CANADA

Department of Forestry

FOREST RESEARCH BRANCH

MORE ABOUT THE "CROWN COMPETITION FACTOR"

(Project Q-82)

by

P.E. Vézina

Quebec District
October 1962

Que. 62-11

MORE ABOUT THE "CROWN COMPETITION FACTOR"

P.E. Vézina[1/]

ABSTRACT

A regression analysis that shows the relationship between crown width and tree diameter is presented for jack pine in Quebec. By use of an equation developed by the method of least squares, "Maximum Crown Area" in square feet can be estimated from tree diameter. The relationship between maximum crown area and tree diameter is used as a basis for computing the "Crown Competition Factor" value of a stand. The CCF value on an acreage basis can be determined by accumulating the MCA values of the individual trees comprising the stand.

INTRODUCTION

The Crown Competition Factor (CCF), an expression of stand density which was developed by Krajicek, Brinkman, and Gingrich (1961), is useful to foresters who are concerned with the study of the comparative value of different parameters of stand density, the establishment of relationships between density and growth, or the development of new thinning and release cutting schedules. In order to apply the new measure of density, equations for estimating crown width of open-grown trees need to be developed. Such equations were given by Krajicek *et al.* (1961) for hickory (*Carya ovata* (Mill.) K. Koch), oak (*Quercus alba* L., *Q. velutina* Lam., *Q. rubra* L.), and Norway spruce (*Picea abies* (L.) Karst.), and by Vézina (1962) for balsam fir (*Abies balsamea* (L.) Mill.) and white spruce (*Picea glauca* (Moench) Voss) trees that had developed without competition throughout their life.

This paper is concerned with the relation of crown width to d.b.h. for open-grown jack pine (*Pinus banksiana* Lamb.) as a prerequisite for applying CCF to jack pine stands.

1/ Research Officer, Forest Research Branch, Department of Forestry, Quebec, P.Q. Canada.

METHODS

The equation developed for estimating crown width of jack pine is based on data collected in the Portneuf watershed, which is located some ten miles west of Forestville, in the Saguenay county, Quebec. This equation was derived by the method of least squares. Crown width was determined to the nearest half-foot from measurements made in two opposite directions at the base of the crown. Similarly, diameter (o.b.) at breast height was taken as the mean of two measurements at right angle on the tree. Other specifications were similar to those used by Vézina (1962).

RELATIONSHIP OF CROWN WIDTH TO TREE DIAMETER

To determine whether the variations in crown widths among the 83 trees bore any relation to tree size, a linear regression analysis was made. Average crown width was used as the dependent (y) variable and diameter breast high as the independent (x) variable. The relation proved to be highly significant ($r = 0.960$), showing that larger trees tend to have larger crowns. The equation for estimating crown width from tree diameter is:

$$(1) \quad CW = 2.036D + 1.763$$

Throughout the range of the sample data, a 1-percent increase in tree diameter is accompagnied by a 2.04-percent increase in crown width. The standard error of estimate for this equation is 1.949 feet. CW, crown width, is measured in feet and D, diameter in inches.

Figure 1 shows the relation between crown width and tree diameter. The two 95-percent confidence bands indicate the limits of the range of population crown width and individual tree crown width for any given tree diameter.

(FIGURE 1 HERE)

The relation between crown width and tree diameter applies most specifically to open-grown jack pine growing on poor sandy, fluvio-glacial soil

in the Boreal forest region (Rowe 1959). Because variable environmental conditions affect tree development differently, another relation may hold for trees growing in a different climate.

Significance of differences in the correlation coefficient (r), the regression coefficient (b_{yx}), and the height (k_{yx}) of the sample regression was tested for white spruce and jack pine, and for balsam fir and jack pine (see Vézina 1962). The regression coefficients and the heights of the sample regressions were in both cases significant at the one per cent level. The differences in the correlation coefficients for the two sets of data, however, were not significant.

ESTIMATING CCF OF A JACK PINE STAND

From the regression analysis of the jack pine data (Fig. 1), the maximum area that could be occupied by the crown of a jack pine tree of specified d.b.h. can be determined as follows:

$$MCA = \frac{\frac{\pi}{4}(CW)^2}{435.60} = 0.0018\,(CW)^2$$

where MCA = "Maximum crown area" value of a jack pine with a crown diameter of CW.

$$(1) \quad CW = 2.036D + 1.763$$

and

$$(CW)^2 = 4.145\,D^2 + 7.178\,D + 3.108$$

then

$$MCA = 0.0075D^2 + 0.0129D + 0.0056$$

CCF value for a jack pine stand can be estimated from a stand table by accumulating the MCA values of the trees comprising the stand as determined from Equation 1.

The formula of CCF values for jack pine stands is therefore:

$$CCF = \frac{1}{A}\left[0.0075(\Sigma D_i^2 N_i) + 0.0129(\Sigma D_i N_i) + 0.0056(\Sigma N_i)\right]$$

where

D_i = Individual d.b.h. or d.b.h. class;

N_i = Number of trees in d.b.h. class;

A = Area in acres.

RELATION OF CCF TO AGE OF STAND

Spurr (1952) and Bickford et al. (1957) suggested that the ideal measure of density should be largely unrelated to the character and age of the stand and the quality of the site. To test how CCF would perform in this respect, 41 study plots established in 20- to 70-year-old even-aged stands of jack pine growing on poor sandy soils in Quebec were analyzed. The plots had been established from 1950 to 1955, and represented a wide range of stocking --- 50 to 130 square feet of basal area. Possible dependence on age of CCF was investigated by means of a scatter diagram (Fig. 2). CCF was plotted over each age and the trend of mean CCF values observed.

(FIGURE 2 HERE)

A change in the CCF values as a function of age was noted. The CCF values for jack pine stands had the tendency to approach an average CCF of 150 to 160 as age increased. Within the lower age classes, however, there was a wide spread of CCF values. This was reflected in the canopy density measurements made by the "moosehorn", which varied within the wide limits of 35 and 85 per cent. Owing to the very small range in the site indices, the relation of CCF to site index could not be analyzed.

In general, CCF did not appear to be related to age, but this would be confirmed by similar tests if ages were still more advanced.

CONCLUSION

The objective of the study was to explore the relationship of crown width to tree diameter for open-grown jack pine. The determination of this relation allows to apply the Crown Competition Factor to the measurement of density in stands of this species. According to the equation developed, crown width will increase 2.04 feet with each increase of one inch in d.b.h. This relation is significantly different from those found previously for balsam fir and white spruce. Open-grown jack pine have wider crowns than either fir or

spruce at any given diameter. Hence, the minimum number of open-grown jack pine of specified d.b.h. on an acre that could produce a full crown closure will be less than that of fir or spruce. It is worthwhile to note that, because of its wider crown, jack pine stands with good stocking also produce less trees per acre than do stands of either fir or spruce of the same average diameter or the same age and site index, as measured by height and age (Kabzems and Kirby 1956, Kirby 1962). This is, to a considerable extent, a reflection of differences in tolerance.

REFERENCES

Bickford, C.A., et al. 1957. Stocking, normality, and measurements of stand density. J. For. 55: 99-104.

Kabzems, A., and C.L. Kirby. 1956. The growth and yield of jack pine in Saskatchewan. Saskatchewan Dept. of Natural Resources, Forestry Branch, Tech. Bull. No. 2. 66 pp.

Kirby, C.L. 1962. The growth and yield of white spruce-aspen stands in Saskatchewan. Saskatchewan Dept. of Natural Resources, Forestry Branch, Tech. Bull. No. 4. 58 pp.

Krajicek, J.E., K.A. Brinkman, and S.F. Gingrich. 1961. Crown competition -- A measure of density. For. Sci. 7: 35-42.

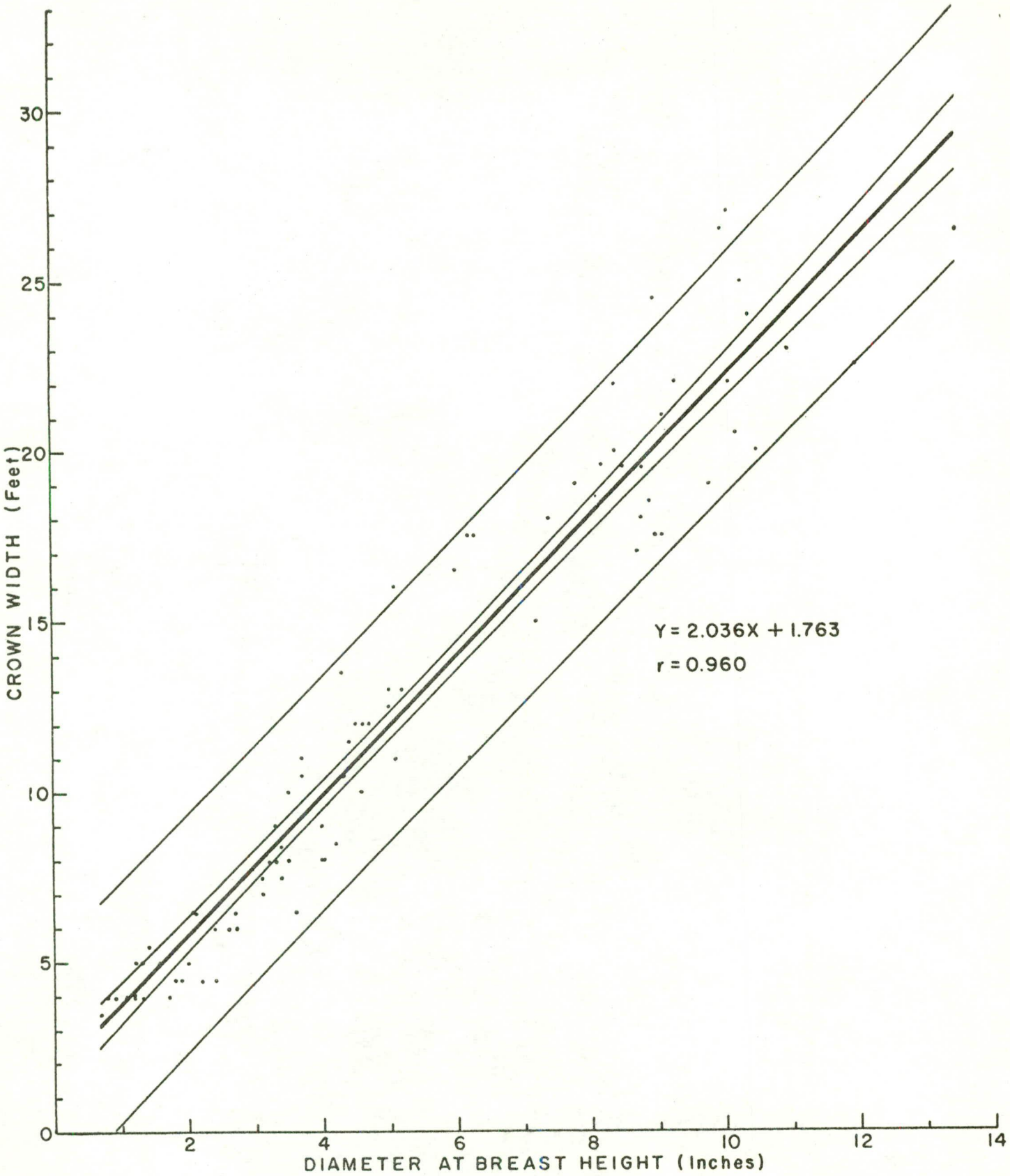
Rowe, J.S. 1959. Forest regions of Canada. Canada, Dept. North. Aff. and Nat. Res., Bull. No. 123.

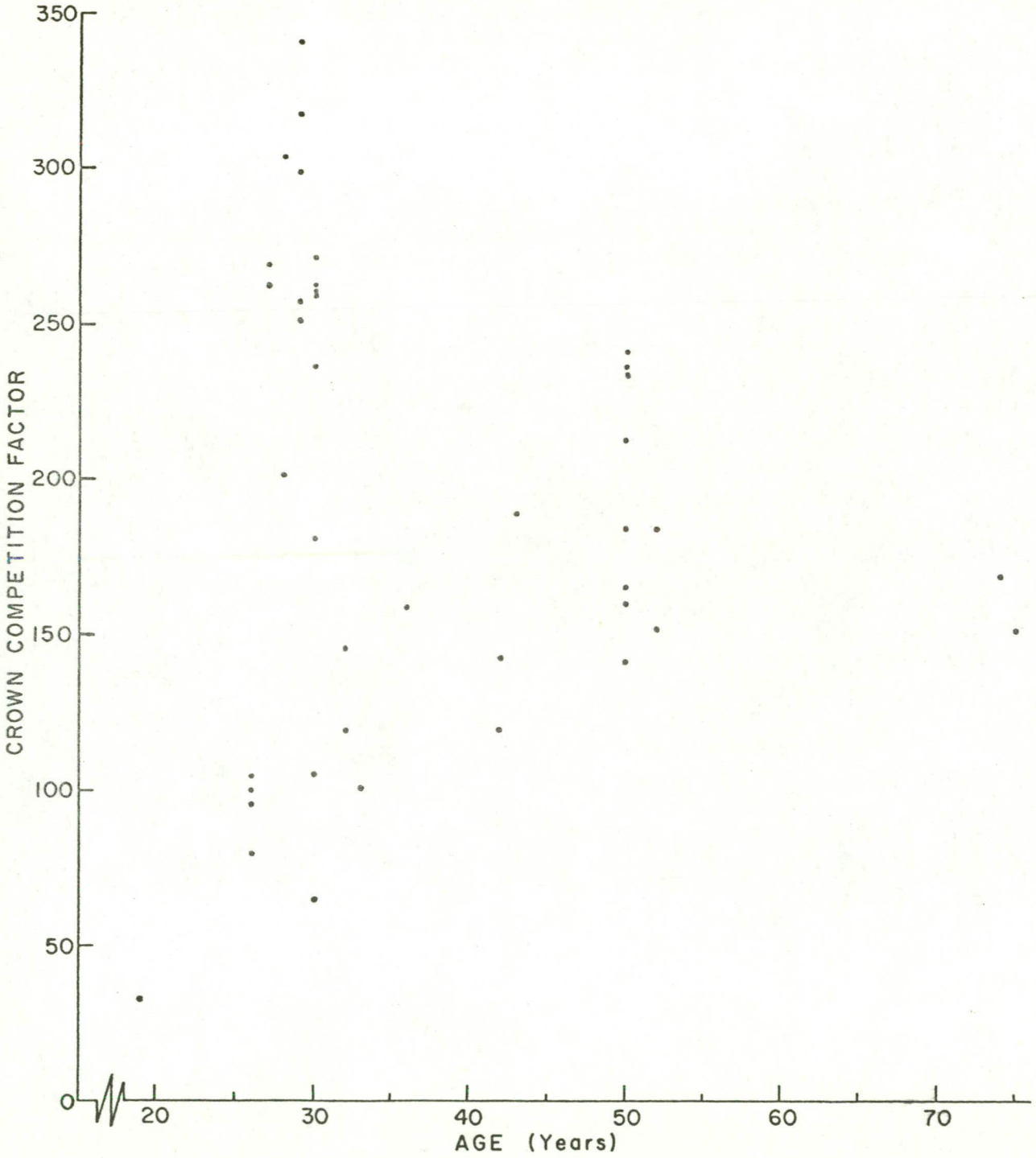
Spurr, S.H. 1952. Forest inventory. Ronald Press, New York.

Vézina, P.E. 1962. Crown width-d.b.h. relationships for open-grown balsam fir and white spruce in Quebec. For. Chron. 38 (In press).

Figure 1. Regression of crown width on d.b.h., and 95-per cent confidence bands for crown width of population (narrow band) and of individual tree (wide band) of given d.b.h.

Figure 2. Scatter diagram relating CCF to age of jack pine stands.


CROWN WIDTH (Feet)
30
25
20
15
10
5
0
2
4
6
8
10
12
14
DIAMETER AT BREAST HEIGHT (Inches)
Y = 2.036X + 1.763
r = 0.960


CROWN COMPETITION FACTOR
350
300
250
200
150
100
50
0
20
30
40
50
60
70
AGE (Years)