SPECIFIC GRAVITY RELATIONSHIPS IN PLANTATION-GROWN RED PINE

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Norway or red pine (*Pinus resinosa* Ait.) has been popular in Maine for forest planting because it will rapidly convert grass and weed cover to a forest floor and because it is relatively free from attack by insects and diseases. Since the first commercial thinnings consist of small-sized trees, the most logical market outlet is for pulpwood. Yield of pulp fiber by weight is directly correlated with the specific gravity of the wood. Consequently, several questions arise: What is the average specific gravity of plantation red pine of a given age? Can the tree specific gravity for young, plantation-grown red pine be predicted satisfactorily by the technique used in predicting tree specific gravity of mature, natural-grown red pine? How do some of the variables encountered affect specific gravity of red pine plantations of the same age?

A method of estimating tree specific gravity from increment cores taken at breast height has been reported in numerous publications and for several species of trees. In most cases the method has been applied to mature, natural-grown trees. A McIntyre-Stennis financed pilot study was initiated to test this method on young, plantation-grown red pine, and to study such other variables as could be measured without adding significantly to the cost of the study.

The Plantation

The stand from which the sample trees were selected was planted with 2-1 stock in 1941 and 1942. At the time of cutting, in 1964, the trees were 25 and 26 years old from seed. Five paired blocks 75x100 feet were planted with tree spac ings of 2, 4, 6, 8 and 10 feet. In Area No. 1 thin ning was to be done as required for good growth. Area No. 2 was left as a check. At the time of sampling, the 2-foot spacing in Area No. 1 had been thinned to 4x4 feet and the 4-foot spacing had been thinned to 8x8 feet.

Sample Tree Selection

Ten trees were selected from each of the 10 blocks. The criteria for selection were that they should have dominant or codominant crowns, single leaders, and no pronounced lean from the vertical — in brief, what might be considered good crop trees to bring to maturity. These trees were randomly selected from the stand, avoiding only the trees on the outer rows.

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Sample Collection

Tree diameter, total height, merchantable height (to a 4-inch top), and length of live crown were measured. Destructive sampling followed standard procedures:

1. Two increment cores at breast height. Random position of first; second at 90° to right.
2. Tree felled, cut into bolts 4.2 feet long.
3. Disks 2 inches thick cut from the top of each bolt and average diameter measured.

Laboratory Determinations

The increment cores were processed to determine specific gravity on a green volume-ovendry basis, and the values averaged for each tree.

The specific gravity of the disks was determined by the method developed by Heinrichs (1954).

Computations

Average weighted tree specific gravity was determined by averaging the specific gravity of the disks at each end of a bolt, multiplying the average by the volume of the bolt in cubic feet, totaling the values, and dividing by the total merchantable volume of the tree.

Average specific gravity of the disks at 4-foot height, 8-foot height, etc., was determined for each 10-tree group and for the entire 100 trees.

Analysis of Data

All data were transferred to IBM cards. A regression analysis was made to establish the equations for predicting average tree specific gravity from the specific gravity of two increment cores at breast height. Wahlgren *et* al. (1966) developed equations for predicting tree specific gravity from increment cores in natural-grown red pine stands. Setting Y equal to average tree specific gravity, and X equal to specific gravity of 2 cores, the equations are:

Plantation-grown: $Y = 0.20564 + 0.35193\ X$
$R^2 = 0.4089$
$F = 27.78$ which is significant to the 1-percent level

Natural-Grown: $Y = 0.20517 + 0.43648\ X$
$R^2 = 0.3780$

Since Wahlgren *et* al. sampled several age classes in the natural-grown red pine, they were able to introduce diameter over age into another equation with significant improvement in the predicting equation; the R^2 was 0.6831. The plantation red pine being of one age, this variable of age could not be used.

Figure 1 shows the two equations on the same graph. While the lines are nearly parallel, indicating a similar relationship between X and Y variables, it is obvious that two distinct populations are involved. The plantation-grown red pine had a mean specific gravity of 0.322 while the natural-grown red pine had an average tree specific gravity of 0.391. The regression line for Wisconsin plantation-grown red pine, reported by Maeglin (1966), assumes a quite different slope, i.e., tree specific gravity increases more rapidly with increase in core specific gravity than in the Maine studies.

Further work is planned to sample successively older plantations in Maine (to about 50 years) to study the effect of age on the regression equation.

Within-Tree Specific Gravity Variation

Within-tree variation in specific gravity has been studied in many species of trees, principally mature, natural-grown trees. In Wahlgren *et al.* (1966) the generalized pattern of specific gravity of the cross-section was a decrease with increased height above the ground for red pine. Maeglin (1966) in his study of red pine plantations in Wisconsin concluded that, except for age differences, the data from plantation-grown red pine of Wisconsin appeared to agree with that of the natural-grown red pine of Maine (fig. 2).

A different pattern of specific gravity distribution vertically in the tree was found in the 25-year-old plantation in Maine. Several groupings of the data were made:

1. Data from all trees (100) were averaged and plotted. This graph (fig. 3) shows a distinct drop in specific gravity from the 4-foot to the 8-foot

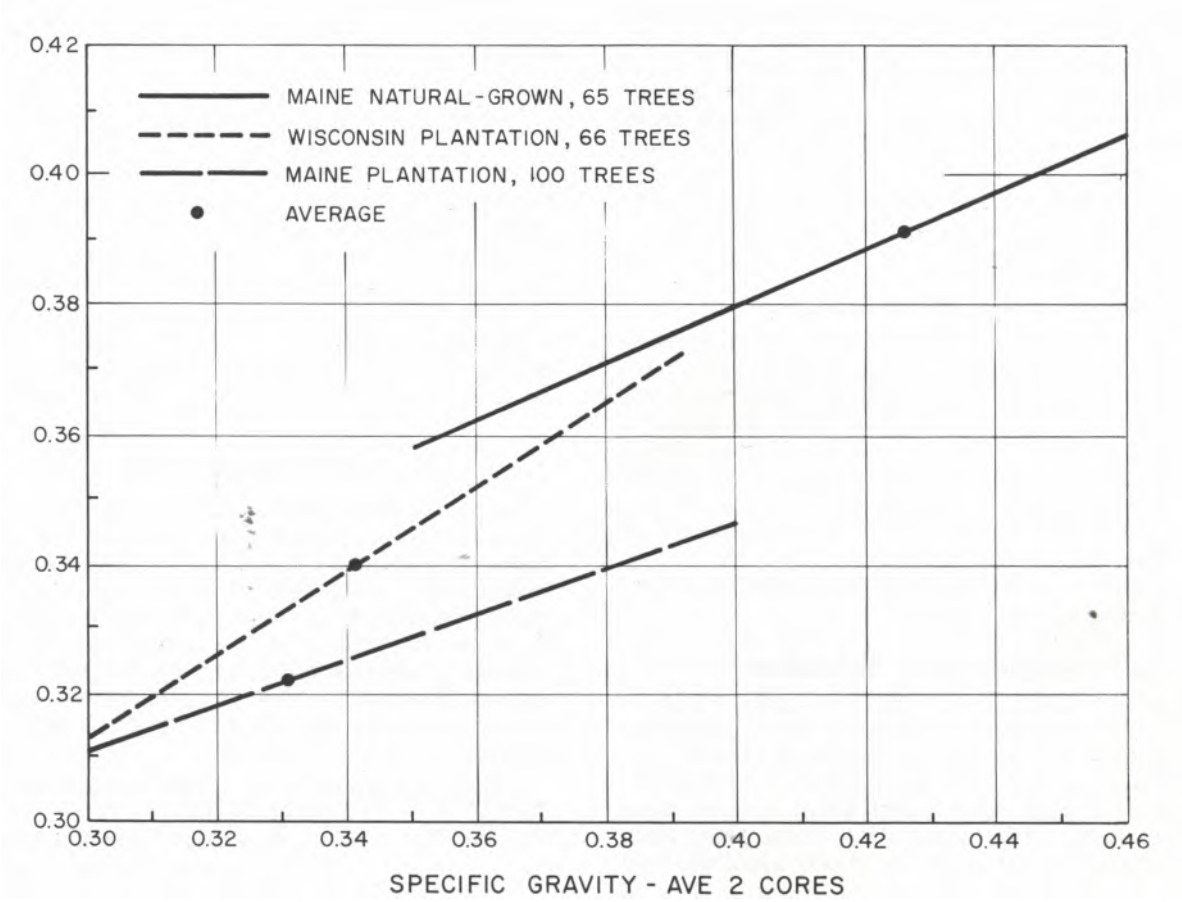

FIGURE 1. — Relationship of core specific gravity to tree specific gravity for red pine. Maine data for natural grown pine from Wahlgren *et al.* (1966) ; Wisconsin data from Maeglin (1966).

height and then a gradual but consistent increase in specific gravity upward in the tree.

2. Data were grouped by merchantable height classes so that at each level above the ground there were the same number of samples.

a. The data from the shortest merchantable height class (16.8 feet) when plotted show a consistent increase in specific gravity with increase in height.

b. The 21.0-foot and 25.2-foot classes show the same pattern as the all-tree graph.

c. The 29.4-foot class, which was represented by only 3 trees, shows a drop in specific gravity to the 8-foot and 12-foot level, followed by an increase in the 21-foot height and then a leveling off of specific gravity values to the 29.4-foot level.

3. Analysis by tree-spacing blocks of 10 trees each. Here, examination of the data for the two extremes of spacing, 2x2 feet and 10x10 feet, of the check blocks (no. 2 planting) gives the following comparisons:

Average —	*2-foot spacing*	*10-foot spacing*
Diameter (b.h.) inches	4.80	6.90
Total height, feet	34.00	30.00
Merchantable length, feet	20.20	18.50
Volume to 4-inch top, cu. ft.	1.83	2.97
Length of live crown, feet	15.50	22.20

In the 2-foot spacing there is a continuous drop in specific gravity from breast height to a 4-inch merchantable top. This pattern is similar to that found in natural-grown red pine in Maine (Wahl-

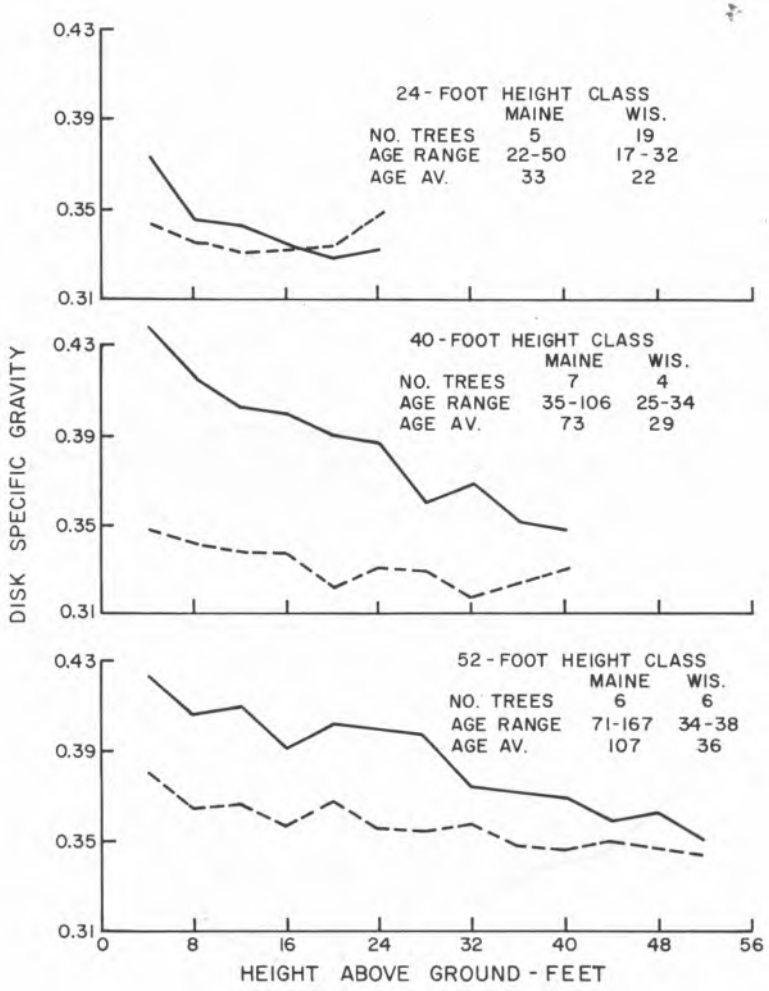

FIGURE 2. — Relationship of three height and age classes to disk specific gravity for red pine. Maine data on natural-grown red pine (solid line) from Wahlgren *et al.* (1966) ; Wisconsin data on plantation-grown red pine (broken line) from Maeglin (1966).

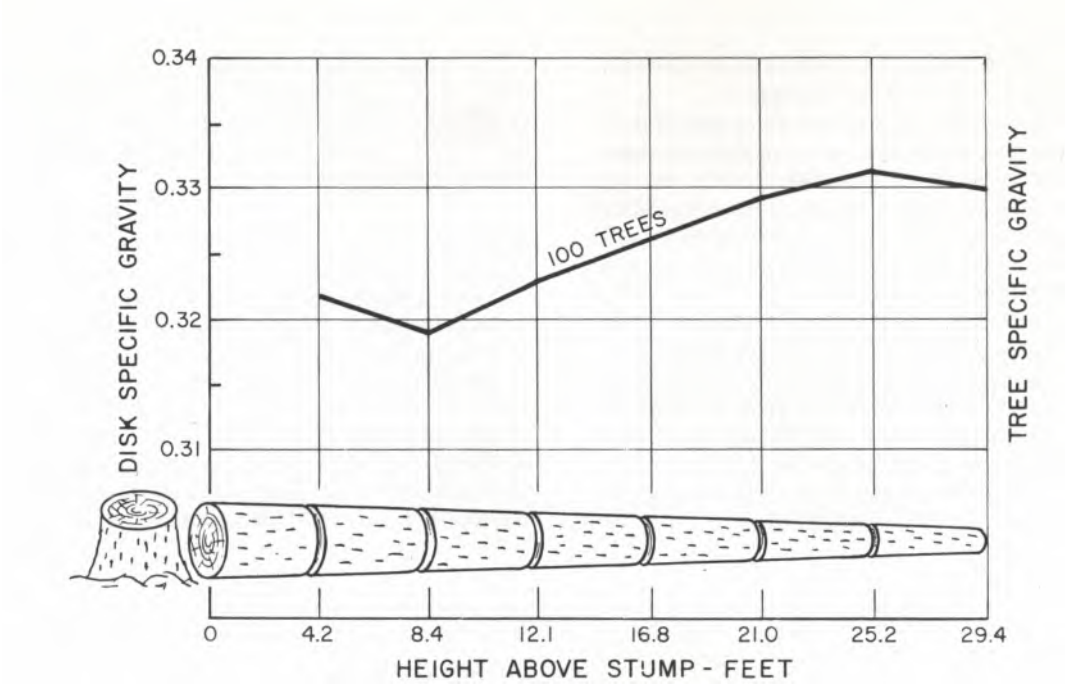

FIGURE 3. — Average specific gravity at various heights above stump for red pine.

gren *et al.* 1966), although the average values are lower (average tree specific gravity 0.325 vs. 0.391) (fig. 4). In the 10-foot spacing, however, the above pattern was reversed, i.e., specific gravity *increased* from breast height to merchantable top (average tree specific gravity 0.318).

Since the tree age is the same in the two areas, the cause for these differences would appear to be in the growth and form of the trees. The trees in the 2-foot spacing have a smaller average diameter, greater total height with consequently less taper to the trunk, and a live crown average length which is shorter by nearly 7 feet.

This leads us to the tentative conclusion: When comparing plantation-grown trees of the same age, those which have been grown under severe crowding (close spacing) will have the least taper and the smallest diameter. They will average higher

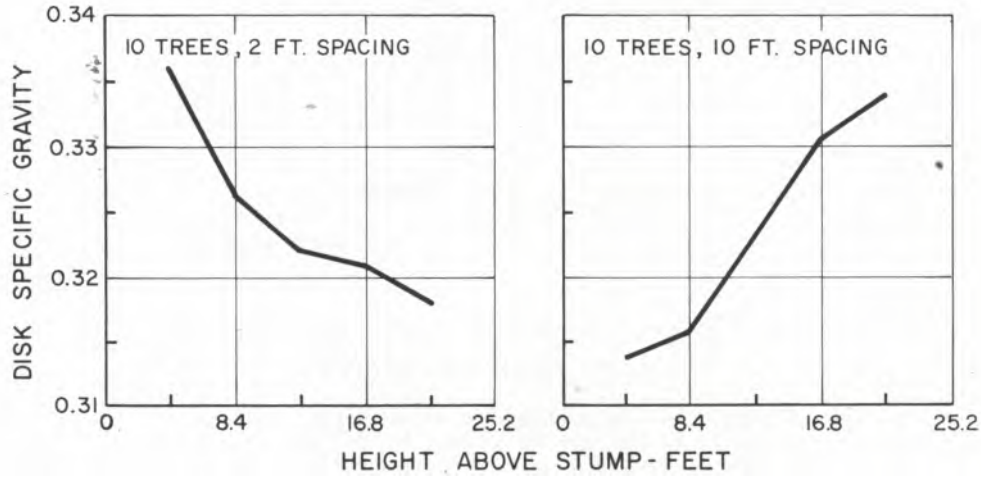

FIGURE 4. — Average disk specific gravity at various heights above stump for red pine.

in specific gravity, and the specific gravity will decrease with height above the ground. Conversely, trees grown at a wide spacing, with larger diameters, more rapid taper, and longer crowns, will average lower in specific gravity, and the specific gravity will increase with height above the ground.

Statistical analysis of the tree specific gravity data (Table 1) has indicated that in no case did a test block, or spacing group, differ significantly from its corresponding control block, unless treatment (thinning) had been involved. A linear trend toward significance was evident, with progressively wider spacings in the central area, until the 95-percent level was reached between the 2x2 and 10x10 blocks. The interaction between areas and blocks was far below any reasonable significance level, however, indicating a uniform response in both test and control areas to spacing changes.

The specific gravity of the trees in the 2x2 spacing that had been thinned to 4x4 was significantly higher than the 4x4 spacing that was thinned to 8x8. As noted above, this difference was not evident in the control blocks, nor was any difference between these blocks and the control blocks with original 4x4 and 8x8 spacing significant. A final comparison of all spacings 8x8 at the time of cutting (8x8 test, 8x8 test-thinned, and 8x8 control) did not indicate any significant differences in tree specific gravity. In all instances, the 95-percent level of significance was applied to the evaluation of the data.

Table 1. — Average tree specific gravity values for various spacings of plantation-grown red pine

Original spacing (ft.)	Area 1 (test)	Area 2 (control)
2x2	1/ 0.325	0.328
4x4	2/ .321	.328
6x6	.325	.324
8x8	.319	.321
10x10	.318	.318
Area average	.322	.323

1/ Thinned to 4x4 spacing.
2/ Thinned to 8x8 spacing.

Literature Cited

Heinrichs, J. Frank. 1954. Rapid specific gravity determinations. J. Forest Prod. Res. Soc. 4 (1) : 68.

Maeglin, Robert R. 1966. Predicting specific gravity of plantation-grown red pine. U.S. Forest Serv. Res. Note FPL-0149. Forest Prod. Lab., Madison, Wis.

Wahlgren, Harold E.; Arthur C. Hart; and Robert R. Maeglin. 1966. Estimating tree specific gravity of Maine conifers. U.S. Forest Serv. Res. Pap. FPL-61. Forest Prod. Lab., Madison, Wis.