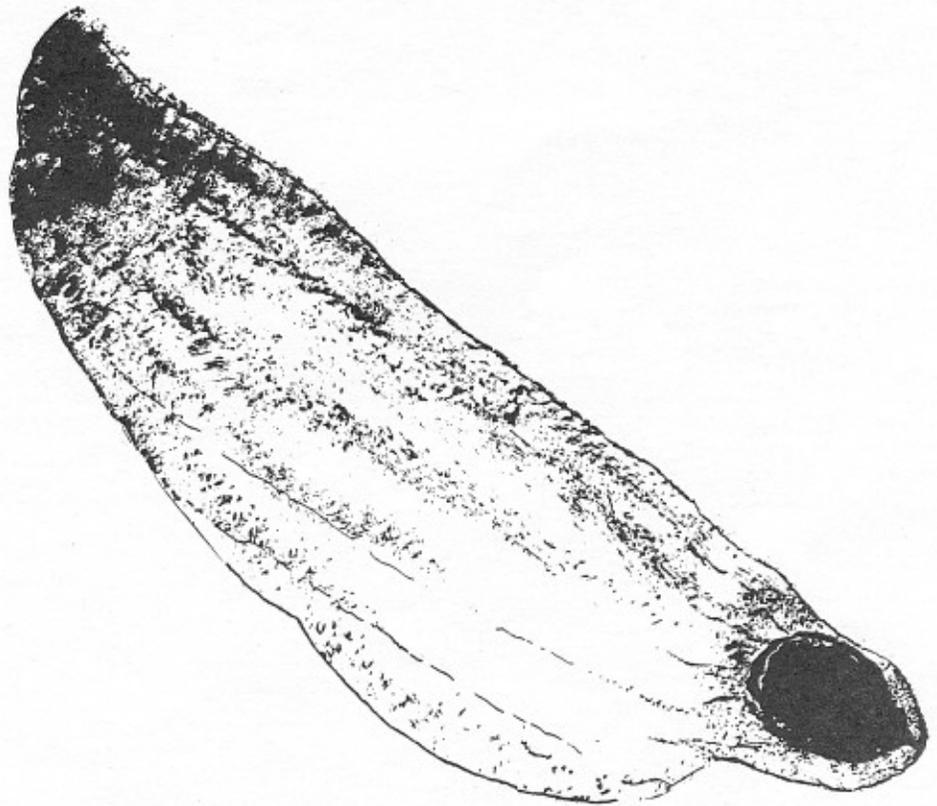
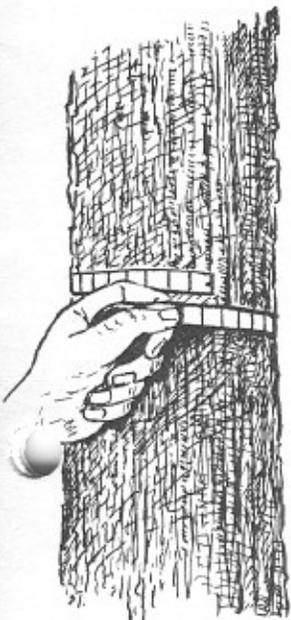
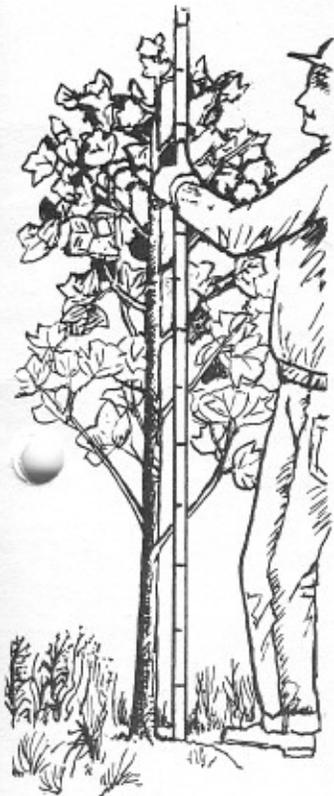


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**A THREE-YEAR LOBLOLLY PINE
DIRECT SEEDING STUDY:
YIELDS AT AGE 24**



**A THREE-YEAR LOBLOLLY PINE DIRECT SEEDING STUDY:
YIELDS AT AGE 24**

by Thomas A. Dierauf

ABSTRACT

A three-year direct seeding study compared eight treatments (two rates x four sowing dates), replicated three times each year for a total of 72 plots. Initial stocking ranged from 230 to 5,340 seedlings per acre at age 3.

The plots were measured when they reached age 24. Pulpwood yields ranged from 6.6 to 29.1 standard cords per acre and averaged 18.5, which is considerably less than would be expected from plantations of the same age on comparable sites with the same site preparation. Yields tended to reach a maximum at initial densities of 2,000 to 2,500 seedlings per acre, but fell off very little at higher and lower densities. Diameter distributions, however, were much better (more large and fewer small trees) for the plots with lower initial densities. Therefore, the lower density plots had a much better chance to be thinned and carried for a sawtimber rotation.

INTRODUCTION

A three-year direct seeding study was installed on the Appomattox-Buckingham State Forest, in the central Piedmont of Virginia, in 1961, 1962, and 1963. There were eight seeding treatments: two rates of sowing (1/2 and 1 pound of seed per acre) in the middle of January, February, March, and April. Dry seed was used in January and February and stratified seed in March and April. The seed was applied using a hand-operated cyclone seeder, on square, one-acre plots. Stocking was sampled at age three, and the results were published in Occasional Report 25, dated March 1967. Stocking varied considerably among the three years, with the one-pound seeding rate giving average stocking of 3,888, 1,472, and 745 loblolly pine seedlings per acre in 1961, 1962, and 1963, respectively.

Site preparation consisted of bulldozing and piling, burning the piles, and disking twice with a bush and bog disk. Even with the intensive site preparation, scattered hardwood sprouts provided serious competition. Vigorous stump sprouts of chestnut oak were particularly troublesome. No attempt was made to control this hardwood competition.

Our reason for measuring the studies as they reached age 24 was to see how yields were affected by the great range in initial stocking, and to see how yields compared with yields from plantations.

SAMPLING YIELDS

The three studies were measured over a three-year period as they reached age 24. Yields were sampled on nine 1/40-acre circular plots spaced evenly over each one-acre plot (Figure 1). The diameter of all living pines, including volunteers, was measured to the nearest inch at breast height. A sample of trees in each diameter class, starting with the five-inch class, was measured for total height, noting which trees were dominant or codominant. All hardwoods larger than .5 inch DBH were tallied by one-inch diameter class, and heights of all dominants and codominants were measured. Loblolly pine yields were computed in standard cords per acre for trees >4.5 inches DBH to a four-inch top outside bark.

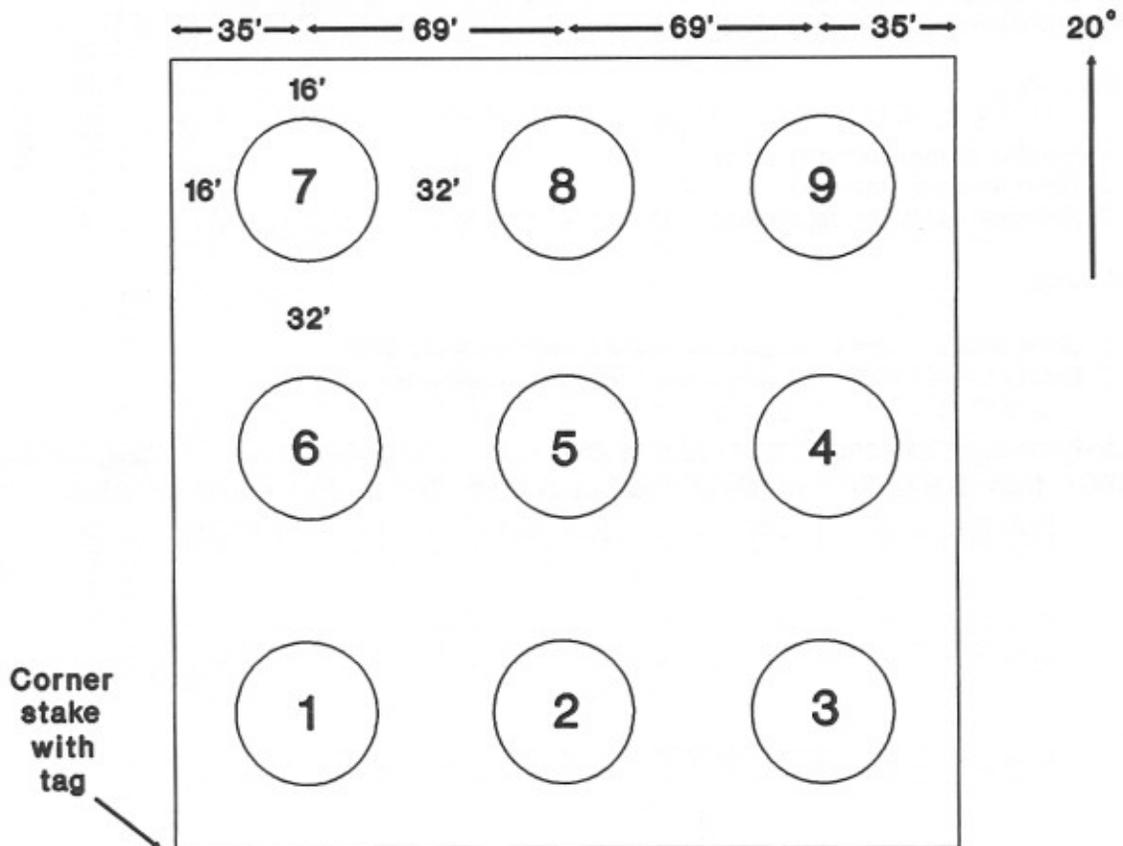


Figure 1. Location of 1/40-acre sample plots (radius = 18.62 ft) on 1-acre square treatment plots.

RESULTS AND DISCUSSION

Data at ages 3 and 24, for all 72 plots of the three-year study, is presented in Table 1. Specifically, Table 1 includes data by seeding year, seeding date, and seeding rate for number of loblolly seedlings per acre at age 3, and for the following at age 24:

Loblolly Pine:

1. Number of trees per acre (No.)
2. Average dominant and codominant height (D&CD Height)
3. Basal area per acre (BA)
4. Standard cords per acre (Cds.)¹

Volunteer Pine:

1. Number of trees per acre (No.)
2. Basal area per acre (BA)
3. Standard cords per acre (Cds.)²

Hardwoods:

1. Basal area per acre in suppressed and intermediate trees (S&I)
2. Basal area per acre in dominant and codominant trees (D&CD)

Loblolly pine yields ranged from 12.8 to 25.6 standard cords per acre among the 24 plots in 1961, from 6.6 to 28.1 cords in 1962, and from 13.1 to 29.1 cords in 1963.

¹MacKinney, A.L. and L.E. Chaiken. 1946. *Volume, yield, and growth of loblolly pine in the Mid-Atlantic Coastal Region*. SEFES Technical Note 33, Table 5.

²Nelson, T.C., J.L. Clutter, and L.E. Chaiken. 1961. *Yield of Virginia pine*. SEFES Station Paper No. 124, Table 1. This volume table was used for shortleaf pine also. We assumed 90 cubic feet of wood plus bark per cord.

Table 1. Data at ages 3 and 24, for all 72 plots of the three-year study.

Seeding Treatment		1961 STUDY										
		Age 3						Age 24			Hardwood Basal Area	
		Loblolly						Volunteer Pine				
		-----						-----			-----	
<u>Date</u>	<u>Rate</u>	<u>Rep.</u>	<u>No.</u>	<u>No.</u>	<u>D&CD Height</u>	<u>BA</u>	<u>Cds.</u>	<u>No.</u>	<u>BA</u>	<u>Cds.</u>	<u>S&I</u>	<u>D&CD</u>
1/15	1/2	1	2090	715	49.4	121	21.4	142	11	.9	19.5	3.3
		2	1980	724	48.2	106	16.9	213	11	.3	18.0	15.6
		3	2200	578	50.3	92	15.8	67	5	.5	30.1	4.3
1/15	1	1	5070	724	50.5	104	16.0	133	8	.6	19.9	8.7
		2	3820	880	49.1	124	18.7	102	6	.3	14.2	6.8
		3	3970	747	46.5	100	14.1	111	7	.3	19.5	10.0
2/15	1/2	1	2210	787	48.9	119	19.4	120	10	1.2	19.4	4.9
		2	2150	747	52.2	132	25.6	58	4	.1	26.3	6.8
		3	2550	627	50.1	105	18.4	27	2	.3	20.7	9.6
2/15	1	1	5340	933	48.5	116	16.0	164	10	.6	18.5	5.8
		2	3870	956	48.1	124	16.9	40	3	.2	24.2	4.1
		3	3650	720	48.2	109	17.2	27	1	.1	22.7	15.3
3/15	1/2	1	1340	516	52.5	116	24.1	142	15	1.8	23.9	7.2
		2	2240	809	50.6	131	23.1	36	1	0	20.2	6.6
		3	2620	796	48.5	116	18.0	80	5	.5	21.8	13.6
3/15	1	1	3370	729	52.1	116	20.3	129	11	1.5	35.6	6.1
		2	2790	791	49.6	115	17.5	98	8	.8	19.3	10.3
		3	3910	849	48.9	116	16.7	89	4	.2	19.1	6.6
4/15	1/2	1	1920	667	50.6	105	17.6	218	19	1.9	23.8	3.2
		2	2250	680	47.1	88	12.8	164	8	.1	14.0	13.5
		3	1570	653	48.6	107	18.8	164	14	1.0	22.9	8.7
4/15	1	1	4290	791	49.8	115	18.0	133	14	2.3	19.9	5.0
		2	3050	893	50.5	124	18.8	84	5	.4	20.0	4.0
		3	3530	911	50.9	134	21.8	36	3	.1	17.2	7.7

1962 Study

Age 24

Seeding Treatment			Age 3	Loblolly			Volunteer Pine			Hardwood Basal Area		
Date	Rate	Rep.	No.	No.	D&CD Height	BA	Cds.	No.	BA	Cds.	S&I	D&CD
1/15	1/2	1	460	484	50.9	84	15.2	49	5	.6	26.2	13.6
		2	560	542	55.0	102	21.2	80	7	1.0	17.6	21.1
		3	1210	484	54.6	95	19.0	22	2	.4	25.7	29.2
1/15	1	1	1710	609	51.7	92	15.5	62	8	1.3	25.7	17.8
		2	1890	720	53.9	137	28.1	31	4	.8	23.0	11.7
		3	1640	871	52.0	128	21.3	67	6	.5	20.2	10.7
2/15	1/2	1	440	333	54.3	87	19.6	89	11	1.7	28.1	22.6
		2	580	196	48.6	37	6.6	116	15	2.5	19.9	17.4
		3	620	293	51.0	71	14.9	111	16	2.8	21.6	19.8
2/15	1	1	2590	720	53.2	104	17.2	18	4	1.1	22.0	22.8
		2	750	560	51.9	101	18.9	67	6	.7	16.3	18.2
		3	1300	676	49.9	96	15.6	76	9	1.2	22.1	17.6
3/15	1/2	1	440	316	48.9	64	12.2	142	15	2.0	33.1	11.4
		2	860	556	54.8	116	24.2	40	9	2.2	24.8	14.2
		3	340	253	50.7	64	13.0	107	18	3.3	17.5	25.4
3/15	1	1	1320	747	54.1	120	21.9	62	10	2.3	23.2	11.5
		2	910	680	51.2	116	21.1	76	10	1.7	18.1	14.9
		3	1070	547	56.0	102	21.5	98	13	2.1	21.2	11.6
4/15	1/2	1	890	444	52.2	92	18.4	67	11	2.2	21.5	16.5
		2	610	298	51.8	73	15.3	67	8	.8	26.8	23.5
		3	710	307	51.3	58	11.2	164	19	3.2	19.4	27.4
4/15	1	1	1260	716	51.4	101	16.8	84	8	1.0	17.8	22.2
		2	1390	493	51.0	80	13.7	58	5	.4	16.4	34.0
		3	1830	742	53.4	116	21.8	53	6	.7	24.9	19.1

1963 Study

Age 24

Seeding Treatment			Age 3	Loblolly			Volunteer Pine			Hardwood Basal Area		
<u>Date</u>	<u>Rate</u>	<u>Rep.</u>	<u>No.</u>	<u>No.</u>	<u>D&CD Height</u>	<u>BA</u>	<u>Cds.</u>	<u>No.</u>	<u>BA</u>	<u>Cds.</u>	<u>S&I</u>	<u>D&CD</u>
1/15	1/2	1	230	316	49.7	94	19.7	169	16	1.8	24.6	12.8
		2	330	249	50.2	88	19.7	120	18	3.3	17.2	16.7
		3	320	218	50.0	65	13.9	138	18	2.8	28.7	24.0
1/15	1	1	490	471	48.1	114	22.0	129	8	.6	24.9	2.4
		2	680	400	49.9	105	21.8	102	13	2.0	22.4	6.2
		3	750	471	49.7	79	14.1	258	15	.7	17.4	22.3
2/15	1/2	1	500	436	51.6	118	25.2	62	7	.8	26.4	2.7
		2	600	378	53.5	121	28.0	116	13	2.0	24.0	10.1
		3	550	316	53.3	84	18.9	120	11	1.1	31.2	15.1
2/15	1	1	950	556	52.1	136	29.1	111	11	1.6	19.8	4.6
		2	910	387	49.4	96	20.0	80	8	1.1	16.4	8.0
		3	870	449	50.8	84	15.7	80	7	.5	26.3	21.6
3/15	1/2	1	730	533	50.4	130	26.6	89	10	1.5	18.2	3.9
		2	620	329	49.2	86	17.2	169	25	3.9	18.8	20.0
		3	640	333	51.3	77	16.1	173	17	2.3	22.9	18.7
3/15	1	1	750	400	46.5	79	13.9	120	12	1.7	19.0	16.1
		2	850	431	50.0	99	20.1	76	7	.8	25.9	19.5
		3	840	391	50.8	76	14.7	124	9	.9	19.1	33.4
4/15	1/2	1	400	271	49.5	77	16.0	160	19	2.4	24.6	19.3
		2	320	289	50.7	92	20.0	124	14	2.1	22.3	17.3
		3	440	338	50.9	86	18.1	178	18	2.1	18.3	20.2
4/15	1	1	480	298	48.4	76	15.5	107	13	2.0	22.6	14.0
		2	750	476	50.6	122	25.7	98	12	1.7	16.9	9.3
		3	620	280	50.3	65	13.1	160	15	1.6	25.4	26.4

Initial Stocking

The relationship between cordwood yields at age 24 and initial loblolly stocking at age three is shown in Figure 2. In 1961, loblolly stocking at age three ranged from 1,340 to 5,340 per acre, and there was a weak, negative, linear relationship between yields and stocking, with a decrease of .11 cords per 100 additional seedlings. In 1962, loblolly stocking at age three ranged from 340 to 2,590 per acre, and there was a weak, positive, linear relationship, with an increase of .32 cords per 100 additional seedlings. In 1963, loblolly stocking at age three ranged from 230 to 950 per acre, and again there was a weak, positive, linear relationship between yields and stocking, with an increase of .36 cords per 100 additional seedlings. Data from all three years is combined in Figure 3. For the pooled data, yields tended to be greatest at 2000 to 2500 seedlings per acre and fell off very gradually at lower and higher stocking levels.

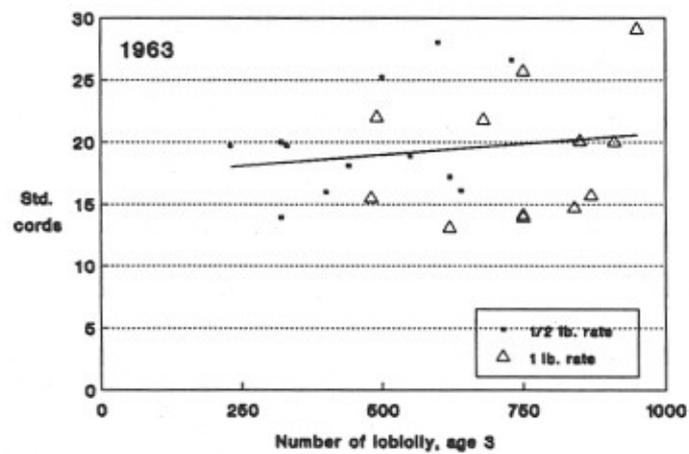
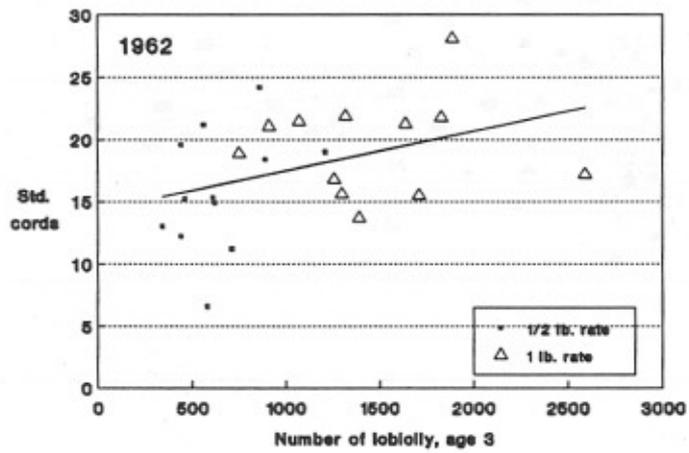
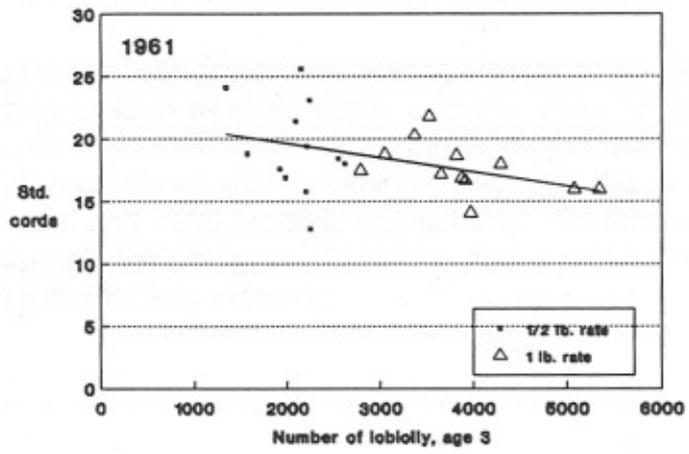


Figure 2. Relationship between loblolly standard cords at age 24 and initial stocking, for the 1961, 1962 and 1963 studies.

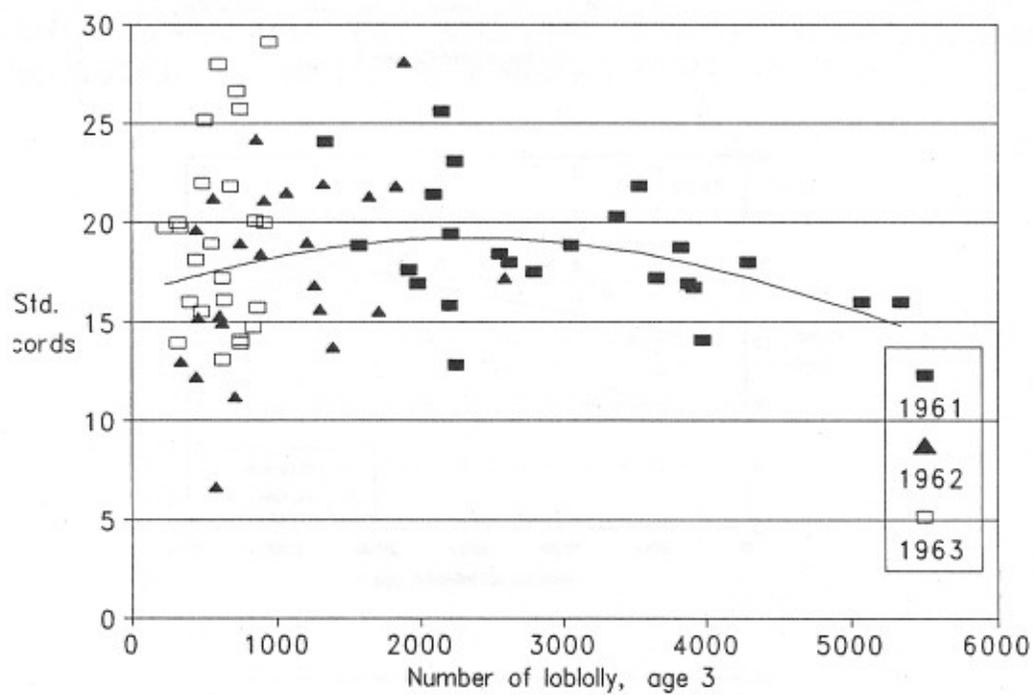


Figure 3. Relationship between loblolly standard cords at age 24 and initial stocking, for the three studies combined.

Variation in Site Quality

Considerable variation in site quality (i.e., average height of dominant and codominant trees) occurred among plots in all three years, and this variation greatly affected yields (Figure 4). The positive slopes of the linear regressions (cordwood increases per one-foot increase in average dominant and codominant height) in Figure 4 are 1.48, 1.88, and 1.44 for the 1961, 1962, and 1963 studies, respectively. Variation in average height of dominant and codominant loblolly pines, therefore, had a much greater effect on yields than the variation in initial loblolly stocking.

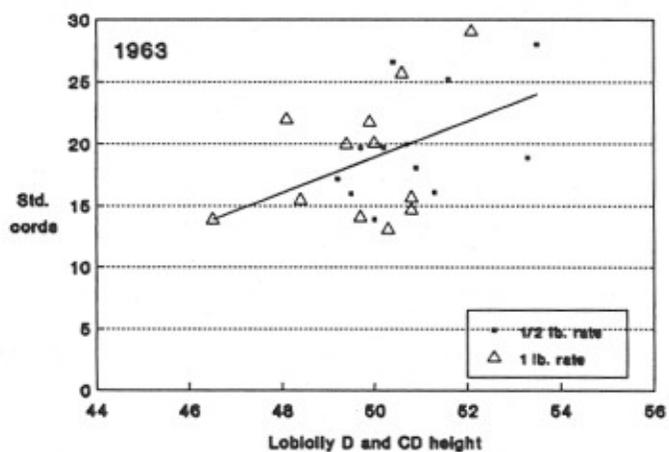
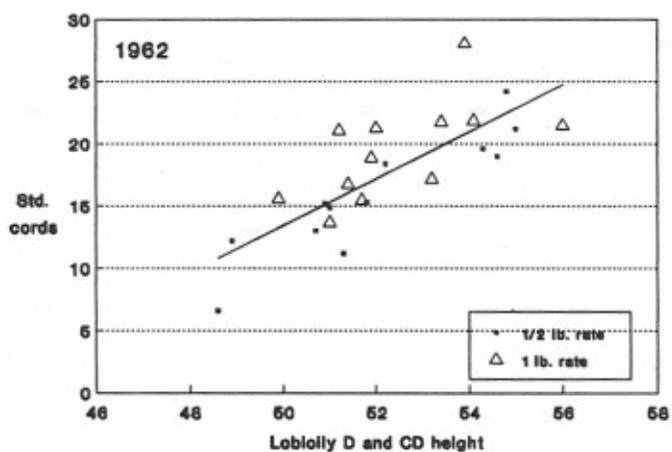
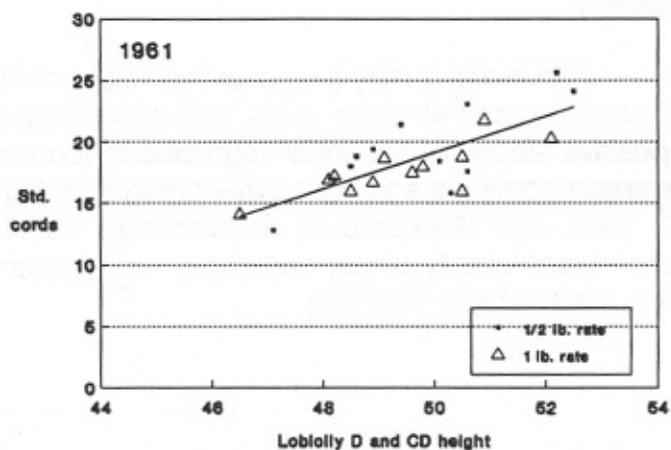


Figure 4. Relationship between loblolly standard cords and average height of dominant and codominant loblolly at age 24, for the 1961, 1962 and 1963 studies.

Hardwood Competition

Hardwood competition was substantial on many of the plots. Considering the intensive site preparation (bulldozing with piling, burning, and double disking), this might seem surprising. Table 1 includes hardwood basal area per acre for each plot by crown class for trees larger than .5 inch DBH. Table 2 presents numbers of hardwoods per acre by one-inch diameter class and crown class. Table 3 presents total numbers of dominant and codominant hardwoods, measured on all 24 plots, by species and average height.

Table 2. Number of hardwoods per acre > .5 inch DBH, by crown class.

DBH	1961			1962			1963		
	S&I	D&CD	COMB.	S&I	D&CD	COMB.	S&I	D&CD	COMB.
1	1,177	----	1,177	855	----	855	849	----	849
2	314	----	314	267	----	267	320	----	320
3	101	----	101	141	6	147	142	18	160
4	31	12	43	41	34	75	32	46	78
5	2	20	22	8	40	48	5	29	34
6	----	12	12	1	25	26	1	20	21
7	----	5	5	----	11	11	----	6	6
8	----	1	1	----	6	6	----	1	1
9	----	----	----	----	1	1	----	1	1
TOTAL	1,625	50	1,675	1,313	123	1,436	1,349	121	1,470
BA	21.21	7.82	29.02	22.27	19.10	41.38	22.25	15.17	37.43

S&I = suppressed and intermediate

D&CD = dominant and codominant

Table 3. Number of dominant and codominant hardwoods by species, with average height and range in height.

Species	1961				1962				1963			
	No.	%	HEIGHTS		No.	%	HEIGHTS		No.	%	HEIGHTS	
			Mean	Range			Mean	Range			Mean	Range
ChO*	199	74	45.2	37-55	329	50	46.1	36-61	240	37	43.2	32-58
WO	4	1	42.8	41-45	28	4	40.5	34-49	14	2	39.1	32-46
ScO	15	6	45.0	39-50	78	12	44.2	36-52	188	29	43.6	33-55
SRO	-	-	-	-	7	1	40.3	34-48	10	2	44.3	34-57
BO	-	-	-	-	5	1	44.6	42-46	-	-	-	-
YP	39	15	51.0	41-64	72	11	48.8	39-58	14	2	46.6	37-58
RM	10	4	44.2	37-48	131	20	44.7	35-57	179	28	40.9	31-50
BL	1	0	53.0	-	4	1	48.8	42-52	-	-	-	-
BC	-	-	-	-	2	0	45.5	45-46	2	0	40.5	40-41
S	-	-	-	-	1	0	51.0	-	-	-	-	-
H	-	-	-	-	1	0	41.0	-	1	0	42.0	-
TOTAL	268	100	--	----	658	100	--	----	648	100	--	----

*ChO-chestnut oak; WO-white oak; ScO-scarlet oak; SRO-southern red oak; BO-black oak; YP-yellow poplar; RM-red maple; BL-black locust; BC-black cherry; S-sycamore; H-hickory

Basal area and cordwood yields of loblolly pine at age 24 were inversely related to the amount of hardwood competition present (Figure 5), and the relationship was stronger with hardwood basal area in just dominant and codominant trees than it was for total hardwood basal area in all trees larger than .5 inch DBH. The slopes of the linear regression lines (cordwood decreases per additional square foot of hardwood basal area) in Figure 5 are -.26, -.31, and -.47 for the 1961, 1962, and 1963 studies, respectively. Hardwood basal area had a greater effect on loblolly yields than initial loblolly stocking.

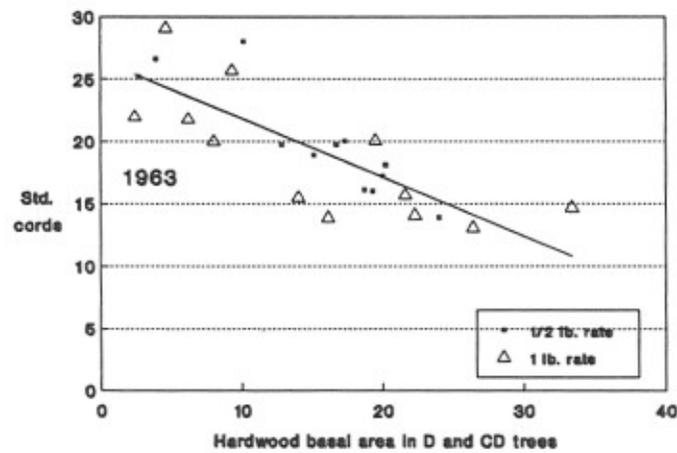
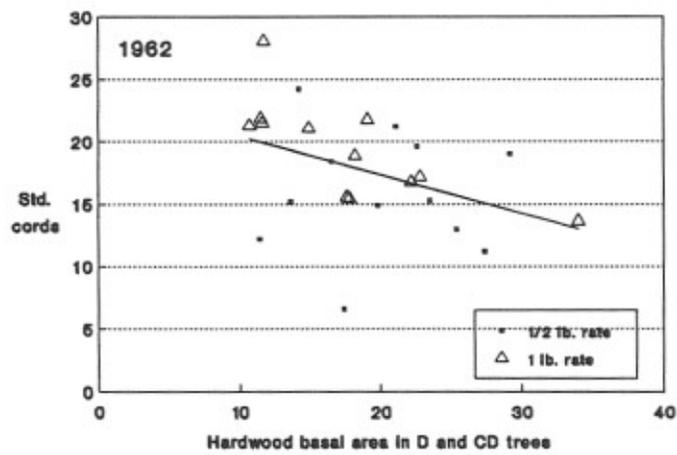
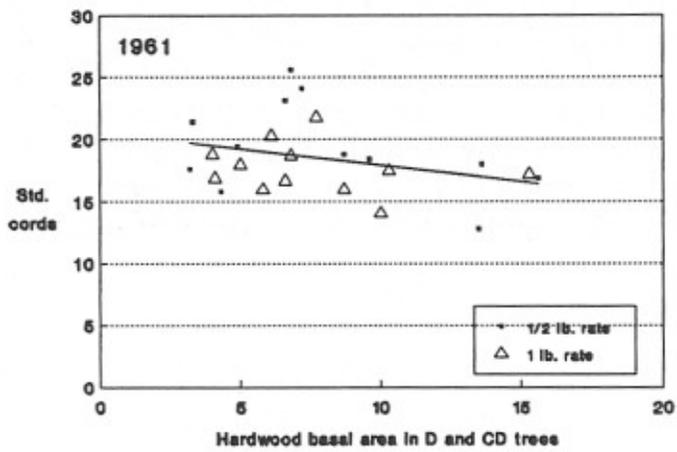


Figure 5. Relationship between loblolly standard cords and hardwood basal area in dominant and codominant trees at age 24, for the 1961, 1962 and 1963 studies.

Volunteer Pines

Considerable numbers of volunteer pines became established on many plots. Most of these were Virginia pine, with considerably fewer shortleaf pine. Because the studies were installed well to the west of the natural range of loblolly pine, there were no loblolly pine volunteers. The direct seeded loblolly pines generally grew considerably faster than the volunteers. The majority of the volunteers were in the two-, three-, and four-inch diameter classes at age 24, and contained little or no merchantable volume. Virginia pines grew faster than shortleaf pines, and practically all of the volunteer volume was in Virginia pine. Table 1 includes the number, basal area, and standard cords per acre for each plot at age 24, and Table 4 summarizes the data for each year.

Table 4. Number, basal area and standard cords per acre in volunteer pines at age 24.

<u>Year</u>	<u>Number</u>		<u>Basal Area</u>		<u>Standard Cords</u>	
	<u>Range</u>	<u>Mean</u>	<u>Range</u>	<u>Mean</u>	<u>Range</u>	<u>Mean</u>
1961	27 to 218	107	1 to 19	8	0 to 2.3	.7
1962	18 to 164	75	2 to 19	9	.4 to 3.3	1.5
1963	62 to 258	128	7 to 25	13	.5 to 3.9	1.7

Opportunities for Thinning

At age 24, it was very difficult to get the 1961 plots thinned because of high initial stocking. Of 828 surviving loblolly per acre on the one-pound plots, only 443 (54 percent) were merchantable (>4.5 inches DBH) and only 120 (14 percent) were larger than 6.5 inches (Table 5). Crowns were short and narrow, and the hazard of ice breakage after thinning was severe. Because they are on the State Forest, most of these plots were thinned, but considerable breakage and some blow-down has occurred. These plots will produce some sawtimber, but yields will be low for the money and effort invested.

The 1962 and 1963 plots, because of lower initial stocking, were thinned without difficulty. On the 1962 plots, 382 of 670 loblolly on the one-pound plots were merchantable (57 percent), and 151 (23 percent) were larger than 6.5 inches (Table 5). On the 1963 plots, which had the lowest initial stocking, 303 of 417 trees on the one-pound plots were merchantable (73 percent) and 173 (41 percent) were larger than 6.5 inches (Table 5). The 1962 and 1963 plots will produce good sawtimber, but per acre yields will be below what would be expected following thinning of well-stocked plantations.

Table 5. Average loblolly pine stand tables at age 24 by seeding year and rate.

DBH	1961		1962		1963	
	<u>½ lb.</u>	<u>1 lb.</u>	<u>½ lb.</u>	<u>1 lb.</u>	<u>½ lb.</u>	<u>1 lb.</u>
2	12	13	9	29	6	17
3	74	128	44	107	18	44
4	159	244	61	152	41	53
5	168	186	62	126	44	64
6	138	137	64	105	53	66
7	90	78	55	83	49	70
8	32	32	38	42	43	43
9	14	9	24	17	38	33
10	2	1	11	6	20	15
11	1	--	6	3	15	9
12	--	--	1	--	6	3
13	--	--	--	--	1	--
TOTAL	690	828	375	670	334	417

Comparison with Plantations

Pulpwood yields at age 24 averaged 18.5, 17.7, and 19.4 cords per acre for 1961, 1962, and 1963, respectively. Yields from plantations on comparable sites receiving the same intensity of site preparation would probably have been between 50 and 100 percent greater. The big advantage of plantations compared to direct-seeded stands is that they start out with optimum numbers of seedlings (assuming satisfactory survival), with uniform spacing between seedlings. Also, the growth rate among planted seedlings tends to be more uniform than among direct seeded seedlings. As a consequence, most planted seedlings reach merchantable size.

Direct-seeded stands, by contrast, rarely end up with optimum stocking and never have uniform spacing. They are usually either overstocked or understocked and, even where overall stocking might be considered optimum, typically there will be localized areas that are overstocked and understocked. On these plots it was common to find localized areas of overstocked seedlings, even on plots that had low overall stocking, and the reverse was also true. In addition, early height growth of direct-seeded seedlings is much more variable than planted seedlings. The consequence of these factors--overstocking, understocking, non-uniform stocking, and non-uniform early growth rate--is that many seedlings never reach merchantable size. In these studies, only 15, 30, and 47 percent of the loblolly seedlings present at age 3 reached merchantable size (i.e., at least 4.5 inches DBH) at age 24, for the 1961, 1962, and 1963 studies, respectively. Trees that never reach merchantable size represent a waste of growth.

Hardwood competition had a greater inhibiting effect on these direct seeded plots than it would have had on planted plots. In understocked areas, hardwoods have a better chance to capture a place in the canopy and reduce pine yields. Another factor that favors hardwoods is the slow, early height growth of direct seeded loblolly seedlings compared to planted seedlings. In the 1961 and 1963 studies, seedlings were planted around the outside edges of the direct seeded plots (that did not abut other direct seeded plots). At ages five and three, for the 1961 and 1963 studies, respectively, average heights (in feet) were:³

	Year	
	<u>1961</u> (age 5)	<u>1963</u> (age 3)
Planted	11.8	4.7
<u>Seeded</u>	<u>9.6</u>	<u>2.2</u>
Differences	2.2	2.5

³See Virginia Division of Forestry Occasional Report No. 23.

Similar direct seeding studies were installed between 1964 and 1967, and heights of planted and direct-seeded seedlings were compared at age 8. Differences (in favor of the planted seedlings) for the four studies were 4.7, 3.9, 4.7, and 2.7 feet for 1964, 1965, 1966, and 1967, respectively.⁴

It is easier to thin planted stands "on time," while crop trees still have large, healthy crowns and before diameter growth is seriously reduced by overcrowding. Direct seeded stands are much more difficult to thin on time. The lower pulpwood yields, large numbers of sub-merchantable trees, and greater numbers of larger hardwoods combine to delay the time that an operational thinning can be made until many crop trees have unsatisfactory crown ratios and growth rates.

In summary, the pine stands obtained at age 24 on these direct seeded plots are much less desirable than those that could have been obtained by planting.

⁴See Virginia Division of Forestry Occasional Report No. 48.