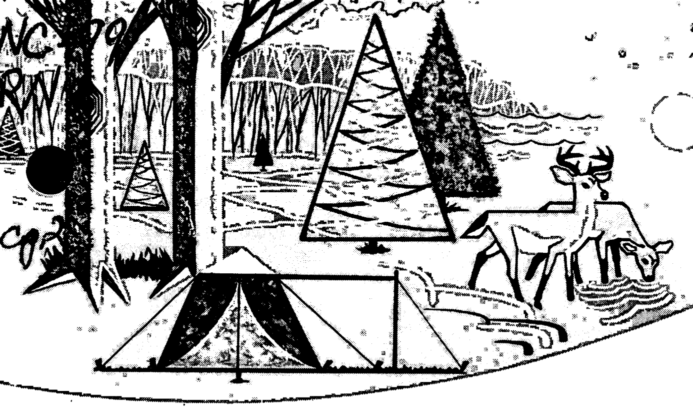

U. S. FOREST SERVICE

RESEARCH NOTE NC-99

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE
Folwell Avenue, St. Paul, Minnesota 55101

Relation of Crown Width to Tree Diameter In Some Upland Hardwood Stands of Southern Illinois

ABSTRACT.—Crown width-d.b.h. relationships in well stocked, uneven-aged stands of oak and hickory were similar to those for open-grown trees and were independent of site, crown class, and species. The irregular crowns of forest grown trees interlace and overlap, however, and measuring crown extensions to the branch tips tended to overestimate effective crown area.
OXFORD: 531:521.2:176.1(773)

Tree diameter at breast height (d.b.h.) is related to the amount of crown growing space the tree occupies. For a given stand, the sum of these growing spaces often is useful for interpreting and predicting stand development and growth. Tree crown mass would be preferable for these purposes, but it is difficult to measure. How well, then, does d.b.h. of forest trees express crown width, a factor related to total crown area? And how does this diameter-crown width relationship vary by stand density, species, crown class, and site?

Previous studies have attempted to answer some of these questions. Bonnor (1964) found that the relationship between stem diameter and crown width x height of lodgepole pine (*Pinus contorta* Dougl.) was unaffected by stand density. On the other hand, open-grown lodgepole pine and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) had wider crowns than forest-grown trees of the same diameter, Smith and Bailey (1964). Smith (1964) concluded from a study of conifers and red alder (*Alnus rubra* Bong.) that d.b.h. gives a valid estimate of the crown-root complex. Our study of oaks and hickories in Illinois indicates that the d.b.h.-crown width relationships for forest-grown trees in uneven-aged stands are similar to those reported for open-grown trees (Krajicek *et al.* 1961).

SOURCE OF DATA

The crown widths and diameters of 675 oak and hickory trees were measured on 60 one-half acre plots located in upland hardwood stands in southern Illinois. The plots were marked to leave residual stands of three structural classes — large, medium, and small trees — and three density classes — 40, 60, and 80 square feet of basal area per acre — on good and average sites. Uncut plots were included. The uneven-aged stands were well stocked but had been partially cut about 40 years earlier. The trees ranged from 40 to 150 years old. Basal area for trees 4.6 trees d.b.h. and larger ranged from about 85 to 110 square feet per acre. The average sites — oak S.I. 61 — supported mixed oaks (*Quercus*) and hickory (*Carya*); on the good sites —S.I. 72, yellow-poplar (*Liriodendron tulipifera* L.) also was present.

On each plot, the residual trees were stratified by species and size class and 50 percent of the trees were randomly selected for intensive study. Sample trees ranged from 5 to 26 inches d.b.h. and included all crown classes except overtopped trees. Cull trees were excluded. Measurements were made at the time of the thinning so treatment had not affected d.b.h. or crown width.

Diameter was measured to 1/20-inch. Crown width was determined by measuring the horizontal distance to the nearest foot on north-south and east-west axes to the tips of the branches as estimated by their vertical projection on the ground. Crown width was assumed to be the average of the two measurements. Individual crowns had varying degrees of irregularity; they were not as uniform or full as open-grown trees.

ANALYSES AND RESULTS

Regression analyses of the relation between average crown width and d.b.h. for individual trees were computed by species, crown class, and site. There was generally a linear relationship between crown width and d.b.h. for all species and crown classes on mixed hardwood and oak-hickory sites (table 1). However, there was considerable variation among these forest-grown trees. Within the limits of the data,[1] the regression lines for the three crown classes had essentially the same slope and when taken together formed a single line from 5 to 26 inches d.b.h. This was true for all species, and species equations were similar. Thus, the three short regressions by crown classes formed essentially one continuous line, and the relationship may be curvilinear. The species-site-crown class regressions were variable, but when intercepts were low the slope coefficients were high (table 1). Ratios of crown width over tree d.b.h. were similar for all species, crown classes and sites. Crown width in feet was two times the d.b.h. in inches.

The crown width-d.b.h. relationships differed little between sites and among the upland oaks and hickory species (table 1). Because yellow-poplar had a lower crown width-d.b.h. ratio than the upland oaks and hickory, it was not included in these data.

The combined crown width-d.b.h. regressions for these forest-grown trees were essentially the same as for open-grown upland oaks (Krajicek *et al.,* 1961) (fig. 1). However, the crown variations in forest-grown trees were much greater than among open-grown trees. Because of crown margin irregularities in the forest-grown trees, measuring crown extensions to the branch tips tended to overestimate effective crown width.

The total crown area of all trees in the stands can be computed by use of the general regression equation for the 675 sample forest-grown trees ($Y = 3.70 + 1.709 X$). This was done assuming that crowns were circular in horizontal cross section and using average crown width (north-south and east-west) as the diameter of the circle. As total computed crown area was consistently greater than one acre of ground surface (table 2), the crowns either must be interlaced and/or overlapping or the method used to compute crown area must overestimate it.

A comparison was made of the general regression for these forest-grown trees and that

[1] *The general range of diameters by crown classes was as follows: Intermediate: 5-12 inches d.b.h., codominant: 8-20 inches d.b.h., and dominant: 14-26 inches d.b.h.*

Table 1. — *Significant*[1] *regressions of average crown width in feet (Y) and tree d.b.h. in inches (X) for trees in well stocked stands*

Species	Site	Crown class	Ratio Y/X	Species coefficients A	Species coefficients B	Number of trees
White oak (Quercus alba L.)	Good	Dominant	1.96	7.2	1.6	45
		Codominant	1.98	3.5	1.7	44
		Intermediate	2.11	3.1	1.8	33
	Average	Dominant	2.02	-0.6	2.1	39
		Codominant	1.97	-1.2	2.1	51
		Intermediate	2.09	7.9	1.1	40
Black oak (Q. velutina Lam.)	Good	Dominant	1.93	8.0	1.5	26
		Codominant	1.86	-5.6	2.3	28
		Intermediate	1.90	1.7	1.7	14
	Average	Dominant	1.97	6.7	1.5	42
		Codominant	1.89	1.6	1.7	50
		Intermediate	1.96	7.9	0.9	18
Northern red oak (Q. borealis Michx.F.)	Good	Dominant	1.87	9.2	1.3	16
		Codominant	2.05	5.3	1.6	19
		Intermediate	1.87	-0.6	2.0	13
Scarlet oak (Q. coccinea Muenchh.)	Average	Dominant	2.06	10.0	1.4	47
		Codominant	2.06	3.3	1.8	35
		Intermediate	2.36	4.0	2.9	16
Hickory (Carya)	Good	Dominant	1.81	7.7	1.3	11
		Codominant	1.99	0.5	2.0	17
		Intermediate	2.07	2.2	1.8	27
	Average	Codominant	2.23	5.3	1.7	20
		Intermediate	2.28	3.3	1.8	24

1/ Nineteen regressions were statistically significant at the one percent level and 4 at the 5 percent level.

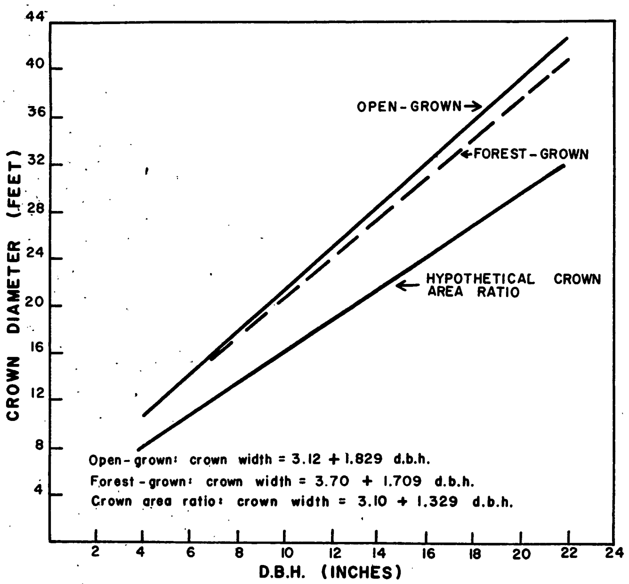

Figure 1. — Comparison of crown width-d.b.h. regressions for open-grown, forest-grown, and trees in hypothetical stands.

Table 2. — *Total crown area*[1] *per acre for upland hardwood unthinned stands*

Stand	Total crown area per acre	Ratio to one acre
	Sq. ft.	
Mixed hardwoods		
1	50,786	1.17
2	48,661	1.12
3	55,292	1.27
Oak-hickory		
4	60,935	1.40
5	51,835	1.19
6	50,118	1.15

1/ Trees 4.6 inches d.b.h. and larger.

for trees in a hypothetical stand where area is allocated to each tree with an assumption of no interlacing or overlapping crowns (fig. 1). The latter equation represents 100 percent stocking (Gingrich 1967). The ratio of average crown area for forest-grown over the hypothetical trees was 1.5 or more for all tree sizes.

CONCLUSIONS

These findings indicate that in the oak-hickory forests studied, bole d.b.h. can be used to estimate crown area occupancy. This implies that, after thinning, both diameter growth and crown area increase in response to increased growing space and the crown area-d.b.h. ratio is generally maintained.

It is suggested that open-grown trees and the forest-grown trees in this study had approximately the same crown width-d.b.h. relationship because the crowns of forest-grown trees interlaced and overlapped. The crown area ratio based on the average crown widths was greater than ground surface unity. Crown shape and fullness for open-grown and forest-grown trees are, of course, not the same. For the oak-hickory trees studied, the ratio of average crown width to bole d.b.h. appeared to be independent of site, crown class, and species.

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