

Height Growth of Loblolly Pine Seedlings in Relation to Seedling Characteristics

BY

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THE CONNECTION between the appearance and the vigor of tree seedlings has been universally recognized in a general way for a long time. With the intensification of forestry practices, however, more definite criteria of seedling vigor are needed. The need is especially strong in even-aged management when natural reproduction is relied upon to establish the next stand. In even-aged management of loblolly pine (*Pinus taeda* L.) the success or failure in attaining a specified stocking of reproduction must be determined to decide what additional silvicultural measures may be needed. We need to find out how to tell which seedlings may survive to become part of the future stand. Reasonably reliable criteria of future seedling growth are essential to distinguish between seedlings of good and poor prospects.

Little work has been done on the relation of seedling growth to seedling characteristics. Wahlenberg,¹ studying the behavior of loblolly pine reproduction in selection stands, found that lower overstory densities were associated with greater height, ground-line diameter, foliated portion of the stem, branch-bearing portion of the stem, number of branches, branch length, needle length, needle weight, bud

length, and bud weight of 3-year-old seedlings. However, quantitative relations between growth and easily measured characteristics of loblolly pine seedlings have not been determined. A study therefore was made to find which characteristic of loblolly pine seedlings is the best indicator of height growth, and how the relation is affected by gross soil differences, previous burning, age, and attack by the Nantucket pine tipmoth (*Rhyacionia frustrana* Comst.).

Procedure

In the fall of 1951, 700 seedlings were selected in clearcut areas of the Bigwoods Experimental Forest. They were distributed among soil groups, surface conditions, and ages as shown in Table 1.

The following characteristics were recorded for each seedling not infested by the tipmoth:

1. Total height.
2. Proportion of the stem bearing needles.
3. Proportion of the stem bearing branches.
4. Number of branches.
5. Needle length (of fully developed needles along the main stem).

¹Wahlenberg, W. G. 1946. Effect of overwood on survival and development of loblolly pine seedlings in southern Arkansas. U. S. For. Serv. Sth. For. Exp. Sta. Typewritten office report.

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TABLE 1. Distribution of sample seedlings among soils, surface conditions, age, and insect attack.

Soil groups and surface condition ¹	2-year-old seedlings		4-year-old seedlings	
	Not infested	Infested ²	Not infested	Infested ²
	Number	Number	Number	Number
Well-drained, friable subsoil, not burned	100	----	100	----
Well-drained, friable subsoil, burned	100	----	----	----
Well-drained, plastic subsoil, not burned	100	100	100	100

¹Grouping of soils is based on surface drainage and consistency of the subsoil. In this case the well-drained, friable group (WF) was represented by loamy fine sands and fine sandy loams with somewhat heavier material appearing below 20 inches. The well-drained, plastic group (WP) was represented by relatively shallow, very fine sandy loams or silt loams grading into very fine sandy clay or silty clay at 5 to 8 inches. Well-drained soils include those with good and imperfect surface drainage.

²The Nantucket pine tipmoth.

6. Terminal bud length.
7. Stem form quotient (ratio of mid-height diameter to ground-line diameter).
8. Height-diameter ratio (ratio of total height to midheight diameter).

The seedlings were located within strips 20 links wide. Those chosen for the infested group were located within the same strips as the undamaged seedlings, so that the two kinds were intermingled and subject to identical environmental conditions. Seedlings showing evidence of tipmoth attack before the last growing season were excluded from the infested group. Thus, the results would not be affected by varying numbers of earlier attacks. Since damage to the terminal buds of infested seedlings prevented satisfactory measurement of length of terminal bud and height of main stem, only total height (to the highest extremity of the crown excluding needles), number of branches, and needle length were recorded. Initially uninfested seedlings that were attacked while the study was in progress were excluded from the data, whereas infested seedlings were not. Many of the 2-year-old but few of the 4-year-old infested seedlings were attacked again during the year of observation. Thus, seedlings that had been attacked in both years or in the preceding year only were compared with seedlings that had never been attacked.

The study was carried through the second growing season so that the relation of current growth to previous growth could be compared with the relations derived from the first year's data. The previous year's growth of the very slow-growing seedlings could not be distinguished with confidence at the time the study was installed.

Results

The significant relations derived from the first year's data are shown in Figure 1. This initial analysis did not include the seedlings infested by the tipmoth.

Multiple and simple correlation coefficients were computed to find how closely height growth could be predicted. The coefficients for the specified independent variables with height growth are as follows:

Height-diameter ratio and height	0.96
Main stem foliage and height	94
Terminal bud length and height	91
Needle length and height	90
Stem form quotient and height	89
Number of branches	85

These coefficients are all very high, indicating that all the derived curves fitted the data closely.

Since any one of these characteristics would predict seedling growth with satisfactory precision, the one that was most promising for field use could be chosen on the basis of ease of application. The number of branches was most satisfactory in

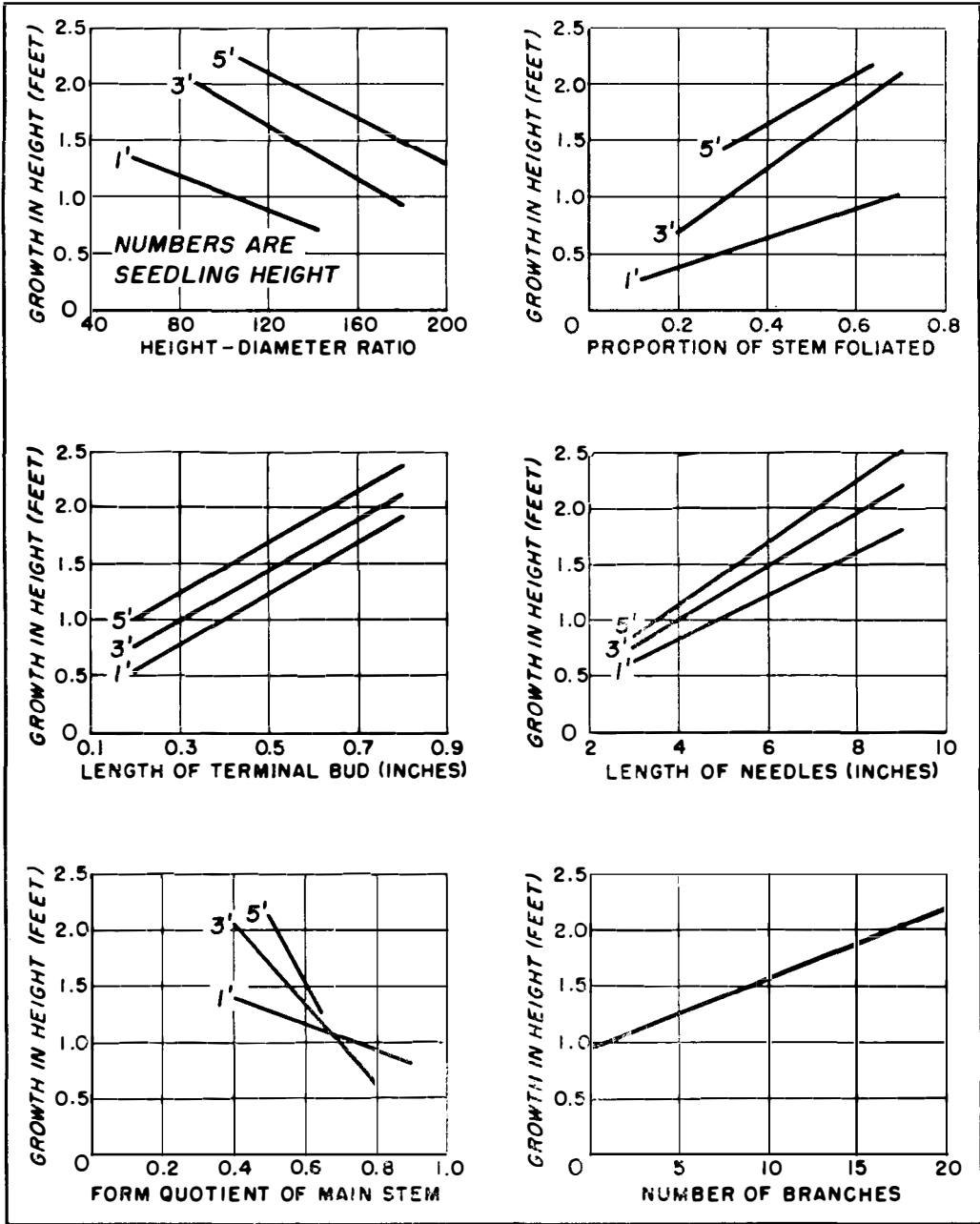


FIGURE 1. Relationship of one year's height growth to indicated seedling characteristics.

that respect because its relation to seedling growth was linear and independent of seedling height, and it could be determined without a measuring instrument. Therefore, the relation of seedling growth to number of branches was examined further to determine how it was affected by environmental conditions, age, and tipmoth attack. With age taken into account, height should also be closely related to growth. A similar analysis, therefore, was made of the relation of growth to height. The second year's data were analyzed in the same way. In addition, the relation of current to previous year's growth was determined. Tipmoth-infested seedlings were excluded in the second year because the initial classification of tipmoth infestation was no longer applicable.

The effects of soil and seedling age on the relations of current growth to branching, height, and previous growth in the second year are shown in Figure 2. These effects were not significantly different from those in the first year in the case of the branch and height relations. In the first year, however, the relation of growth to height was curvilinear.

The effect of the soil difference on the growth of the older seedlings is significant when growth is related to height but not when growth is related to number of branches. Thus, 5-year-old seedlings of a given height had larger crowns and grew faster on the lighter than on the heavier soil. However, on both soils their current growth bore the same relation to their previous growth.

In contrast to the older seedlings, the younger seedlings of a given height and number of branches grew faster on the heavier soil. In the relation of current to previous growth, the only significant difference was caused by the greater current growth of the 3-year-old seedlings on the heavier soil (Fig. 2, c). The area in which these seedlings were located had been disked before the harvest cut, which could conceivably have improved the soil characteristics enough so that the seedlings grew faster than on the lighter, normally better soil.

The effect of burning is not shown in the graphs. Seedlings of the same initial height grew 0.43 foot more in the first year and 0.48 foot more in the second year

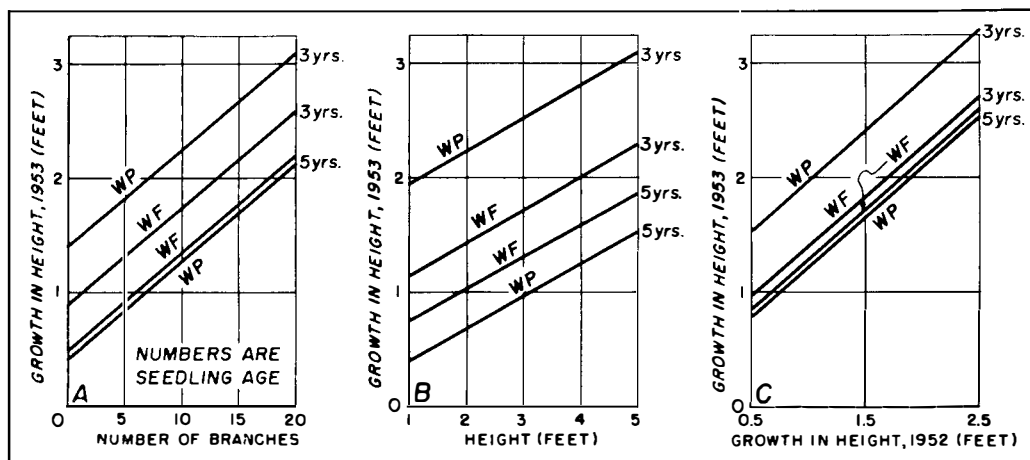


FIGURE 2. The effect of soil and age on the relations of current seedling height growth to number of branches, initial height, and previous height growth. WP means well-drained plastic soil and WF means well-drained friable soil.

on the burned than on the unburned area. Seedlings with the same number of branches grew 0.37 foot more in the first year and 0.56 foot more in the second year in the burned than in the unburned area. That comparison involved only the younger seedlings on well-drained, friable soil (Table 1). This result agrees with earlier findings that loblolly pine seedlings in a burned area grow faster than those in an unburned area.²

The differences in height growth associated with initial tipmoth attack were quite unexpected. Infested 2-year-old seedlings grew 0.32 foot, a significant amount, more in height than uninfested seedlings of the same height and branching, and infested 4-year-old seedlings grew 0.45 foot more than uninfested seedlings of the same height and branching. The conduct and observations of this study suggest no rational explanation for that behavior.

The variation in height growth of similar seedlings attributable to soils, surface conditions, age, and tipmoth attack was accounted for by covariance analyses. The following multiple correlation coefficients show how closely the indicated seedling characteristics were associated with subsequent height growth when the above factors were taken into account:

First year	
Number of branches	0.90
Initial height	0.92
Second year	
Number of branches	0.87
Initial height	0.89
Previous season's growth	0.93

The correlation of current with previous growth is significantly higher than the correlations of growth with number of branches or initial height.

Discussion

The use of branching and seedling height as indicators of future growth is compli-

cated by the influence of environmental factors. Different parts of seedlings do not remain in the same relation to each other with changes in soil conditions. Thus, seedlings of the same age and height had developed more branches on the lighter than on the heavier soil, and seedlings with the same number of branches or of the same height grew faster in one place than in another.

Growth, however, reflects environmental differences in about the same way in one year as in the next. Consequently, the relation of current height growth to previous height growth should be largely independent of these differences as long as the environmental conditions do not change appreciably from year to year.

Such a change might have caused the significantly faster growth for a given amount of previous growth of the 3-year-old seedlings on the heavier, disked soil. Disking undoubtedly improved soil characteristics, but that should not have caused a change in the relation of current to previous growth since it occurred before seedling establishment. The decomposition of the incorporated raw organic material, however, would tend to monopolize the available nitrogen and mineral nutrients for the first few years. As decomposition was completed, these substances would be released with the result observed here—greater current growth for a given amount of previous growth than in an undisked area.

It is apparent, therefore, that previous growth is the seedling characteristic that is most promising for field use, not only because it is more closely related to current growth but also because its relation to current growth, in the absence of diskings, is not affected by differences among well-drained soils. The relation of current to previous growth for all except the 3-year-old seedlings in the heavier, disked soil, is as follows:

$$\text{Current growth} = 0.35 + 1.02 (\text{previous growth})$$

²Pomeroy, K. B. and K. B. Trousdell. 1948. The importance of seed-bed preparation in loblolly pine management. *Sth. Lumberm.* 177 (2225): 143-144.

Since disking is not yet a general practice, this relation should be widely useful as an aid in judging the prospects of loblolly pine reproduction.

On the basis of the results reported here, little can be said about the effect of tipmoth attack on seedling growth. Under the conditions of this study, attack only in the preceding growing season did not deter seedling growth. Other work³ has shown that tipmoth attack reduces height growth somewhat. Occasionally, particularly in plantations, attacks on some seedlings reach such an intensity that height growth is almost stopped.

Summary

Because information about future growth of loblolly seedlings is needed to evaluate the stocking of reproduction under even-aged management methods, the relation of growth to seedling characteristics and to

³Wenger, K. F. 1954. Release of loblolly pine reproduction. U. S. For. Serv. Southeast. For. Exp. Sta. Type. rept.

gross soil differences, prescribed burning, seedling age, and Nantucket tipmoth attack was investigated. The height-diameter ratio, proportion of the main stem foliated, proportion of the main stem branched, stem form quotient, terminal bud length, needle length, number of branches, previous year's growth, and total height were studied. All of these except the branched proportion of the main stem were highly correlated with height growth in the succeeding year.

Seedlings of a given height and number of branches grew faster in a burned than in an unburned area. Seedlings attacked by the Nantucket tipmoth in only the preceding year grew faster than uninfested seedlings of the same height and number of branches.

The previous year's growth was deemed most promising for field use because its correlation with growth was very high, its relation to growth was linear and independent of seedling height, it was easily measured, and under normal conditions, it was not affected by gross soil differences, prescribed burning, or seedling age.