NORTH CENTRAL FOREST EXPERIMENT STATION
Research Note NC-246
1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.
1979

SPACING AFFECTS KNOT SURFACE IN RED PINE PLANTATIONS

Paul R. Laidly, *Forest Mensurationist,*
and **Robert G. Barse,** *Forestry Technician,*
Grand Rapids, Minnesota

ABSTRACT.— Quantifies the effect of spacing on branch diameter, number of branches, and knot surface in a red pine plantation.

OXFORD: 245.1:232.43:174.7 *Pinus resinosa.*
KEY WORDS: *Pinus resinosa,* knot surface, poles, piling, branch diameter.

The spatial distribution of trees influences not only main stem diameter growth but also the growth of branches. Wide spacing in plantations results in greater diameter growth at breast height (4.5 feet) than close spacing but the large branches associated with wide spacing reduces tree quality. Close spacing results in smaller branches, but more of the branches die due to shading and produce loose knots. The purpose of this note is to quantify the effect of spacing on number of branches and branch diameter, both of which influence one tree quality characteristic — knot surface.

METHODS

The study area, located in Burnett County in northwestern Wisconsin, was planted in the spring of 1958 with 2-1 red pine (*Pinus resinosa Ait.*) nursery stock on soil described as Plainfield sand.[1] Seedlings were planted at spacings of 5- by 5-, 7- by 7-, 9- by 9-, and 11- by 11-feet. Site index is estimated at 70 feet. Mean height of dominant and codominant trees is 32 feet, and mean stand diameters for the four spacings are 4.3, 5.5, 6.5, and 7.3 inches, respectively. Total tree age is 23 years.

Six trees from each of the four spacings were sampled. Only dominant or codominant trees were selected because they represent potential crop trees. Diameter of all branches greater than 0.10 inch was measured in each whorl up to and including the third whorl below the terminal bud. Measurements were made 1.0 inch from the tree bole.

RESULTS

Branch Diameters

The 5- by 5- and 11- by 11-foot spacings are significantly[2] different in mean branch diameter from each other and the other spacings. Comparisons between the 7- by 7- and 9- by 9-foot spacings

[1]Study maintained in cooperation with Burnett County and Wisconsin Department of Natural Resources.

[2]All statistical tests of significance were made at the 5 percent level.

showed barely nonsignificant differences, and except for one or two whorls, the 9- by 9-foot spacing consistently had larger diameter branches than the 7- by 7-foot spacing (table 1).

Branch diameter increased with height above ground to 3 feet for the 5 by 5 spacing and to 8 feet for the 11 by 11 spacing and remained constant to 17 feet for the 11 by 11 spacing and 24 feet for the 5 by 5 spacing. The other spacings were intermediate between these. Stiell (1964) observed this same relation. Wambach (1967) hypothesized this relation as total tree height increases faster than height to live crown at young ages. Thus, up to a certain age, each successive whorl lives slightly longer than the whorl below it. For this study, these ages are 5, 6, 7, and 8 years from planting for the 5- by 5-, 7- by 7-, 9- by 9-, and 11- by 11-foot spacings, rspectively.

The top whorl measured in this study was 3 years old. Within the last 5-year history of this stand, branch diameter growth decreased markedly for branches 4 years old regardless of spacing. Branch diameter growth virtually ceases at branch ages 5 to 7 years, progressing from the 5- by 5- to 11- by 11-foot spacings. Therefore, branch size in plantations 15 to 20 years old may be a good indication of branch size for red pine until the first thinning.

Number of Branches

Number of branches per whorl did not differ significantly between the four spacings (table 1). Similar results were observed by Stiell (1964) and Wambach (1967). Whorls above 3 feet averaged 6 branches per whorl (due to natural pruning, fewer branches remained below 3 feet). The number of branches was uniform from whorl to whorl — probability of having < 5 or > 7 branches is 0.07 and 0.14, respectively, and probability of having < 4 or > 8 is only < 0.03.

Knot Surface

Knot surface is defined as the sum of branch diameters and is a recognized standard of unsuitability for poles and piling. Eight inches of knot surface in any linear foot for branches greater than 0.49 inch is a common upper limit for product acceptance (Panshin *et al.* 1950). Trees in the 9- by 9- and 11- by 11-foot spacings either have exceeded or are rapidly approaching this 8-inch knot surface limit (table 1). This is particularly critical in the live crown because these branches will continue to grow after the first thinning.

The trees in this study have not attained the minimum top diameter and length for building poles, utility poles, natural taper piling, or standard piling. Currently, thinnings would yield

Table 1.— *Characteristics of dominant trees in a 20-year-old red pine plantation*[1]
(Site Index 70)

Characteristic	Spacing (feet) 5	7	9	11
Total height(ft.)	32	32	32	32
Height to live crown(ft.)	15	15	13	9
Live branches/tree(No.)	48	48	54	66
Dia. live branches 9 ft. to 17 ft.(in.)	.72	1.01	1.01	1.09
Live branches > 4 years old(No.)	24	24	30	42
Dia. live branches > 4 years old(in.)	.73	.93	1.01	1.07
Dead branches/tree(No.)	60	60	54	42
Dia. dead branches above 8 ft.(in.)	.73	.91	.93	1.13
Dia. dead branches below 8 ft.(in.)	.66	.76	.81	.86
Knot surface[2] below 17 ft.				
Mean(in.)	3.8	4.9	5.6	6.0
Maximum(in.)	6.5	8.1	9.2	10.6

[1]2-1 trees planted; total tree age is 23 years.
[2]Measured 1 inch from bole.

pulpwood and posts, and knot surface is not a recognized standard of unsuitability for these products. Thinnings in 10 years will yield building poles, in 20 years will yield small utility poles plus a few natural taper piling, and in 30 years will yield some standard piling.

DISCUSSION

It is evident from this study, and implied by Stiell (1964) and Wambach (1967), that even at close spacings red pine retain most dead branches up to 20 years. Arend (1955) noted persistent dead branches to the ground in closely spaced red pine after 40 years. Thus, to produce an abundance of clear wood on rotations less than 100 years, pruning will be necessary regardless of spacing.

One advantage of wide spacing is to shorten the time to the first commercial thinning. However, this will necessitate pruning before the first thinning to minimize the size of the stem's "knotty" core and increase tree quality by allowing knots to be overgrown with strong clear wood. Crop trees in the 9- by 9-foot and wider spacings should be pruned before the first thinning, whereas pruning of crop trees in spacings closer than 9 by 9 feet could be delayed until the first thinning.

In the absence of pruning, plantation spacings 11 by 11 feet and wider would sharply curtail or eliminate the production of poles and piling.

LITERATURE CITED

Arend, J. L. 1955. Development of closely spaced red pine, white pine, and Norway spruce after 40 years. U.S. Dep. Agric. For. Serv., Tech. Note 439, 1 p. U.S. Dep. Agric. For. Serv., Lake States For. Exp. Stn., St. Paul, Minnesota.

Panshin, A. J., E. S. Harrar, W. J. Baker, and P. B. Proctor. 1950. Forest products: their sources, production, and utilization. 549 p. McGraw-Hill Book Co., Inc., New York.

Stiell, W. M. 1964. Twenty-year growth of red pine planted at three spacings. Can. Dep. For., Publ. 1045, 24 p.

Wambach, Robert F. 1967. A silvicultural and economic appraisal of initial spacing in red pine. 282 p. Ph.D. Thesis, Univ. Minnesota.

☆U.S. GOVERNMENT PRINTING OFFICE: 1979--667127/331