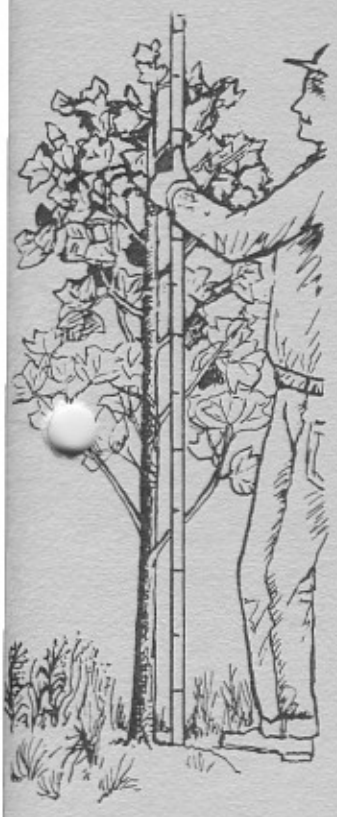

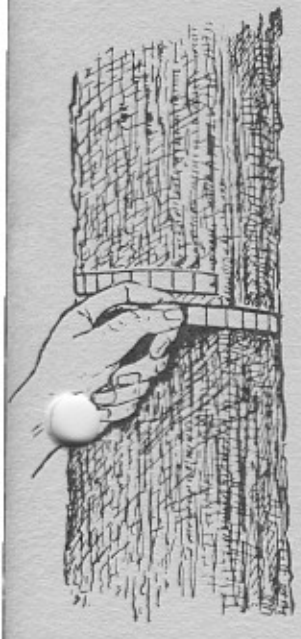

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PRE-COMMERCIAL LOBLOLLY PINE THINNING STUDY

Virginia Division of Forestry
Department of Conservation and Economic Development

RESULTS AT AGE 23 OF A LOBLOLLY PINE PRE-COMMERCIAL THINNING STUDY

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ABSTRACT

Pre-commercial thinning treatments were applied to a four-year-old loblolly pine stand established by artificial seeding. Treatments involved bulldozing strips, bulldozing strips plus hand-thinning, hand-thinning alone, and a check.

Measurements were made at ages 4, 10, 17 and 23. Pre-commercial thinning increased diameter growth and pulpwood yields, and seemed to increase height growth of dominant and co-dominant trees. At age 23, average DBH of the 100 largest trees per acre and average pulpwood volumes were:

Treatment	Mean DBH 100 Largest	Standard Cords
Check	7.2	17.9
Dozing only	8.2	22.6
Dozing plus hand thinning	8.7	25.0
Hand thinning only	8.4	27.6

INTRODUCTION

A long term evaluation of pre-commercial thinning in loblolly pine was initiated more than 20 years ago in Louisa County in Virginia's central piedmont. The stand was established by artificial seeding on a gently rolling, upland site where logging debris and brush had been bulldozed into windrows. Stratified and treated[1/] seeds were sown with a cyclone seeder at the rate of one pound per acre on May 1, 1961. Pre-commercial thinning treatments were applied late in the fourth growing season, on July 27 and 28, 1964.

1/ After stratification, the seed was treated with Arasan, Endrin, and aluminum flakes.

PROCEDURE

There were four treatments:

1. Check

2. Bulldozed strips approximately 7 feet wide separated by leave strips approximately 4 feet wide.

3. Bulldozed as above, with pines in the leave strips hand-thinned to an approximate spacing of 6 feet between seedlings.

4. No bulldozing, with entire plot hand-thinned to an approximate spacing of 7 to 8 feet between seedlings.

Four randomized blocks were laid out between windrows. Measurement plots were 1/10 acre (one chain x one chain) surrounded by an 11-foot buffer treated the same as the plot.

Numbers of seedlings on the plots varied considerably prior to treatment. Among the four check plots, initial stocking (estimated by sampling) ranged from 1,467 to 4,667 loblolly pine seedlings per acre.

Hand-thinning was done by cutting off unwanted seedlings with brush hooks. Many of these cut seedlings recovered and persisted for years, mostly as over-topped trees. In bulldozed strips, we tried to skim the surface of the ground with the bulldozer blade. Two passes, in opposite directions, were made in each strip. Even so, many seedlings that were run over survived, eventually straightened up, and persisted; again, mostly as over-topped trees. By age 23, most trees that survived hand-cutting and bulldozing had died of suppression.

Scattered, large hardwoods in windrows adjacent to the plots were girdled when the plots were installed. In the spring of 1966, when seedlings were five years old, all hardwood sprouts that over-topped pine seedlings were chopped off.

MEASUREMENTS

Age 4 Measurement

Three transects, each 6.6 feet wide and 66 feet long, were evenly spaced on each check plot, to provide a 30 percent sample. All pine seedlings on these transects were counted, and total heights of six of the tallest seedlings on each transect were measured. On all plots of both bulldozed treatments, all seedlings within the leave strips were counted. There were six leave strips on each 1/10 acre measurement plot, and total heights of three of the tallest seedlings in each leave strip were measured. On plots that were hand-thinned to an approximate spacing of 7 to 8 feet, all pine seedlings were counted, and total heights of 18 of the tallest seedlings evenly distributed over each plot were measured.

Age 10 Measurement

We made a 100 percent tally by one inch DBH classes of all pine trees on every plot. Trees under 4.5 feet tall were not tallied, but there were few of these. Seedlings that survived being chopped off or run over by the bulldozer practically all fell into the 1/4-inch (0 to 1/2) and 1-inch DBH classes, although a few made it into the 2-inch class. On the check plots, total height of every fifth dominant or co-dominant tree was measured, and on all thinned plots, every fourth dominant or co-dominant tree was measured.

Age 17 Measurement

We again made a 100 percent tally by one inch DBH classes of all pine trees on every plot. Total heights were measured on a sample of trees greater than 4.5 inches DBH, and recorded by DBH class so an average height for each DBH class could be calculated. Hardwoods larger than 1.5 inches DBH were tallied. Hardwoods smaller than 1.5 inches DBH, and many in the 2 inch DBH class, were strictly understory trees. All hardwoods were grouped together, but oak predominated.

Age 23 Measurement

The same measurement procedure was followed as for the age 17 measurement.

RESULTS

Number of Pine Trees

Number of pine trees per acre at each of the four measurements is shown in Table 1. All loblolly pine seedlings resulted from direct seeding, since the study area is west of the natural range of loblolly pine. Virginia pine seedlings were all volunteers, and were generally smaller than loblolly pine seedlings. There were so few shortleaf pine seedlings that they were included with the Virginia pines.

For the three thinning treatments, the number of pine seedlings was greater at the 10-year measurement (and still greater at the 23-year measurement on some plots) than at the 4-year measurement. This "increase" was caused by the "re-sprouting" of trees that were cut off and the recovery of trees run over by the bulldozer.

The numbers of loblolly pine seedlings on the check plots in Replications A and B seem to have increased between ages 4 and 10. The reason for this is that seedling numbers on check plots at age 4 were estimated by sampling, whereas at age 10 and later all pine trees were counted. From age 10 on, numbers of trees on the check plots decrease with each measurement as expected.

Table 1. Number of Pine Trees per Acre

Age	Treatment	Replication A Lob.	A Va.P.	B Lob.	B Va.P.	C Lob.	C Va.P.	D Lob.	D Va.P.	Means Lob.	Means Va.P.
4	Check	4667	633	2600	267	3400	200	1467	833	3034	483
	Doze	600	330	930	180	970	120	1530	210	1008	210
	Doze & Thin	470	100	510	30	420	0	560	10	490	35
	Hand Thin	760	20	810	0	710	60	750	100	758	45
10	Check	4740	740	3370	300	3080	200	1360	900	3138	535
	Doze	830	980	1140	390	1450	370	1610	400	1258	535
	Doze & Thin	990	990	760	430	890	130	1390	320	1008	468
	Hand Thin	1080	980	1300	560	980	320	860	1150	1055	752
17	Check	2640	330	2240	170	1980	140	1130	350	1998	248
	Doze	790	640	1060	270	1210	320	1220	260	1070	372
	Doze & Thin	880	530	720	330	750	100	1060	230	852	298
	Hand Thin	930	420	1130	350	710	110	760	600	882	370
23	Check	1310	130	1240	60	960	70	750	110	1065	92
	Doze	510	250	690	160	670	100	780	60	662	142
	Doze & Thin	630	130	540	130	520	0	590	40	570	75
	Hand Thin	720	100	720	80	510	50	690	130	660	90

Pine Basal Area

Basal area per acre at the 10, 17, and 23 year measurements is shown in Table 2. On the check plots in Replications A and C, which had 4,667 and 3,400 loblolly seedlings per acre when the study was installed, basal area actually declined between ages 17 and 23 (mortality exceeded growth). Only on the check plot in Replication D, which had only 1,467 loblolly pines per acre at the time the study was installed, did basal area increase appreciably between ages 17 and 23.

Mortality was heavy among volunteer Virginia pines, and at age 23 Virginia pine basal area was little or no greater than it was at age 10. By age 23, loblolly pine was dominant on all plots and most of the surviving Virginia pines were over-topped, with only an occasional Virginia pine in a co-dominant crown position.

Table 2. Pine Basal Area per Acre

		Replication									
		A		B		C		D		Means	
Age	Treatment	Lob.	Va.P	Lob.	Va.P	Lob.	Va.P	Lob.	Va.P	Lob.	Va.P
10	Check	74	7	89	3	91	2	49	14	76	6
	Doze	42	14	48	9	52	6	57	5	50	8
	Doze & Thin	44	10	43	5	45	1	53	2	46	4
	Hand Thin	52	7	69	4	70	4	42	9	47	6
17	Check	122	9	140	4	142	3	108	14	128	8
	Doze	103	28	102	17	102	13	117	6	106	16
	Doze & Thin	101	17	95	10	101	1	106	4	101	8
	Hand Thin	112	9	134	5	130	6	98	14	118	8
23	Check	119	9	144	3	123	3	125	8	128	6
	Doze	125	21	117	18	102	10	125	4	117	13
	Doze & Thin	131	12	114	7	125	0	111	2	120	5
	Hand Thin	132	5	141	2	143	5	124	8	135	5

Pine Height Growth

Height growth of dominant and co-dominant trees seems to have been affected by treatments, as shown in Table 3. At age 4 there were no differences among treatments, but differences began to show up at age 10 and these differences became progressively larger at ages 17 and 23.[2/] There is considerable variation in site index from plot to plot, even within replications (and even within plots), due to the rolling terrain on which the study is installed. The plots with higher site index, as expected, occur on low areas between ridges. Removal of top soil by the bulldozing operation, especially on the ridges, seems to have contributed to the variation in site index.

2/ An analysis of variance was carried out on the age 23 heights in Table 3, and the differences among treatments were not significant.

Table 3. Dominant and Co-Dominant Average Height - Loblolly Pine

Age	Treatment	Replication A	B	C	D	Means
4	Check	6.1	5.2	7.1	5.3	5.9
	Doze	5.1	6.1	6.1	5.8	5.8
	Doze & Thin	4.9	5.2	5.2	6.5	5.4
	Hand Thin	5.6	6.5	6.7	4.4	5.8
10	Check	18.7	20.7	23.5	21.3	21.0
	Doze	21.2	22.6	21.9	22.4	22.0
	Doze & Thin	22.1	22.1	20.9	23.0	22.0
	Hand Thin	21.6	23.2	24.9	21.3	22.8
17	Check	37.9	39.5	39.4	42.0	39.7
	Doze	41.1	39.9	41.3	40.7	40.8
	Doze & Thin	41.2	40.1	41.7	42.3	41.3
	Hand Thin	38.3	41.8	46.5	40.8	41.8
23	Check	46.2	48.3	47.1	51.4	48.2
	Doze	52.3	48.9	47.1	48.4	49.2
	Doze & Thin	52.0	48.4	56.2	53.0	52.4
	Hand Thin	48.3	51.3	57.1	49.9	51.6

It is possible that our selection of dominant and co-dominant trees varied between check plots and thinned plots. To evaluate this possibility, we also calculated the average height of the five tallest trees measured on each plot (50 per acre). This did not change the apparent relationship between treatments and height. Comparing average heights of all dominant and co-dominant trees with average heights of the five tallest trees on each plot, the five tallest trees averaged about one foot taller at age 4, two feet taller at ages 10 and 17, and three feet taller at age 23, as shown in Table 4.

Table 4. Average Height of Five Tallest Trees Measured on Each Plot

Age	Treatment	Replication A	B	C	D	Means
4	Check	7.3	6.3	8.6	6.3	7.1
	Doze	6.4	7.2	7.6	7.3	7.1
	Doze & Thin	5.7	6.1	6.2	7.4	6.4
	Hand Thin	6.4	7.1	7.8	5.4	6.7
10	Check	20.8	23.4	25.0	23.0	23.0
	Doze	23.4	23.2	23.6	24.6	23.7
	Doze & Thin	24.4	23.8	22.6	24.8	23.9
	Hand Thin	23.8	25.8	27.0	22.6	24.8
17	Check	38.6	40.4	41.0	45.2	41.3
	Doze	42.8	40.6	44.4	42.6	42.6
	Doze & Thin	43.8	42.4	44.0	44.6	43.7
	Hand Thin	40.4	43.8	49.4	42.8	44.1
23	Check	48.6	52.8	50.2	56.6	52.0
	Doze	56.4	51.4	51.0	50.6	52.4
	Doze & Thin	54.4	52.6	58.4	56.0	55.4
	Hand Thin	50.4	53.6	59.8	54.2	54.5

Pine Diameter Growth

Pre-commercial thinning treatments, as expected, increased diameter growth. Table 5 presents average diameters at age 23 for all pine trees, and Table 6 presents average diameter of the 100 largest trees per acre (10 per plot). Based upon the 100 largest trees per acre, which should comprise most of the final crop trees if the plots are thinned again and carried to a sawtimber rotation, pre-commercial thinning increased DBH 1 inch to 1-1/2 inches by age 23.[3/] Table 7 presents average stand tables at age 23 for each of the four treatments.

3/ An analysis of variance was performed on the diameters in Table 6. Differences between treatments were tested using Duncan's New Multiple Range Test. Treatment means in Table 6 followed by the same letter are not significantly different at the .05 level.

Table 5. Average DBH at Age 23 of All Trees, Loblolly and Virginia Pine

Treatment	Replication A	B	C	D	Means
Check	3.8	4.3	4.5	4.9	4.4
Doze	5.5	5.0	4.9	5.1	5.1
Doze & Thin	5.5	5.3	6.4	5.3	5.6
Hand Thin	5.3	5.4	6.7	5.1	5.6

Table 6. Average DBH at Age 23 of the 100 Largest Trees per Acre
(All loblolly, except one Virginia pine on the check plot of Replication A)

Treatment	Replication A	B	C	D	Means
Check	7.2	7.1	7.3	7.3	7.2 a
Doze	9.2	8.4	7.6	7.6	8.2 b
Doze & Thin	9.0	8.4	9.0	8.5	8.7 b
Hand Thin	8.0	7.8	9.3	8.4	8.4 b

Table 7. Average Numbers of Pine Trees (Loblolly and Virginia Pine) at Age 23 by DBH Class

DBH Class	Treatment: Check	Doze	Doze & Thin	Hand Thin
1	8	0	12	12
2	112	35	45	42
3	278	135	62	60
4	315	152	98	92
5	205	178	82	138
6	120	112	105	190
7	58	108	118	105
8	50	48	65	65
9	5	28	42	38
10	2	8	15	8
11	2	2	0	0
Totals	1,155	806	644	750
Mean DBH	4.3	5.1	5.6	5.5

Pine Pulpwood Yields

Pulpwood volumes in standard cords were calculated for the 17 and 23 year measurements.[4/] The results are shown in Table 8. At age 23, the hand-thinning treatment had produced the greatest yield, about ten cords per acre more than the check. The dozing plus hand-thinning treatment was close behind the hand-thinning treatment, followed by dozing alone, which still produced almost five cords per acre more than the check.[5/]

Table 8. Standard Cords per Acre - Trees Greater Than 4.5 Inches DBH to a 4 Inch Top Outside Bark

Age	Treatment	Replication A	B	C	D	Means
17	Check	4.5	8.1	9.6	10.7	8.2
	Doze	14.6	11.6	10.5	12.0	12.2
	Doze & Thin	13.4	13.3	14.4	12.8	13.5
	Hand Thin	12.9	18.5	23.4	12.6	16.8
23	Check	12.8	19.3	17.0	22.6	17.9 a
	Doze	28.8	22.7	17.1	21.9	22.6 ab
	Doze & Thin	27.3	23.1	28.3	21.1	25.0 ab
	Hand Thin	23.8	28.0	35.3	23.5	27.6 b

Volume growth was slightly greater for the three thinning treatments than for the check over the six year period between ages 17 and 23. At the age 17 measurement we thought that the reverse might occur, since there were considerably more trees below the threshold diameter of 4.5 inches on the check plots, and we expected that there might be more ingrowth on the check than on the thinned plots. This did not happen. There are still, at age 23, far more 3 and 4 inch trees on the check plots than on the thinned plots (see Table 7), but it is obvious now that few of these trees will grow into the 5 inch diameter class, as they are all low vigor trees with short crowns.

4/ The following volume tables were used:

Loblolly Pine - MacKinney, A. L. and L. E. Chaiken. 1956. "Volume, Yield and Growth of Loblolly Pine in the Mid-Atlantic Coastal Region." SEFES Technical Note #33, Table 5.

Virginia Pine - Nelson, T. C., J. L. Clutter, and L. E. Chaiken. 1961. "Yield of Virginia Pine." Station Paper #124, Table 1. Cubic foot volumes were divided by 90 to convert to standard cords.

5/ An analysis of variance was performed on cordwood volumes at age 23. Differences between treatments were tested using Duncan's New Multiple Range Test. Treatment means followed by the same letter in Table 1 are not significantly different at the .05 level.

Pulpwood yields of the four check plots at age 23, and average heights of dominant and co-dominant trees, are inversely related to the number of loblolly pine seedlings present when the study was installed, as shown in Table 9. The correlations are strong: cords at age 23 are almost perfectly correlated with number of loblolly seedlings at age 4 ($r = -.999$), and height at age 23 is closely correlated with number of seedlings ($r = -.951$).

Table 9. Comparison of Check Plots

Replication	No. Loblolly Seedlings Age 4	D & CD Height Age 23	Standard Cords Age 23
A	4,667	46.2	12.8
C	3,400	47.1	17.0
B	2,600	48.3	19.3
D	1,467	51.4	22.6

Hardwoods

At the age 23 measurement, hardwoods larger than 1.5 inches DBH were not an important stand component, as shown in Tables 10 and 11. Most hardwoods were over-topped, relatively few were in an intermediate crown position, and only one hardwood (on one of the 16 plots) was in a co-dominant crown position at age 23. On the 16 plots, there were only 3 hardwoods in the 5-inch DBH class and one hardwood in the 6-inch DBH class.

Table 10. Average Number of Hardwood Trees per Acre at Age 23, by DBH Class

	DBH Class					
Treatment	2"	3"	4"	5"	6"	Totals
Check	175	38	22	2	-	237
Doze	252	48	10	2	2	314
Doze & Thin	215	50	12	-	-	277
Hand Thin	228	42	-	2	-	272

Table 11. Hardwood Basal Area at Age 23, Trees Over 1.5 Inches DBH

Treatment	Replication A	B	C	D	Means
Check	5	6	6	15	8
Doze	7	9	7	13	9
Doze & Thin	6	8	9	10	8
Hand Thin	8	3	11	8	8

DISCUSSION

All three pre-commercial thinning treatments increased diameter growth and pulpwood yields. Hand-thinning, and dozing plus hand-thinning of the leave strips were more successful than dozing alone. Thinning increased average DBH of the 100 largest pine trees per acre by 1.0 to 1.5 inches, and cordwood volumes by 5 to 10 cords at age 23.

Increases in diameter and cordwood yields of this magnitude may not justify the cost of pre-commercial thinning, but these are not the only benefits. Future management opportunities are improved as well. On the plots that were pre-commercially thinned, the chances are much better for successfully thinning and carrying the stands to a sawtimber rotation. On all pre-commercially thinned plots, there are enough well-distributed potential crop trees, with adequate live crown ratios, to make a satisfactory thinning. This is not true on the check plots, with the exception of the check plot in Replication D, which had only 1,467 loblolly pine seedlings per acre when the plots were installed. On the other three check plots, even most of the dominant and co-dominant trees are spindly and have short crowns, and would be poor risks to leave in a thinning operation due to their high susceptibility to damage from wind, ice and snow. On these three check plots the only reasonable option seems to be a clear-cut for pulpwood before age 30.