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CROWN SIZE AND STEM DIAMETER IN RED SPRUCE AND BALSAM FIR

by

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ABSTRACT

Some relationships between crown size and stem diameter at breast height having application in silviculture, aerial inventories of forest resources and fire protection, were determined from 48 red spruce and 80 balsam fir growing together in the same stands. For trees of the same d.b.h., spruce crowns vary less in width and average slightly wider than fir crowns, lengths are similar for both species, but spruce crowns are much heavier. All relationships examined were highly significant for both species but the strongest correlation was between d.b.h. and crown weight.

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Crown Size and Stem Diameter in Red Spruce and Balsam Fir[1]

by
B. C. Wile[2]

INTRODUCTION

In silviculture an understanding of the relationship in a tree between crown size and stem size is, among other things (Kittredge 1944), useful in estimating volume from aerial photographs and amount of slash after cutting.

The study reported here was undertaken at the Acadia Forest Experiment Station in south-central New Brunswick, for the purpose of defining the relationships between stem diameter at breast height and crown width, crown length and crown weight, for red spruce, *Picea rubens* Sarg., and balsam fir, *Abies balsamea* (L.) Mill.

METHODS

The trees selected for the study were located in 60-year-old stands of predominately spruce and fir. The soil was a fresh, well drained sandy loam: the site index was 50[3]. Basal area of all species and site classes combined averaged 125 square feet per acre.

Stem diameter at 4.5 feet, and crown width, length, and weight were measured on 48 spruce and 80 fir. Trees ranged in crown class from suppressed to dominant and in age from 40 to 65 years, but most were in the 50 to 60 year group. Crown width or diameter was determined by averaging two measurements taken at right angles. Crown length was measured to the lowest live branch. To weigh the crowns, the trees were felled, and green foliage and supporting twigs up to $\frac{1}{4}$-inch in diameter were collected on a tarpaulin and weighed in the field to the nearest $\frac{1}{4}$-pound. (The combined weight of green foliage and twigs is referred to as crown weight in this paper.) Additional data on stem diameter and height were collected from neighbouring trees.

Tree height and all measurements of crown were related to stem d.b.h. Curves of height over diameter were fitted by Dwight's (1937) method. The relations, between d.b.h. and crown width and length, are straight line functions. Those between d.b.h. and crown weight can be transformed to straight lines by expressing both variables as logarithms. Equations were derived and significance tested as in linear regression.

RESULTS AND DISCUSSION

Crown Width

In common with other species (Spurr 1948, Minor 1951), spruce and fir have a positive linear relationship between crown width and stem diameter (Table 1).

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3 Based on the total height in feet of dominant spruce and fir at a breast high age of 50 years.

Crowns of spruce average about 1.5 feet wider than those of fir, for trees of the same diameter. But there is more variation in the width of fir crowns, apparently depending largely on the available growing space, and this results in poorer correlation with stem diameter. Consequently, estimates of stem diameter and volume (Nash 1948) depending on measurements of crown width, such as those made from aerial photographs, should be more accurate for spruce than for fir. When crown width (Wd) is measured the equations for estimating d.b.h. (D) are,

(*a*) red spruce $D = 0.572\ Wd + 1.611$

(*b*) balsam fir $D = 0.458\ Wd + 2.579$

Formulae for the relation of crown width to stem diameter, when d.b.h. is measured, (Table 1) may be simplified to "rules-of-thumb". These are D+2 for spruce, and D+0.5 for fir. That is the crown width in feet is approximately equal to the stem d.b.h. in inches plus a constant depending on the species. Thus in the stands examined a 6-inch spruce uses about 8 feet of growing space and a 6-inch fir about 6.5 feet.

Crown Length

Crown length is very similar for spruce and fir of the same stem diameter (Table 1). Crown length increases from 56 per cent of tree height for 3-inch trees to 77 and 79 per cent for 10-inch trees. Length of clear bole, that is tree height minus crown length, is greatest for 7-inch spruce (15.5 feet) and 6-inch fir (17.6 feet), and decreases to about 11 feet for 10-inch trees. For a butt log, 16 feet long, clear of limbs, artificial pruning would be necessary for most trees in these stands.

Crown length is more strongly related than crown width to stem diameter (Table 1).

Crown Weight

Spruce crowns ranged in green weight from 8 to 194 pounds, and fir crowns from 3 to 116 pounds. For a given d.b.h, a spruce crown is 70 to 80 per cent heavier than a fir crown (Table 1). Crown weight is more closely correlated with d.b.h. than the other two measures of crown used in this study. The correlation is especially good for spruce.

Obtaining crown weight is tedious, and destructive to trees, but once the relationship between d.b.h. and crown weight is established for a species and site it should be applicable to trees of different crown class and to stands of different density (Kittredge 1948, p. 35). In conjunction with a stand table the crown weight to d.b.h. relationship can be used to estimate weight of slash resulting from cutting. Such estimates can be useful in predicting fire hazard and in planning silvicultural operations.

The green weight of fine slash from one stand of this study, resulting from cutting only spruce and fir in and above the 4-inch class is estimated to be 23,100 pounds per acre. This weight represents 95 square feet of basal area out of 119. Crowns of spruce and fir below the 4-inch d.b.h. class and crowns of other species are not included.

SUMMARY AND CONCLUSIONS

1. Crown and stem measurements were made on 48 red spruce and 80 balsam fir from 60-year-old stands with an average basal area of 125 square feet and a site index of 50, on fresh, well drained, sandy loam soils, at the Acadia Forest Experiment Station in south-central New Brunswick.
2. There is good, positive, linear correlation between stem d.b.h. and crown width and length in red spruce and balsam fir. There is excellent correlation between d.b.h. and green weight of needles and twigs (crown weight), that can be made linear by logarithmic transformation.
3. For trees of the same d.b.h.,
   (*a*) crowns of spruce are less variable in width and average about 1.5 feet wider than those of fir.
   (*b*) crown lengths of spruce and fir are similar.
   (*c*) spruce crowns are 70 to 80 per cent heavier than those of fir.
4. There would be a greater quantity of slash from spruce stands than from fir stands, similar in other respects.
5. Estimates of stem diameter and volume made from aerial photographs by measuring the width of tree crowns, should be more accurate for spruce than for fir.
6. In the stands sampled crown length is never less than 56 per cent of tree height, for trees in and above the 3-inch class.

SOMMAIRE ET CONCLUSIONS

1. L'auteur a mesuré le houppier et le fût de 48 épinettes rouges et de 80 sapins baumiers qui se trouvaient dans des peuplements de 60 ans, et dont la surface terrière moyenne était de 125 pieds carrés et l'indice de fertilité, de 50; ces sujets poussaient en sol du type sablolimoneux, bien drainé, à la station forestière expérimentale de l'Acadie, au Nouveau-Brunswick central-sud.
2. La corrélation linéaire entre le DHP du fût, le diamètre du houppier et la hauteur du sapin baumier et de l'épinette rouge a été nettement et positivement établie. Il existe aussi une corrélation bien nette entre le DHP et le poids des aiguilles et des branchillons des arbres sur pied (poids du houppier), qu'on peut établir à l'aide de calculs logarithmiques.
3. Dans le cas d'arbres de même DHP,
   a) chez l'épinette, le diamètre des houppiers est plus uniforme que chez le sapin et il mesure en moyenne 1.5 pied de plus;
   b) la hauteur du houppier est la même pour l'épinette et pour le sapin;
   c) le poids du houppier de l'épinette dépasse de 70 à 80 p. 100 celui du sapin.
4. Étant donné des arbres semblables en tous points, la quantité de déchets est plus élevée dans les peuplements d'épinette que dans les peuplements de sapin.
5. L'estimation du diamètre et du volume du fût, faite sur photo aérienne d'après le diamètre du houppier, serait plus exacte dans le cas de l'épinette que dans celui du sapin.
6. En ce qui concerne les peuplements à l'étude, la hauteur du houppier n'est jamais inférieure à 56 p. 100 de la hauteur totale de l'arbre, dans le cas des sujets de 3 pouces ou plus de diamètre.

TABLE 1. CROWN AND STEM RELATIONSHIPS IN RED SPRUCE AND BALSAM FIR

Item	d.b.h. (inches)								Equation†	r^2 †† per cent	Number of trees
	3	4	5	6	7	8	9	10			
Red Spruce											
Tree height (ft.)	25	31	36	40	44	47	49	51		—	219
Crown width (ft.)	4.5	5.6	6.7	7.8	8.9	10.0	11.1	12.2	Wd=1.197D+0.278	63	48
Crown length (ft.)	14.1	17.7	21.3	25.0	28.5	32.2	35.9	39.5	L=3.630D+3.185	69	48
Crown weight (lbs.)	12.8	24.6	40.9	61.7	87.5	118.6	154.8	196.8	log W=2.268 log D+0.026	91	48
Balsam Fir											
Tree height (ft.)	25	32	38	43	46	48	50	51		—	320
Crown width (ft.)	3.2	4.3	5.3	6.4	7.5	8.5	9.6	10.7	Wd=1.072D−0.034	49	80
Crown length (ft.)	14.3	18.0	21.7	25.4	29.2	32.9	36.6	40.4	L=3.728D+3.074	68	80
Crown weight (lbs.)	7.1	13.8	23.1	35.2	50.2	68.4	89.8	114.8	log W=2.314 log D−0.254	72	80

†All correlations are significant at the 0.01 level.
††The correlation coefficient, r, squared and multiplied by 100: the larger the number the stronger the association between the two variables.

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