Effect of Competition on Wood Relative Density Development in Red Pine (*Pinus resinosa* Ait.) Stands

G.R.Larocque *Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, P.O. Box 3800, 1055 du P.E.P.S., Sainte-Foy (Québec) Canada G1V 4C7*

ABSTRACT

Forest management is becoming more and more intensified in North America in order to increase sawlog production in the shortest possible time. The most applied silvicultural treatment consists in thinning stands to increase the growth rate of residual trees. While much information has been gathered on the effects of thinning treatments on individual tree growth, much less work has been undertaken to examine the effectson wood quality. Thus, there is a need to look more closely at the relationship between stand dynamics and wood formation. The present study examined how differentlevels of competitive stress affectwood relative density of red pine (*Pinus resinosa* Ait.) for different ages. As the stands grew older, ring relative density and earlywood and latewood relative densities increased and the proportion of earlywood decreased. However, these changes, which were closely related to crown development, occurred more and more slowly with a decrease in the intensity of competition.

INTRODUCTION

Forest management practices are evolving rapidly in North America to respond to the environmental concerns expressed by the public and to increase the amount of wood that can be harvested per unit area. Stand thinning and the control of initial stand density at the time of planting, which may result in increasing substantially the growth of individual trees, are the most applied silvicultural treatments to augment sawlog production. Much information has been collected on the effect of thinning treatments on individual tree growth for many species growing on sites of various fertility levels. However, the effect of such treatments on wood quality has not been fully investigated, particularly with regard to the quality of the fiber, as a decrease in wood density and fiber length may occur (Senft *et al.* 1985). Furthermore, the establishment of plantations with large initial spacings, which can be favored to reduce the number of thinning treatments, can result in different proportions of earlywood and latewood and of juvenile and mature wood (Brazier 1977). Thus, there is a need to examine more closely to what extent stand dynamics and wood formation are linked. The objective of the present paper is to discuss management implications of the effect of competitive stress on wood relative density based upon a study conducted in red pine (*Pinus resinosa* Ait.) stands by Larocque and Marshall (1995).

MATERIALS AND METHODS

The stands under study originated from a spacing trial established in 1953 at the Petawawa National Forestry Institute, Chalk River, Ontario (Stiell and Berry 1977). Square spacings varied between 1.2 and 6.0 m. Detailed measurements of total height, dbh (diameter at breast height), crown dimensions, and stump and upper stem diameters were undertaken every year from ages 13 to 24, every two years from ages 24 to 30, and at age 33. Increment cores were sampled at breast height on 30 trees within each spacing, the selection of which was based on stratified random sampling in order to have adequate representation of variation in tree size. Relative density was measured on a direct reading X-ray densitometer located at the Western Laboratory of Forintek Canada Corp. in Vancouver, British Columbia. More information on the procedures can be found in Larocque and Marshall (1995).

RESULTS AND DISCUSSION

The trees growing in the different initial spacings showed the long-term pattern that is usually observed under quite different intensities of competitive stress (Figure 1). Average dbh for all spacings was very close at early ages, but differences among initial spacings accentuated as the stands grew older. By age 33,

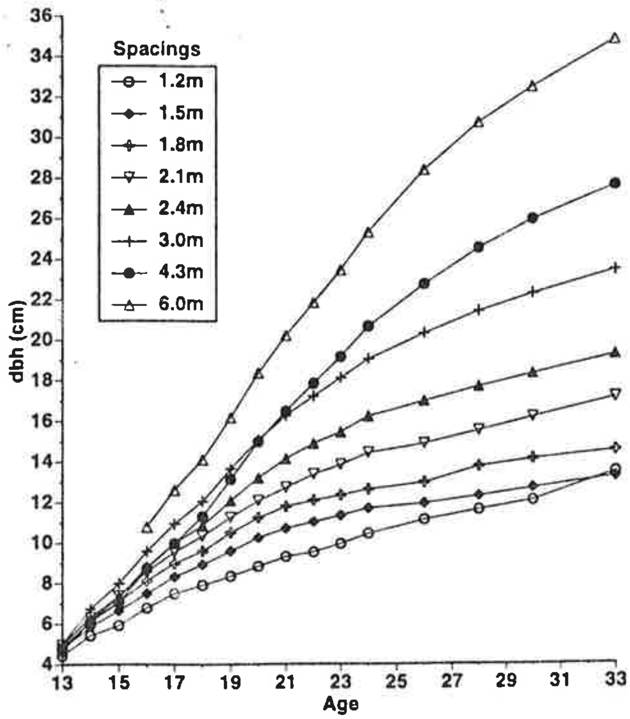

FIGURE 1. Mean cumulative dbh for all initial spacings. (Adapted from Larocque and Marshall 1993)

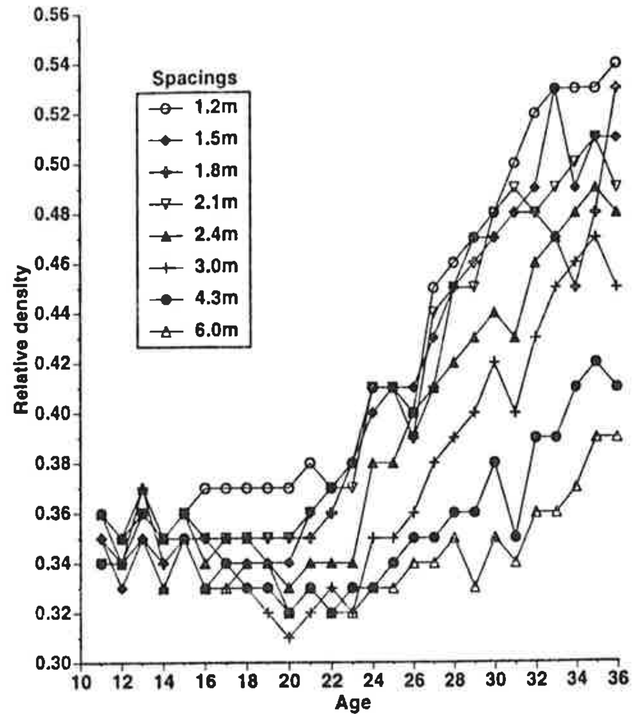

FIGURE 2. Mean relative densities of rings for all initial spacings. (Adapted from Larocque and Marshall 1995).

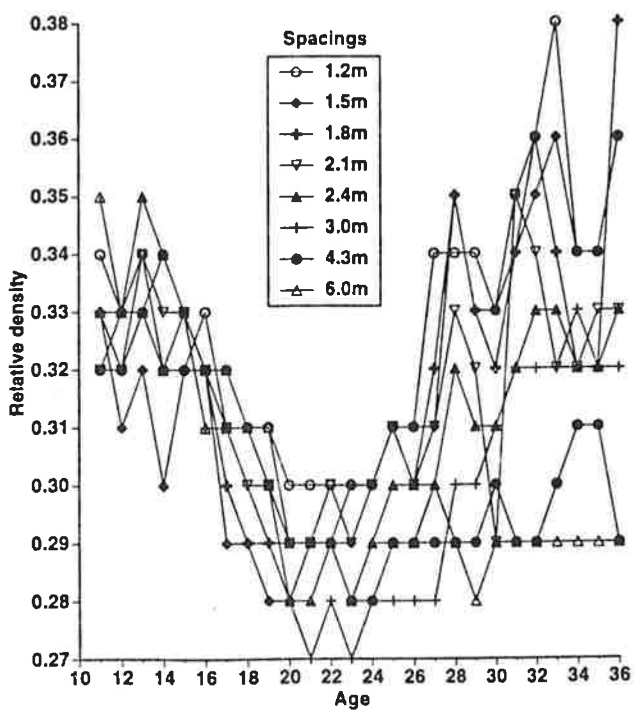

FIGURE 3. Mean relative densities of earlywood zones for all initial spacings. (Adapted from Larocque and Marshall 1995).

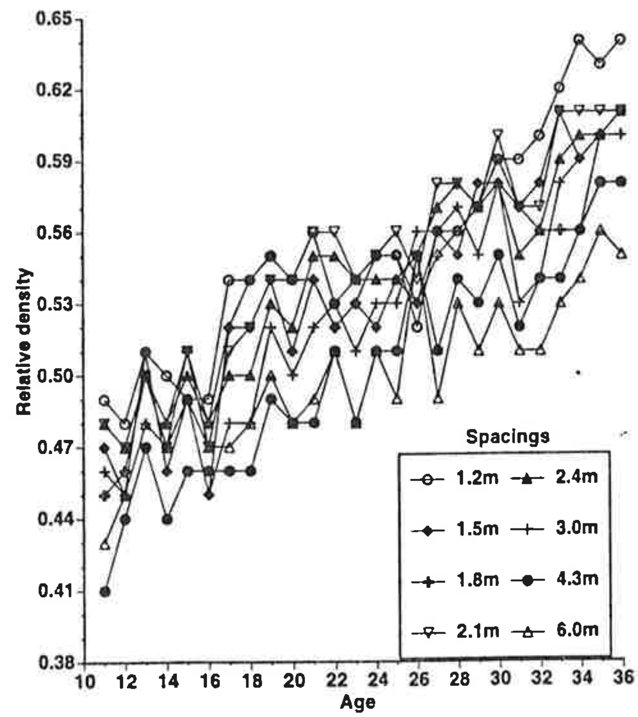

FIGURE 4. Mean relative densities of latewood zones for all initial spacings. (Adapted from Larocque and Marshall 1995).

average dbh of trees in the 6.0 m spacing was three times greater than that of trees in the 1.2 m spacing.

Wood relative density also varied considerably under different levels of competitive stress (Figure 2). However, contrary to dbh growth, ring relative density increased with a decrease in initial spacing. While average relative density was very close for all spacings at early ages, differences among spacings increased gradually. The closer the spacing, the faster relative density increased. When considered separately, earlywood and latewood zones were characterized by different patterns. For earlywood relative density, the general trend was an increase with a reduction in spacing (Figure 3). It first decreased until ages 18 to 23, remained approximately the same for about three to five years, and increased thereafter. Compared with ring relative density, however, it did not increase appreciably with age. Relative density of latewood zones increased sharply with age for all spacings and with a reduction in initial spacing (Figure 4). Differences among spacings were more pronounced than those obtained for earlywood. Changes in the proportion of earlywood were also quite drastic, particularly in the closest spacings (Figure 5). As the intensity of competitive stress increased, the earlier and faster the proportion of earlywood decreased.

These results indicate that the selection of initial stand density has a strong influence on wood development of red pine trees. They even suggest a strong negative relationship between growth rate and wood density of individual rings, which is a controversial subject (e.g., Petty *et al.* 1990, Barbour *et al.* 1992, Johansson 1993, DeBell *et al.* 1994). However, such a relationship is not supported strongly by this study (Table 1): the majority of the regression equations derived between ring width and ring relative density explained less than 50% of the variation in ring relative density. In fact, the present study rather provides strong evidence on the critical effect of crown development, particularly crown recession, on wood formation. This can be seen in Figure 6, which illustrates, for two trees representing small and large trees for quite different levels of competitive stress, how changes in ring relative density, latewood relative density, and proportion of earlywood were closely related to crown development. The closer the spacing, the faster crowns receded, ring and latewood relative densities increased, and proportion of earlywood decreased. Earlywood relative density did not vary substantially.

The parallel course between changes in relative densities and proportion of earlywood and crown development, as illustrated in Figure 6, highlights the importance of the physiological processes occurring in the foliage on wood formation. Wood formation consists of the radial accumulation of cells that originate from the cambium whose activity is controlled by crown development which, in turn, is influenced by biotic and abiotic factors. Crown dimensions, foliage distribution, needle age, efficiency of leaves and of branches, shoot elongation rate, and buds and apical meristem activities are all factors that affect wood formation (Larson 1962, 1964, 1967, 1969). Crown dimensions and the efficiency of branches are closely related. However, branches do not all have the same effect. According to Larson (1969), the most influential branches are those located in the top one-third of the crown. Also, the faster crowns recede, the closer to the pith the formation of mature wood takes place (Larson 1969).

Table 1. Linear regression equations between ring relative density and ring width

Age	Intercept	Slope	r^2
11	0.39896	-0.00671	0.29
12	0.39709	-0.00704	0.29
13	0.39559	-0.00539	0.10
14	0.35612	-0.00201n	0.01
15	0.36801	-0.00244	0.04
16	0.37384	-0.00566	0.18
17	0.36998	-0.00437	0.18
18	0.36980	-0.00546	0.15
19	0.35931	-0.00306	0.09
20	0.36841	-0.00650	0.30
21	0.38422	-0.00908	0.36
22	0.38137	-0.00966	0.37
23	0.39113	-0.01272	0.38
24	0.41953	-0.01328	0.48
25	0.42372	-0.01737	0.52
26	0.40977	-0.01423	0.34
27	0.45254	-0.02449	0.51
28	0.46994	-0.02875	0.51
29	0.48774	-0.04135	0.58
30	0.50666	-0.04541	0.56
31	0.52355	-0.05642	0.66
32	0.52173	-0.05684	0.53
33	0.52878	-0.05911	0.47
34	0.52012	-0.05077	0.37
35	0.52006	-0.04100	0.33
36	0.52978	-0.04936	0.40

n: Not significant at the level of probability of 0.05.

Can the forester realistically influence the quality of the wood by regulating crown development? Three means are available to control crown development: (1) selection of initial spacing, (2) thinning, and (3) pruning. The results of this study clearly indicate that

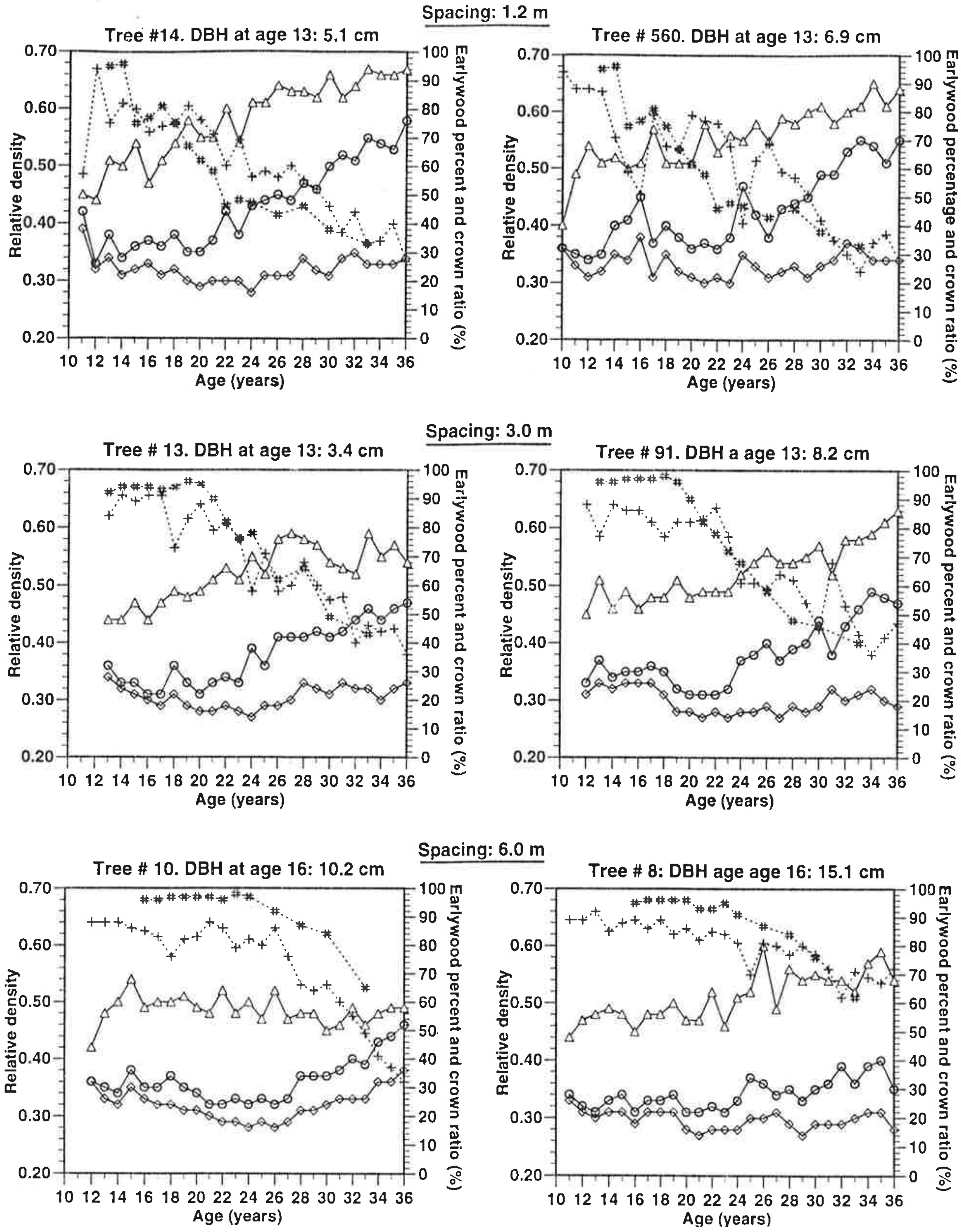

FIGURE 6. Relative density values and proportion of earlywood for trees originating from different spacings superimposed with crown ratio. (O : ring relative density; ◇ : earlywood relative density; △ : latewood relative density; + : percentage of earlywood; # : crown ratio). (Adapted from Larocque and Marshall 1995).

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