many full seeds as fruits from trees on the other areas (table 1). The 2-year average of 52 full seeds per fruit from Delta trees is considerably above the seven or eight seeds per fruit given in the Woody-Plant Seed Manual *(4)*, but it is about the same as an 8-year average of 58 for various collections near Stoneville *(1)*.

Table 1.—*Seed production and quality*

Site and year	Relative fruit-fulness	Full seed per fruit	Germ-inative capacity	Germ-inative energy
	Percent	*Number*	*Percent*	
Delta				
1965	58.8	58	97	20.0
1966	58.8	45	94	20.0
Average	58.8	52	96	20.0
Loess				
1965	52.9	21	95	18.9
1966	26.3	19	91	16.9
Average	39.6	20	93	17.9
Coastal Plain				
1965	42.2	22	94	20.8
1966	14.4	12	91	17.6
Average	28.6	17	92	19.2

Sound seeds from all sources germinated about equally well (table 1). Germinative capacity ranged from 79 to 100 percent; germinative energy varied between 11.4 and 24.2. Seed quality was slightly better in 1965 than in 1966, but the difference was too small to be of practical importance.

Not surprisingly, fruit diameter and weight were positively correlated with seed production and quality. Conditions which favored good seed set and development also favored growth of the fruit heads.

Most of the tree and site variables studied were very weakly correlated with seed production and quality; none could safely be used to select good seed trees or seed orchard sites.

Although the reasons were not evident, it appears that, in central Mississippi, the Delta is best suited for sweetgum seed production.

LITERATURE CITED

1. Bonner, F. T.
   1967. Handling hardwood seed. Southeast. Area Forest Nurserymen's Conf. Proc. 1966: 163-170. U. S. Dep. Agr. Forest Serv. Southeast. Area, State and Priv. Forest.
2. Broadfoot, W. M., and Krinard, R. M.
   1959. Guide for evaluating sweetgum sites. U. S. Dep. Agr. Forest Serv. Southern Forest Exp. Sta. Occas. Pap. 176, 8 pp.
3. Czabator, F. J.
   1962. Germination value: an index combining speed and completeness of pine seed germination. Forest Sci. **8**: 386-396.
4. USDA Forest Service.
   1948. Woody-plant seed manual. U.S. Dep. Agr. Misc. Pub. 654, 416 pp.