SOUTHERN FOREST EXPERIMENT STATION

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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 1[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.

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