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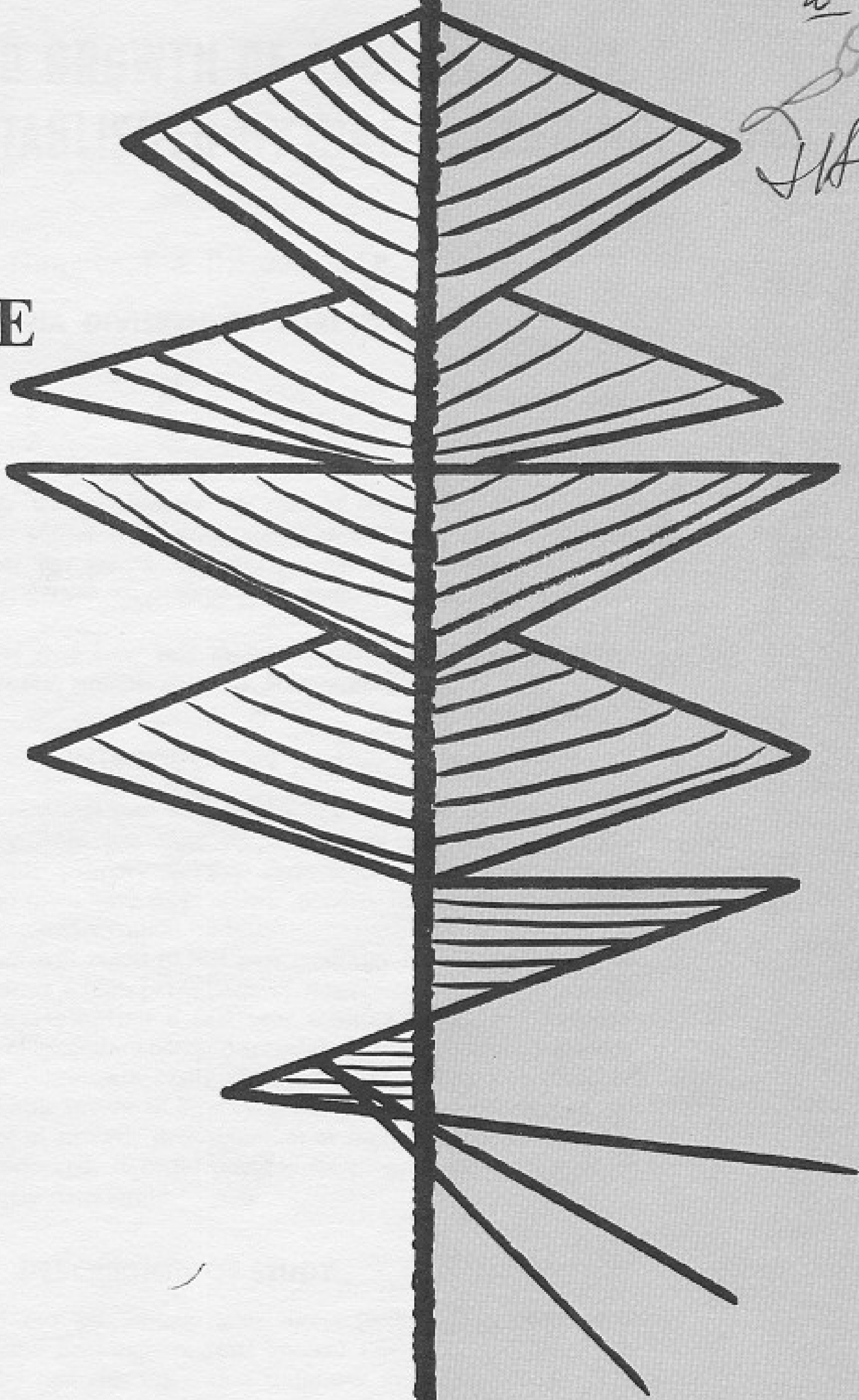
ESTABLISHED BY DIRECT SEEDING



Virginia Division of Forestry
Department of Conservation and Economic Development

SURVIVAL AND GROWTH OF LOBLOLLY PINE SEEDLINGS ESTABLISHED BY DIRECT SEEDING

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ABSTRACT

The purpose of the study was to determine the effect of two seedling characteristics: (1) height and (2) presence or absence of secondary needles at the end of the first growing season, on subsequent survival and growth. A strong correlation exists between these two seedling characteristics—the proportion of seedlings with secondary needles increases with height.

Taller seedlings survived and grew better than shorter seedlings. Seedlings with secondary needles survived and grew better than seedlings with only primary needles.

INTRODUCTION

Direct seeding produces seedlings that vary greatly in size at the end of the first season. Heights may vary from less than an inch to as much as a foot. The smallest seedlings have only primary needles and do not have terminal buds, whereas the larger seedlings often have most of their needles in fascicles (secondary needles) and have well-developed terminal buds.

Direct seeding sometimes will result in first year seedlings that are generally of small size, while at other times a high percentage of large seedlings are produced. The purpose of this study was to find out if first year seedling height and maturity (as evidenced by presence of secondary needles) are related to survival and growth. These two seedling characteristics are easily observed in the field, and could be useful in judging the probable success of direct seeding projects at the end of the first season. The advantage of an early determination of success is obvious: should the area be judged understocked, it could possibly be planted before the effects of site preparation completely deteriorate.

DESCRIPTION OF STUDY

The study was carried out on loblolly pine direct seeding plots installed in 1962, 1963 and 1964 on the Buckingham State Forest. The plots had been prepared for direct seeding by first clearing with a bulldozer and then discing. The soils are in the Tatum and Nason series which are common in the central Virginia Piedmont. They are well-drained soils with very fine sandy loam to silt loam topsoil. Topography on the plots is rolling.

Permanent transects were established in the fall at the end of the first growing season, for all three years. The location of all seedlings on each transect was plotted on graph paper. For each seedling the height to the nearest half inch was recorded, along with a notation as to whether the seedling had secondary needles (at least one fascicle) or only primary needles. The number of transects established and the total number of seedlings plotted for each study year are shown in Table 1.

Table 1. Number of Transects Established and Seedlings Plotted

Study Year	No. Transects	No. Seedlings Plotted
1962	7	184
1963	12	393
1964	14	897

Hardwood resprouting following seeding was relatively light because of the thorough site preparation,and no follow-up release work was done. Seedlings that did occur under hardwood sprouts, however, tended to be tall and spindly.

Seedlings on the 1962 transects were remeasured three times: in the fall of 1963, June of 1965, and the fall of 1965. The 1963 and 1964 transects were remeasured just once, in the fall of 1965. Thus, final measurements were made in the fall of 1965, when the seedlings were 4, 3, and 2 years old respectively.

CORRELATION BETWEEN HEIGHT AND SECONDARY NEEDLES

The presence of secondary needles was correlated with height. None of the shortest seedlings had secondary needles. As height increased the proportion of seedlings with secondary needles increased to the point where all of the tallest seedlings had secondary needles.[1] Table 2 gives the percent of seedlings with secondary needles, and average heights for seedlings with and without secondary needles for each study year.

Table 2. Percent of Seedlings with Secondary Needles and Average Heights

Study Year	Percent with Secondaries	Height at end of first season (in inches)			
		Without Secondaries		With Secondaries	
		Average	Range	Average	Range
1962	19	2.4	(1.0—6.5)	4.2	(2.0—7.5)
1963	30	2.1	(1.0—5.0)	3.9	(1.5—8.5)
1964	49	2.2	(0.5—8.0)	4.5	(1.0—12.0)

RESULTS

Survival

Table 3 summarizes survival percent for the three study years. Frost heaving during the first winter killed 15 percent of the seedlings, and partial frost heaving was a contributing factor to the remaining percentage lost on the 1962 transects. Frost heaving was insignificant on the 1963 and 1964 transects.

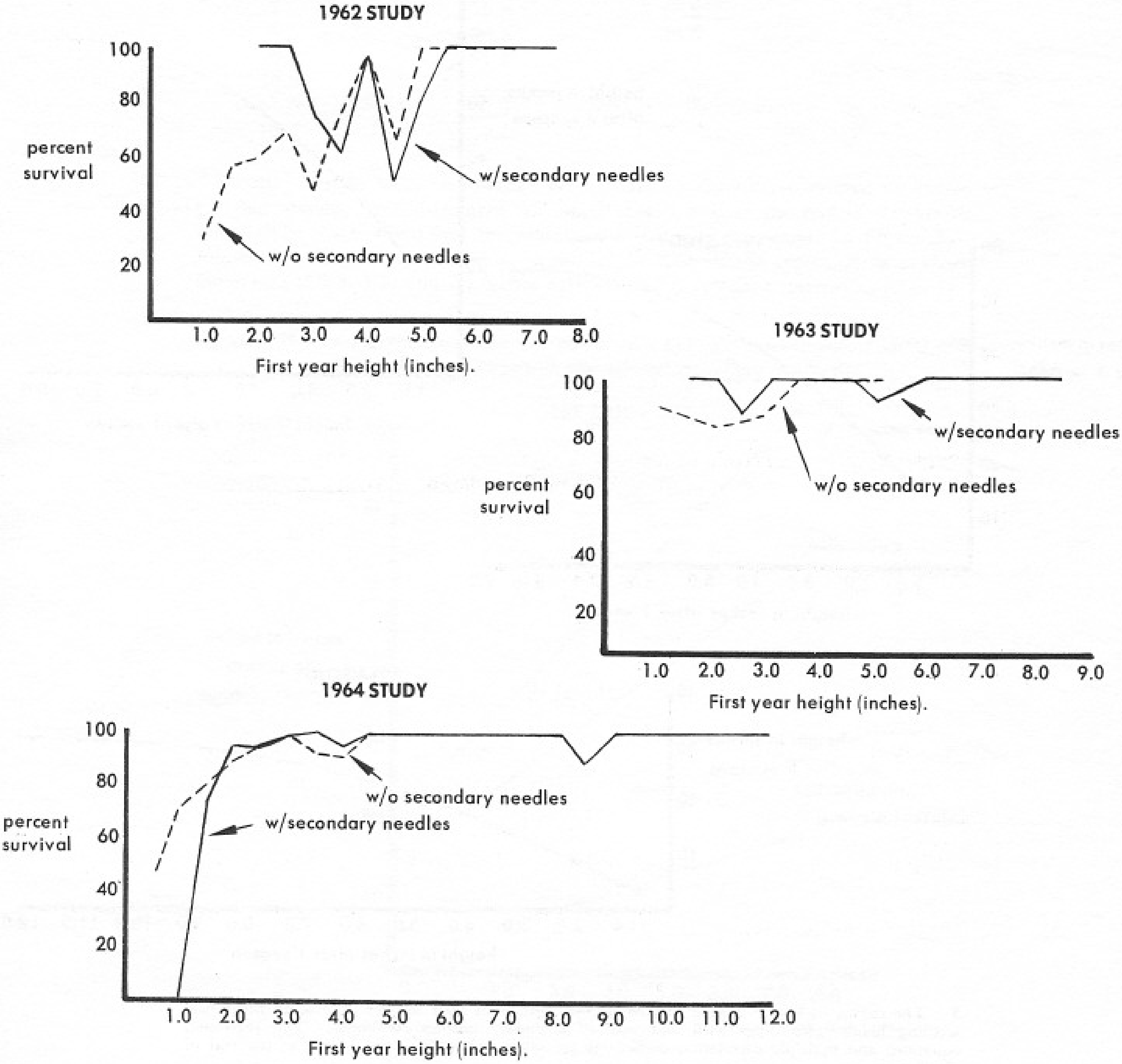
Table 3. Average Survival Percent by Study Year

Study Year	Fall 1963	Fall 1964	Fall 1965
1962	66.3	65.2	64.6
1963			90.0
1964			91.9

1 Simple correlation coefficients were calculated for the relation between first year height and percent of seedlings with secondary needles (using only the intermediate height classes, for which the percentage of seedlings with secondary needles was greater than zero and less than 100 percent). These correlation coefficients were .95, .98, and .96 for 1962, 1963, and 1964 respectively.

Survival was related to first year height as shown in Figure 1. In general, the taller the seedling at the end of the first season the better it survived. When seedlings with and without secondary needles were combined, the effect of first year height on survival was statistically significant for all three years (at the .005, .025, and .005 probability levels for 1962, 1963, and 1964 respectively). When seedlings within the same height classes were compared, seedlings with secondary needles generally survived somewhat better, but the difference was statistically significant only in 1963 (at the .025 probability level).[2]

Figure 1. Average survival percent plotted over first year heights for seedlings with and without secondary needles.

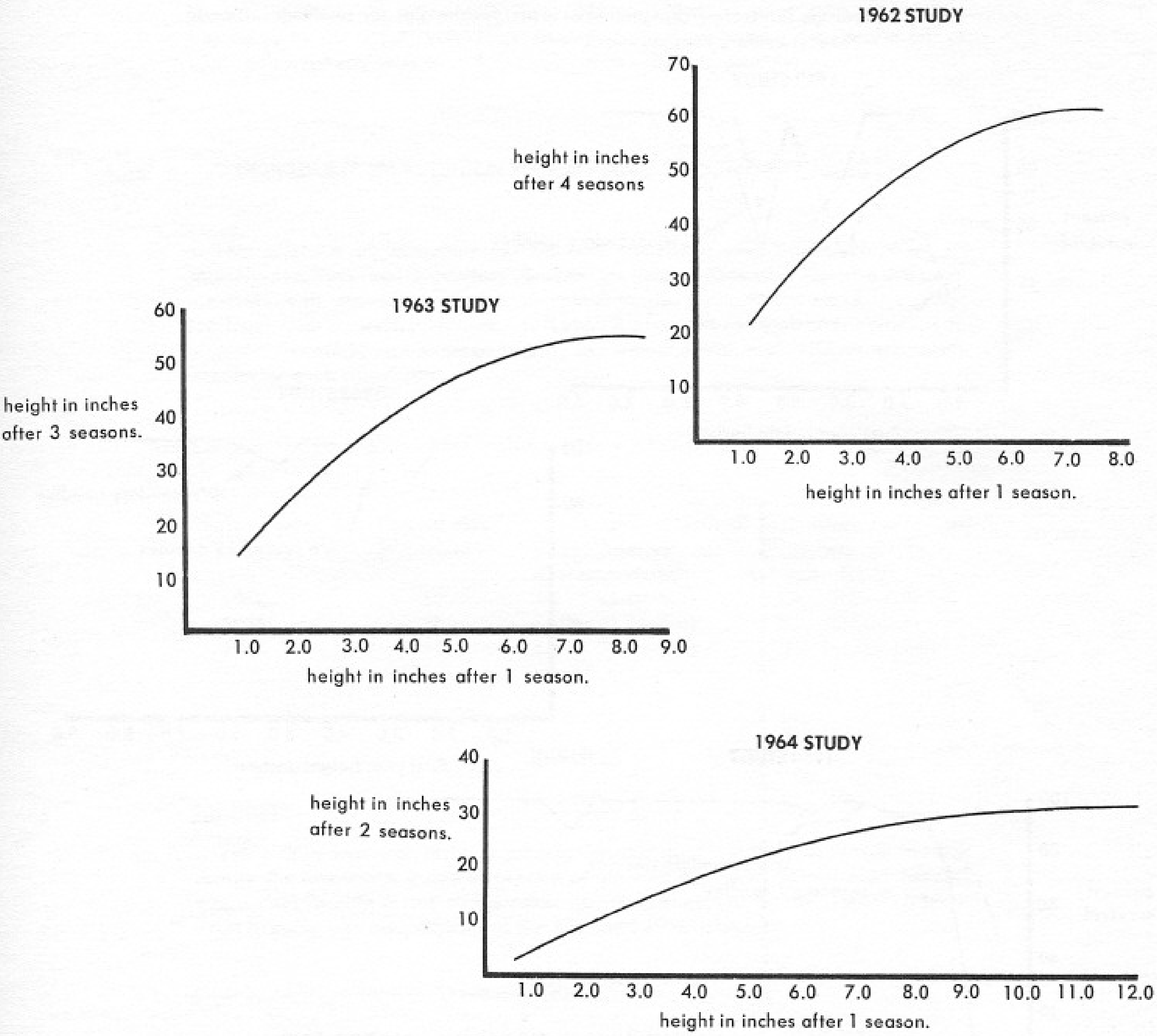


2 Analyses of variance were made for each year, excluding the shortest height classes in which none of the seedlings had secondary needles and also the tallest height classes in which all of the seedlings had them. Average survival percents were transformed to arc sin. Effect on survival of both first year height and presence of secondary needles was tested using the theoretically determined error variance of 821 for binomial data transformed to arc sin (reference *Statistical Methods* by George W. Snedecor, Fifth Edition, pp. 231 and 338; and *Principles and Procedures of Statistics* by Robert G. D. Steel and James H. Torrie, p. 394). Interaction between the effect of initial height and presence of secondary needles was not significant in any of the three years.

Height Growth

Continued height growth was strongly related to first year height, as shown in Figure 2 and Table 4.[3] In general, the taller the seedling at the end of the first season the more rapidly it grew in following seasons.

Figure 2. Average heights in the fall of 1965 plotted over first year heights (seedlings with and without secondary needles combined, all heights in inches).



3 The curves in Figure 2 were derived by the method of least squares applied to individual seedling heights (seedlings with and without secondary needles combined). The regression equations and multiple correlation coefficients are given below. X is the height at the end of the first season.

1962 study: Ht. at age 4 $= 8.005 + 14.905\,X - 1.040\,x^2$, $R^2 = .303$

1963 study: Ht. at age 3 $= 2.359 + 12.779\,X - .781\,x^2$, $R^2 = .494$

1964 study: Ht. at age 2 $= .119 + 5.573\,X - .249\,x^2$, $R^2 = .569$

The additional reduction in residual sum of squares due to fitting the square of first year height was highly significant for 1963 and 1964 (.005 level), but just missed being significant at the (.05 level) in 1962.

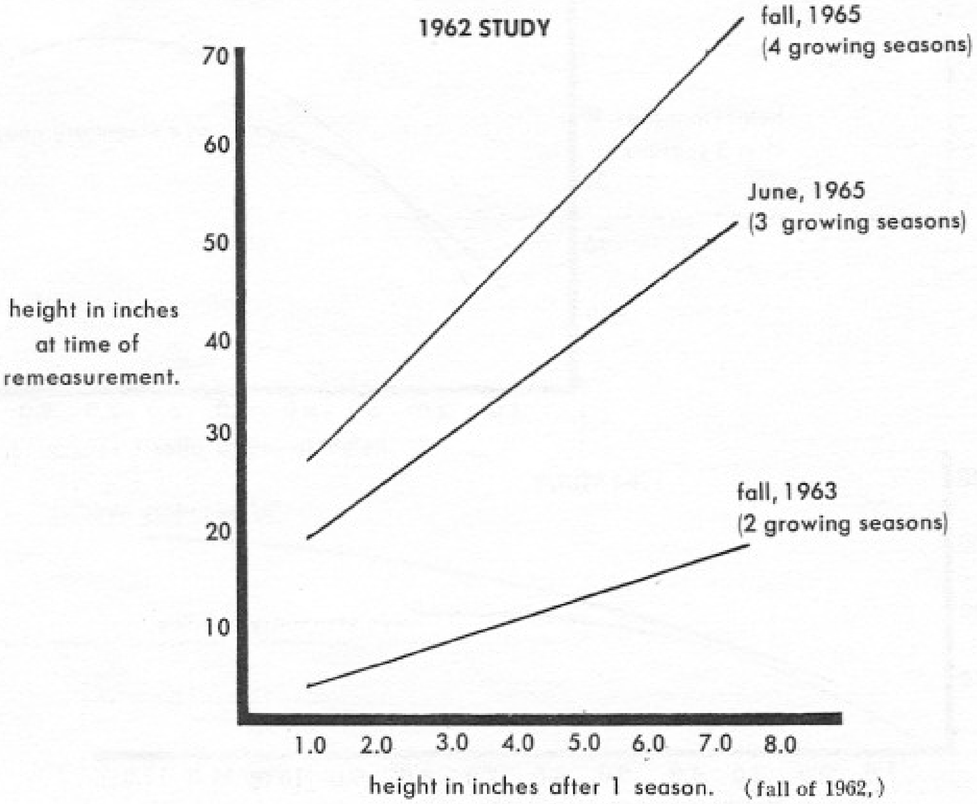
Table 4 was derived by substracting first year heights from the heights predicted by the regression equations.

Table 4. Relation of continued height growth to height at end of the first season (seedlings with and without secondary needles combined; all heights in inches)

	Average Height Growth from End of First Season to Fall, 1965		
Height at End of First Season	1964 Study (1 Year's Growth	1963 Study (2 Year's Growth)	1962 Study (3 Year's Growth)
1.0	4.4	13.4	20.9
2.0	8.3	22.8	31.7
3.0	11.6	30.7	40.4
4.0	14.4	37.0	47.0
5.0	16.8	41.7	51.5
6.0	18.6	44.9	54.0
7.0	19.9	46.5	54.4
8.0	20.8	46.6	
9.0	21.1		
10.0	21.0		
11.0	20.3		
12.0	19.1		

Seedling heights were remeasured three times on the 1962 transects: after two growing seasons, in mid-June of the fourth season, and at the end of the fourth season. The effect of first year height increased with time, as shown in Figure 3.[4] A one inch difference in height at the end of the first season increased to average differences of 2.2, 5.2, and 7.1 inches with successive remeasurements.

Figure 3. The relationship between average heights at successive remeasurements and first year heights (seedlings with and without secondary needles).

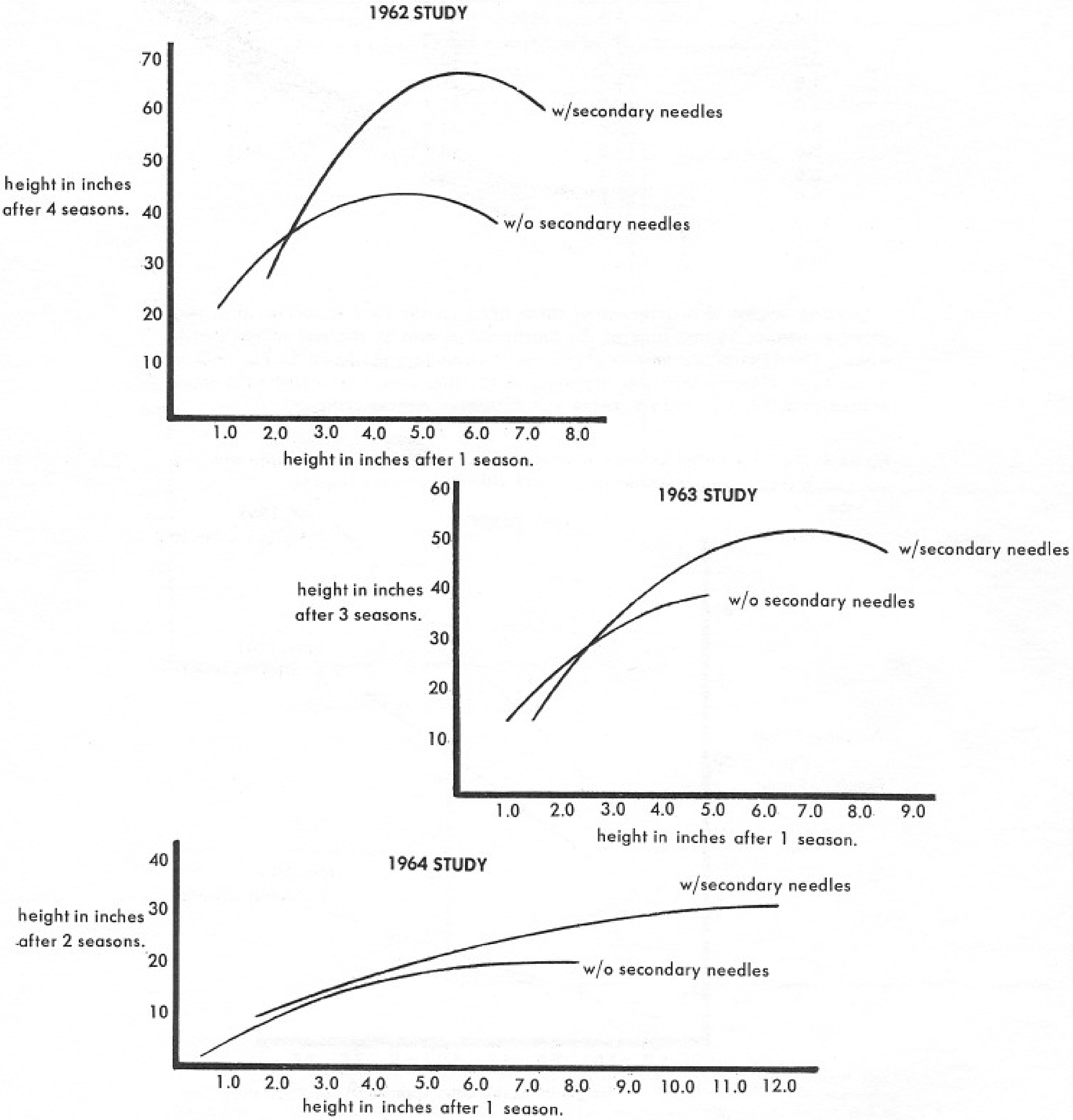


4 Linear regression lines are plotted in Figure 3 because the square of first year height failed to make significant reductions in residual sums of squares. The reduction for the final remeasurement was close to being significant at the .05 level, but the reductions for the earlier two remeasurements were far from being significant. The regression equations and simple correlation coefficients are:

After 2 seasons:	Height $= 1.604 + 2.195$ X, $r^2 = .458$
Early in 4th season:	Height $= 13.606 + 5.202$ X, $r^2 = .311$
After 4 seasons:	Height $= 20.006 + 7.070$ X, $r^2 = .280$

The relationship between presence or absence of secondary needles and later height growth is shown in Figure 4. The difference in height between seedlings with and without secondary needles increased with increasing first year height.[5]

Figure 4. Average heights in the fall of 1965 plotted over first year heights for seedlings with secondary needles and without secondary needles.



5 Separate regression equations were calculated for seedlings with and without secondary needles (these are plotted in Fig 4). An attempt was made to use co-variance analysis to test the differences in height growth between seedlings with and without secondary needles. Regression coefficients were significantly different for all three years, and the residual mean squares for the separate regression equations were significantly different for two of the study years. Therefore, it was not possible to adjust final mean heights for differences in first year mean heights, and so statistical tests could not be made.

William L. Hafley, Associate Professor of Forest Biometrics at North Carolina State University, made suggestions for the statistical analyses and his help is gratefully acknowledged.

CONCLUSIONS

1. Seedlings surviving at the end of the first growing season are apparently good prospects to survive until mortality from competition begins.

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2. Seedings which were taller at the end of the first growing season survived and grew better in subsequent growing seasons.

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3. Seedlings with secondary needles survived and grew better than seedlings without secondary needles.

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4. First year height by itself is a good indicator of future survival and growth. However, first year seedling height together with the presence or absence of secondary needles is an even better indicator.