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D.b.h./Crown Diameter Relationships in Mixed Appalachian Hardwood Stands

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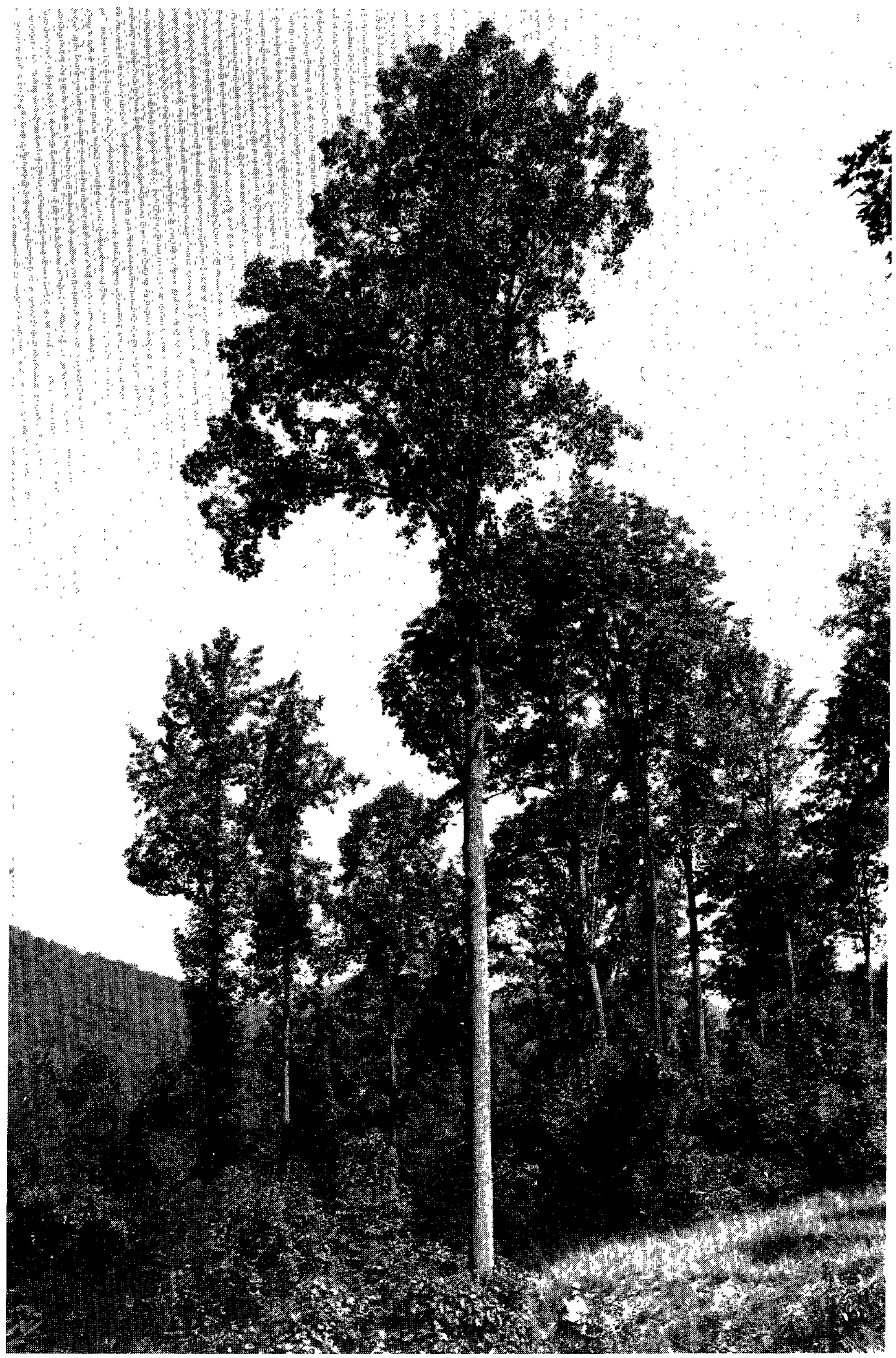

Abstract

Linear regression formulae for predicting crown diameter as a function of stem diameter are presented for nine species found in 50- to 80-year-old mixed hardwood stands in north-central West Virginia. Generally, crown diameter was closely related to tolerance; more tolerant species had larger crowns.

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Introduction

In order to apply any silvicultural system, it is essential to understand how trees grow and react to various cultural treatments. Growth rates of trees are directly affected by the intensity of competition. Crown dimensions are feasible expressions of the cumulative effects of competition (Curtis 1970, Krajicek et al. 1961). This paper reports diameter breast height (d.b.h.)/crown diameter relationships for unmanaged, even-aged mixed hardwood stands in West Virginia.

Methods

Nine species were selected for study: hickory (Carya cordiformis and Carya ovata), northern red oak (Quercus rubra L.), scarlet oak (Quercus coccinea Muenchh.), white ash (Fraxinus americana L.), yellow-poplar (Liriodendron tulipifera L.), black cherry (Prunus serotina Ehrh.), sugar maple (Acer saccharum Marsh.), red maple (Acer rubrum L.), and beech (Fagus spp.). These are common species in mixed hardwood stands in the central Appalachian mountains. Data were collected from a total of 52 even-aged stands ranging in ages from 50 to 80 years and located in north-central West Virginia. These were typical second-growth stands with scattered individual trees up to 150 years old.

Northern red oak site index (SI) class ranged from 55 to 85 feet in stands estimated by using height/age relationships (Schnur 1937). Within each stand, trees of the study species were randomly selected. All crown classes were included so long as the trees were reasonably healthy and had normal crowns that showed no signs of damage such as top breakage or disease. For each study tree, diameter outside bark at 4.5 feet (d.b.h.) and crown diameter along two axes were measured. Crown diameter was measured by two people using a 100-foot tape and ocularly estimating the crown edges. A total of 1,955 study trees were included with 98 to 549 trees for each of the nine study species. D.b.h. ranged from 3.0 to 36.3 inches, and crown width ranged from 5 to 70 feet.

All data were grouped by species and 10-foot red oak site index class. For each group, the data were fit to the following equations:

$$CD = a + b(D)$$
$$CD = a + b(D^2)$$
$$CD = a + b(D) + C(D)^2$$
$$CD = a + b(\log(D))$$
$$\mathrm{Log}(CD) = a + b(D)$$
$$\mathrm{Log}CD = a + b(\log(D))$$
$$1/CD = a + b(D)$$
$$1/CD = a + b(a/D)$$

where CD = crown diameter
D = d.b.h.

Results

Equation Selection

None of the data transformations gave a better fit than the linear regression using only D. Therefore, the linear regression form of CD = a +b(D) was selected.

Differences Due to Site Index

Except for scarlet oak, which was observed only in SI class 60 stands, all species were observed in stands in which the SI class ranged from 60 to 70, 60 to 80, or 70 to 80 feet. Differences due to SI class were tested by statistically comparing the slopes and intercepts of each species/site index class equation to those from a single species equation using the data from all trees for a species regardless of site index class. Significant differences were found among the SI classes only for red oak and yellow-poplar. For red oak, SI 70 and 80 were not different.

Differences Among Species

Differences among species were tested by statistically comparing slopes and intercepts of individual species equations to those from equations which included all trees from two or more species. No significant differences were found among hickory, red oak SI 70 and 80, scarlet oak, and white ash. Also red oak SI 60, red maple and black cherry were not significantly different. Therefore, equations for the white ash, hickory, red oak SI 70 and 80, and scarlet oak group and the red oak SI 60, red maple, black cherry group were calculated. The resultant six equations are shown in Table 1. Coefficients of determination (R^2) ranged from 0.59 to 0.68 for the six equations. Intercepts (a) ranged from 4.951 feet for yellow-poplar, site index 80, to 17.845 for sugar maple, while slopes (b) ranged from 1.022 for sugar maple to 2.030 for the yellow-poplar, SI 80 (Table 1).

Table 1.—Slopes (b) and intercepts (a) for linear regression equations crown diameter =a +b(d.b.h.)

Equation No.	Species	No. of observations	a	b	r^2	SE(a)
1	Beech	98	16.734	1.291	0.61	1.665
2	Sugar maple	241	17.845	1.022	0.68	0.691
3	White ash/ oak group[1]	607	13.571	1.318	0.59	0.768
4	Red maple, black cherry[2]	566	12.596	1.073	0.62	0.518
5	Yellow-poplar, SI 70	109	5.203	1.383	0.61	1.753
6	Yellow-poplar, SI 80	334	4.951	2.030	0.59	1.530

[1]Oak group contains hickory, scarlet oak, and red oak SI 70 and 80.

[2]Also includes red oak SI 60.

Validation of Equations

The six equations were validated by splitting the data into a regression data set and a test data set. The regression equations for the six species and SI classes were calculated using the regression data set and these equations were used to calculate predicted values and residuals for the test data set. The SAS procedure PROC MEANS (SAS 1985) was used on the residuals to test whether there were differences for each group and for the data set as a whole. The variance estimates of the residuals were also compared to the variances obtained with the regression data set. Since the variances of the two procedures were nearly identical and the tests indicated that none of the mean residuals were significantly different from zero, the equations were assumed to be valid.

Crown Diameters

Crown diameters calculated using the formulae from Table 1 are shown in Table 2. Yellow-poplar SI 70 and red maple/black cherry have the smallest crowns, while yellow-poplar SI 80 and beech have the largest. It is interesting to note that yellow-poplar SI 80 has the largest crowns for trees over 16 inches d.b.h. However, yellow-poplar over 16 inches d.b.h. have crowns only about 3 to 8 feet larger than beech.

Table 2.—Estimated crown diameter by 2-inch d.b.h. classes calculated using the formulae from Table 1.

Species	D.b.h. class 6	8	10	12	14	16	18	20	22	24	26
	Feet										
Beech	25	27	30	32	35	37	40	43	45	48	50
Sugar maple	24	26	28	30	32	34	36	38	40	42	44
White ash/oak group[1]	22	24	27	29	32	35	37	40	43	45	48
Red maple/black cherry group[2]	19	21	23	26	28	30	32	34	36	38	40
Yellow-poplar SI 70	14	16	19	22	25	27	30	33	36	38	41
Yellow-poplar SI 80	17	21	25	29	33	37	42	46	50	54	58

[1]Oak group contains hickory, scarlet oak, and red oak SI 70 and 80.

[2]Includes red oak SI 60.

Discussion

These equations and tables are based on data collected from even-aged stands that were 50 to 80 years old. Therefore, most of the 4- and 6-inch trees were overtopped, as were many of the 8-inch trees. These equations may not accurately describe d.b.h./crown diameter relationships of trees in stands less than 50 years old. For example, 6-inch SI 70 yellow-poplar trees in a 25-year-old stand will most likely be codominant and may not have crowns that are 14 feet in diameter as estimated in Table 2.

Generally, the intolerant species, black cherry and yellow-poplar SI 70, have the smallest crowns. Beech has the largest crowns for diameters up to 16 inches. Sugar maple has larger crowns than the white ash/oak group up to 14 inches d.b.h. However, for trees 20 inches d.b.h. and larger, the white ash/oak group, beech and sugar maple have crowns about the same size. Since most of the study trees at least 20 inches d.b.h. were codominant, it can be concluded that for these 50- to 80-year-old stands, codominant white ash/oak group species beech and sugar maple have about the same size crowns.

These crown diameter data suggest that there are three major species groups for trees at least 16 inches d.b.h. The first is beech and yellow-poplar SI 80, with the largest crowns. The second group, with intermediate-size crowns contains sugar maple, white ash, and the oaks. The third group, with the smallest crowns includes red maple, yellow-poplar SI 70, and black cherry. Growth and yield researchers working in these stands are investigating various even-age management strategies. If relative stand density (Marquis et al. 1984) proves to be a viable management tool in Appalachian hardwood stands, these three species groups may prove to be useful.

Leak (1983) reported that in New Hampshire beech also had larger crowns than sugar maple or red maple. Hough (1935) also found that young beech had the largest crowns in Pennsylvania hardwood stands. Lake States northern hardwoods have about the same size crowns as the Appalachian red maple/black cherry group (Godman and Tubbs 1973).

Conclusions

D.b.h. is a reasonably good predictor of crown diameter in 50- to 80-year-old even-aged Appalachian hardwood stands. In these mixed stands, beech has the largest crowns, while yellow-poplar SI 70 and black cherry have the smallest. Three general crown width groups are evident. Beech and yellow-poplar SI 80 have the largest crowns, followed by a second group of sugar maple, white ash, red oak, scarlet oak, and hickory. Red maple, yellow-poplar SI 70, and black cherry form the third group with the smallest crowns.

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