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Bark Volume of Yellow-Poplar, Red, Black, And Scarlet Oak, and Red Maple in Northern West Virginia*

C. B. KOCH

UTILIZATION of bark presents a major problem in the more complete use of forest products. The bark removed annually in the production of lumber, pulp and other wood products exceeds 20 million tons. Only a small percentage of this is utilized for fuel, mulch and a few other uses. The remainder must be disposed of, frequently at a financial loss.

Considerable attention has been focused recently on more efficient utilization and disposal of bark. In order to expedite this effort, additional information is needed concerning the volume of bark actually available in standing trees of different species and sizes. This report deals with bark volumes of standing trees of several commercially important hardwood species. Variation in bark volume within and between trees is also considered.

Literature Review

Information relating specifically to bark volume has been obtained primarily by mensurationists. They have found that, at least for some species, the ratio of diameter-inside-bark or bark thickness to diameter-outside-bark at a particular height is approximately constant. Thus, at the specific height investigated (usually at breast height), bark volume, expressed as a percentage of total volume, is unaffected by diameter. Linear equations relating bark thickness to diameter-outside-bark for a number of species are summarized by Spalt and Reifsnyder (7).¹ They also present values for bark thickness expressed as a percentage of d.b.h. Assuming a constant relationship between variables, such values may be used to estimate bark volume percentages. *The Forestry Handbook* (6, Section 1, p. 3) provides bark thickness values for trees of different diameters for

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¹Numbers in parenthesis refer to literature cited.

several hardwood and softwood species. The same publication (Section 1, pp. 3-5) gives bark volume expressed as a percentage of total cubic foot volume for a number of species. In some species, percentage bark volume (based on measurements at breast height) tends to decrease as diameter and/or age increases (2,4,5).

The ratio of bark thickness to diameter other than at breast height has received little attention. Pemberton (5) found that the ratio varied inversely with height in redwood. Miller (3) reports a curvilinear decrease in bark thickness with increasing height for slash pine.

Probably because of the limited commercial value of bark, bark volume tables have been prepared for only a few species. *The Forestry Handbook* (6, Section 1, p. 5) presents a cubic foot volume table for the bark of eastern hemlock. Warner and Goebel (8) have prepared bark volume tables for several species of southern pine.

Perhaps the greatest lack of information regarding volume is the effect of height within d.b.h. classes and the effect of diameter at other than breast height. Such information is important because bolts of equal diameter may occur at varying heights, depending on size of trees.

Description of Study Areas

Two study areas in northern West Virginia were used for this investigation. They will be referred to as the Coopers Rock and Tygart Valley areas.

Five species, red oak (*Quercus rubra* L.), black oak (*Quercus velutina* Lam.), scarlet oak (*Quercus coccinea* Muenchh.), yellow-poplar (*Liriodendron tulipifera* L.) and red maple (*Acer rubrum* L.) were sampled on the Coopers Rock area. This area is part of the West Virginia University Forest located in Preston County, West Virginia at an elevation of about 2,500 feet above sea level.

It was heavily cut over about 50 years ago, subsequently burned, and is now stocked with essentially even-aged stands, mainly of sprout origin. The site on which the yellow-poplar trees were located has an eastern exposure and a moderate slope. The average age of the largest trees of this species sampled (14-16 inches d.b.h.) was 37 years based on a ring count at stump height. The site on which the red oak, black oak and scarlet oak trees were located is at a slightly higher elevation and has a north exposure. The average age of the largest trees sampled (14-16 inches d.b.h.) was 51 years.

Two species, red oak and yellow-poplar were investigated on the Tygart Valley area. This tract is located near Dailey in Randolph County,

West Virginia. The area is currently under the management of the Division of Forestry of West Virginia University. The yellow-poplar trees investigated were located at an elevation of about 2,300 feet above sea level on a northeast-facing slope. The average age of the sample trees 14-16 inches d.b.h. was 58 years. The site on which the red oak sample trees were located is about 2,500 feet above sea level and has a southwestern exposure. The average age of the trees 14-16 inches d.b.h. was 53 years.

Relationship of Bark Volume to Stem Diameter and Bark Thickness

The volume of bark contained in a section of a stem is dependent on the average total diameter outside bark (D), the average bark thickness (t) and the length of the section (l). Total volume of wood and bark may be expressed as $V_T = \pi D^2 l / 4$. The volume of the wood will equal $\pi d^2 l / 4$ where d is diameter inside bark or $d = D - 2t$. The bark volume, V_B , will therefore equal the difference between the two or $\pi l / 4 (D^2 - d^2)$. The ratio of bark volume to total volume may be expressed

as $V_B / V_T = 1 - \left(\frac{d}{D}\right)^2$. If total volume is known, actual bark volume may

be computed as $V_B = V_T \left[1 - \left(\frac{d}{D}\right)^2 \right]$. Meyer (1) has shown that the

average of a number of observations of d/D may be most accurately obtained by computing a ratio of sums as $\bar{d}/\bar{D}$.

The theoretical relationship between bark volume, expressed as a percentage of total volume, and d/D is shown graphically in Figure 1. It should be noted that while the relationship is curvilinear, an assumption of linearity will produce an error of little practical significance within the range of d/D values normally encountered.

The ratio d/D is generally considered constant for a particular species since, when values of d at breast height are plotted over corresponding values of D , a straight line passing through or nearly through the origin results. For some species, the ratio is not constant but increases with increasing d.b.h. Whether or not a linear relationship between d and D exists as height increases within trees has not been investigated. Variation in d/D at a specific height in trees of different diameters has also received little attention.

Part of this report deals with variation in d/D (or V_B/V_T) of red oak, scarlet oak, black oak, yellow-poplar and red maple trees with height within trees and with diameter between trees at given heights.

Figure 1. Theoretical relationship between per cent bark volume and d/D .

Bark Volumes to a Four-Inch Top of Yellow-Poplar and Red Oak

In the following section, equations and tables for estimating cubic foot bark volume of yellow-poplar and red oak are presented. The information should be applicable for most sites in northern West Virginia.

COLLECTION OF DATA

At each location (Coopers Rock and Tygart Valley), a minimum of ten yellow-poplar and ten red oak trees were randomly selected for sampling in each of six d.b.h. classes (4-6 inches, 6-8 inches, 8-10 inches, 10-12 inches, 12-14 inches, and 14-16 inches). For each tree sampled, diameter outside bark (D) was measured to the nearest 0.1 inch with a diameter tape at 1.5 feet above the ground, 4.5 feet above the ground, and at subsequent 6-foot intervals to a 4-inch top. Bark thickness (t) was measured with a Swedish bark gauge to the nearest 0.05 inch at two diametrically opposite sides of the stem at the same heights.

The total volume of each stem section was computed by the Smalian formula. Bark volume of each section was computed by the formula

$V_B = V_T \left[1 - \left(\frac{d}{D} \right)^2 \right]$ as derived previously. Total bark volume of each tree was obtained by summation of volumes of individual sections.

Development of Estimating Equations and Bark Volume Tables

Graphic plotting of both total volume and bark volume against the square of the diameter breast high (D^2) and against height to a four-inch top indicated essentially linear relationships for both species investigated. For this reason, bark volume was related to tree size for each species on each location by least squares solutions of equations of the form $V = a + bX$ where $X = D^2H/10$, a is a constant and b is the slope of the regression. The estimating equations are shown below:

Red Oak

Coopers Rock	$V = 0.367 + 0.00400 (D^2H/10)^{**2}$
Tygart Valley	$V = 0.359 + 0.00425 (D^2H/10)^{**}$
Combined	$V = 0.353 + 0.00417 (D^2H/10)^{**} \quad r = 0.95768$

Yellow-poplar

Coopers Rock	$V = 0.364 + 0.00489 (D^2H/10)^{**}$
Tygart Valley	$V = 0.355 + 0.00588 (D^2H/10)^{**}$
Combined	$V = 0.359 + 0.00547 (D^2H/10)^{**} \quad r = 0.95693$

No significant difference was found between regression coefficients for red oak at the two locations. For yellow-poplar, the regression coefficient for trees at Tygart Valley was significantly greater than that for trees at Coopers Rock. From a practical standpoint, however, the use of the equation based on combined observations seems justified. The estimated bark volumes of trees with $D^2H/10$ values of 2,000 or less, as estimated by the equation based on combined observations, will be within 10 per cent of those obtained by use of either of the other equations.

Bark volumes as computed from the bark volume equations are shown in Table 1 and 2.

Variation in Per Cent Bark Volume Within and Between Trees

The ratio of bark volume to total volume of a bolt or log may be expressed as

$$\frac{V_B}{V_T} = \left[1 - \left(\frac{d}{D} \right)^2 \right]$$

where d and D are average diameters inside and outside bark, respectively. As bark thickness increases in relation to outside diameter, the ratio

²Significant at the 1 per cent level.

TABLE 1
Cubic foot bark volume of yellow-poplar.

D.b.h. (inches)	Height to a four-inch top (feet)																			Basis (No of trees)	
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100		105
4.5	45	48	52	56	60	64	68	72	76	80	86										3
4.5	47	52	58	64	69	75	80	86													3
5.0	50	56	63	70	77	84	91	98	104												9
5.5		61	69	77	86	94	102	110	119	127											11
6.0		65	75	85	95	105	115	124	134	144	154										12
6.5		71	82	94	105	117	128	140	152	163	175	186									8
7.0		76	90	103	116	130	143	156	170	183	197	210									9
7.5		82	97	113	128	144	159	174	190	205	220	236	251								8
8.0			106	123	141	158	176	193	211	228	246	264	281								11
8.5			115	135	155	174	194	214	234	253	273	293	312	332							6
9.0			124	147	169	191	213	235	257	280	302	324	346	368	390						14
9.5			135	159	184	209	233	258	283	307	332	357	382	406	431						9
10.0			145	173	200	227	255	282	309	337	364	392	419	446	471						14
10.5			156	187	217	247	277	307	337	368	398	428	458	488	518	548					13
11.0			168	201	234	268	301	334	367	400	433	466	499	532	565	598					12
11.5				217	253	289	325	361	398	434	470	506	542	578	615	651	687				7
12.0				233	272	312	351	390	430	469	508	548	587	627	666	705	745				8
12.5				250	292	335	378	420	463	506	549	592	634	677	720	762	805	848			5
13.0				267	313	360	406	452	498	544	591	637	683	729	775	822	868	914			13
13.5					335	385	435	484	534	584	634	684	734	784	833	883	933	983			4
14.0					358	411	465	518	572	626	679	733	786	840	894	947	1001	1054	1108		4
14.5						496	553	611	668	726	783	841	898	956	1014	1071	1128	1186	1244		6
15.0						528	590	651	713	774	836	897	959	1020	1082	1144	1205	1267	1328		5
15.5						562	627	693	759	824	890	956	1022	1087	1153	1219	1284	1350	1416	1482	2
16.0						596	666	736	806	876	946	1016	1086	1156	1226	1296	1366	1436	1506	1576	5

TABLE 2
Cubic foot bark volume of red oak.

D.b.h. (inches)	Height to a four-inch top (feet)															Basis (No of trees)					
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80		85	90	95	100	105
4.0	42	45	49	52	55	59	62														0
4.5	44	48	52	56	61	65	69	73													5
5.0	46	51	56	61	67	72	77	82	87												17
5.5		54	60	67	73	80	86	92	98	105	111										10
6.0		58	65	73	80	88	95	103	110	118	125										13
6.5		62	70	79	88	97	106	115	123	132	141	150									7
7.0		66	76	86	97	107	117	127	138	148	158	168									11
7.5		70	82	94	106	117	129	141	153	164	176	188	200								10
8.0			89	102	115	129	142	155	169	182	195	209	222								14
8.5			96	111	126	141	156	171	186	201	216	231	246	261							9
9.0			103	120	137	154	170	187	204	221	238	255	272	289	306						12
9.5			111	129	148	167	186	205	224	242	261	280	299	318	336						7
10.0			119	140	160	181	202	223	244	265	286	306	327	348	369						11
10.5			127	150	173	196	219	242	265	288	311	334	357	380	403	426					6
11.0			136	161	187	212	237	262	288	313	338	363	388	414	439	464					6
11.5				173	201	228	256	284	311	339	366	394	421	449	476	504	532				8
12.0				185	215	246	276	306	336	366	396	426	456	486	516	546	576				7
12.5				198	231	263	296	328	361	394	426	459	491	524	556	589	622	654			6
13.0				212	247	282	317	352	388	423	458	493	529	564	599	634	670	705			7
13.5					263	301	339	377	415	453	491	529	567	605	643	681	719	757			14
14.0					280	321	362	403	444	485	526	567	607	648	689	730	771	812	853		3
14.5						386	430	474	518	561	605	649	693	737	780	824	868	912	956		4
15.0						411	458	504	551	598	645	692	739	786	833	880	927	974	1020		4
15.5						436	486	536	586	636	686	737	787	837	887	937	987	1037	1087	1137	2
16.0						462	516	569	622	676	729	783	836	889	943	996	1049	1103	1156	1210	4

d/D decreases, and per cent bark volume increases. If the ratio of d/D is constant within and between trees of a particular species, then per cent bark volume will also be constant. If, on the other hand, d/D varies appreciably within species, an accurate estimation of bark volume requires an understanding of this variation.

The following section deals with variations in d/D (or V_B/V_T) of red oak, scarlet oak, black oak, yellow-poplar and red maple trees with height-within-trees and with diameter-between-trees.

PROCEDURE

The red oak and yellow-poplar trees sampled were the same as those used for determination of total bark volume on the Coopers Rock area (see preceding section). In addition, five black oak, five scarlet oak, and five red maple trees were sampled in each of three d.b.h. classes (4-6 inches, 8-10 inches, and 12-14 inches). Values of d/D were determined for each tree at heights above ground of 1.5 feet, 4.5 feet, and at subsequent 6-foot intervals to a top diameter of approximately 4 inches.

Measurements of d and D at breast height were also made on an additional 20 yellow-poplar and red oak trees in each of six d.b.h. classes (4-6 inches to 14-16 inches in 2-inch increments).

RESULTS AND DISCUSSION

Average values of d/D for each combination of height and d.b.h. class for the five species investigated are presented in the Appendix (Tables I-V). Averages for grouped heights and d.b.h. classes are also shown. Each value for yellow-poplar and red oak is the mean of ten observations. Values for black oak, scarlet oak, and red maple are means of five observations.

Mean values of d/D and per cent bark volume based on all observations are compared with those based on observations at breast height in Table 3. Per cent bark volume values based on measurements made at breast height were greater for all species except red maple.

Red maple exhibited the lowest per cent bark volume and yellow-poplar the highest. Within the red oak group, black oak contained the highest per cent bark volume and scarlet oak the lowest.

Effect of height in tree within d.b.h. classes:

The relationships between d/D and height in trees in the smallest 4-6 inch and 12-14-inch d.b.h. classes for the five species investigated are illustrated respectively in Figures 2 and 3. The results of tests of significance of the effect of height within all d.b.h. classes are shown in Table 4.

TABLE 3
Average d/D values and bark volume percentages.

Species	d/D		$V_B/V_T \times 100$	
	Overall	At breast height	Overall	At breast height
Yellow-poplar	0.912	0.902	16.8	18.6
Red oak	0.929	0.924	13.7	14.6
Black oak	0.927	0.916	14.1	16.1
Scarlet oak	0.934	0.927	13.1	14.1
Red maple	0.958	0.960	8.2	7.8

TABLE 4
Level of significance of effect of height in tree on d/D for different d.b.h. classes.

Species	D.b.h. (in.)					
	4-6	6-8	8-10	10-12	12-14	14-16
Yellow-poplar	1%	1%	1%	1%	N.S.*	N.S.
Red oak	1%	1%	N.S.	N.S.	N.S.	N.S.
Black oak	5%		5%		N.S.	
Scarlet oak	5%		N.S.		N.S.	
Red maple	N.S.		N.S.		N.S.	

*Not significant.

Height had no significant effect on the d/D ratio of red maple in any of the d.b.h. classes investigated (Table 4). On the basis of the results of this study, a d/D value of 0.96 (bark volume percentage of 8.2) would be reasonable for bolts removed at any height for all d.b.h. classes. This is somewhat less than the value presented by Meyer (1) who worked with bark thickness of red maple in Pennsylvania. However, no explanation can be offered for the difference.

Above 4.5 feet, height had no significant effect on d/D values of the oak species within the larger d.b.h. classes (Table 4 and Figure 3). The effect of height was pronounced, however, in the smaller d.b.h. classes in which d/D increased markedly with height to 16 feet (Figure 2).

In the smaller d.b.h. classes, the effect of height on d/D of yellow-poplar was pronounced (Table 4). Values of d/D increased significantly with height in all d.b.h. classes up to 12-14 inches. Within the two largest d.b.h. classes (12-14 inches and 14-16 inches), d/D values were essentially constant above a height of 10 feet.

The effect of d.b.h. on per cent bark volume at a given height:

The relationships between d/D at representative heights and d.b.h. for red maple, red oak and yellow-poplar are illustrated in Figure 4. The d/D values at breast height for yellow-poplar and red oak are based on

Figure 2. Relationship between d/D and height above ground of trees 4-6 inches d.b.h.

Figure 3. Relationship between d/D and height above ground of trees 12-14 inches d.b.h.

30 observations for each species. The remaining curves are plots of values shown in Tables I, II and V in the Appendix.

The effect of d.b.h. on d/D of red maple was statistically insignificant at all heights.

At stump height and breast height, d/D ratios of all three red oak species increased significantly with d.b.h. Above breast height however, the effect in increasing d.b.h. on d/D was statistically insignificant (Table 5).

At all heights below 28 feet, the d/D ratio of yellow-poplar increased significantly with increasing d.b.h., the increase being most pronounced through the smaller d.b.h. classes. In the larger trees, d.b.h. had little practical effect on d/D at any height (Table 5).

Variation of d/D among trees when D remains constant:

The height-in-tree from which a bolt of a given diameter is removed is dependent on the size of the tree. For example, a bolt with an average diameter (D value) of 6 inches may be taken from the base of a tree 6-8

Figure 4. Relationship between d/D at representative heights and d.b.h.

TABLE 5

Level of significance of effect of d.b.h. on d/D at different heights.

Species	Height above ground (ft.)										
	1.5	4.5	10	16	22	28	34	40	46	52	58
Yellow-Poplar	1 %	1 %	1 %	1 %	5 %	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Red oak	5 %	5 %	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.*	N.S.
Black oak	1 %	5 %	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Scarlet oak	1 %	5 %	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Red Maple	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

*Not significant.

Figure 5. Relationship between d/D and height where D is maintained constant by increasing height.

inches d.b.h. or from higher in the stem of a larger tree. The data discussed previously for yellow-poplar and red oak were analyzed to determine whether d/D (or per cent bark volume) varied significantly with height in trees when diameter outside bark remained constant. In other words, the analysis was designed to answer the question of whether the per cent bark volume of bolts of a given diameter removed from near the ground in small trees is significantly different than that of bolts of the same diameter removed from near the tops of larger trees.

The procedure consisted of selecting a given value of D (values selected ranged from 4 to 13 inches in 1-inch increments) and segregating d/D values according to height among trees at which the particular value of D occurred. The results are shown graphically for representative diameters in Figure 5. The results of tests of significance of the effect of height in tree on d/D for the individual diameters investigated are shown in Table 6.

Reference to Figure 5 and/or Table 6 indicates that the effect of height above 4.5 feet on bark volume of red oak bolts of a given diameter is

TABLE 6

Results of tests of significance of effect of height in tree on d/D for different values of D.

Diam. bark outside	Species	
	Yellow-poplar	Red oak
4	N.S.+	N.S.
5	***+	N.S.
6	**	N.S.
7	**	N.S.
8	N.S.	**
9	**	N.S.
10	N.S.	N.S.
11	*	*
12	N.S.	N.S.
13	N.S.	N.S.

+ Not significant

++ Significant at 1% level.

* Significant at 5% level.

small. This was anticipated since, as discussed in the previous sections, d/D values at given heights were not materially affected by d.b.h. In addition, the effect of height above 16 feet on d/D values within d.b.h. classes was of little consequence.

The effect of height on d/D, where D was held constant, was statistically significant for most diameters up to 8 inches in yellow-poplar (Table 6). The effect of height was essentially the same as that found within d.b.h. classes, being greatest in the smallest trees.

Summary and Conclusions

Patterns of variation in per cent bark volume within and between trees of the two major species investigated, yellow-poplar and red oak, are summarized in Figures 6 and 7 respectively. The values shown were obtained by averaging mean d/D ratios among which no significant differences occurred and converting to per cent bark volume.

For the species investigated, the following points are apparent:

1. Per cent bark volume of red maple is essentially constant regardless of tree size or position within tree.
2. In yellow-poplar and the oak species investigated, per cent bark volume varies inversely with height in trees 8-10 inches d.b.h. and smaller.
3. In trees larger than 8-10 inches d.b.h., the variation in per cent bark volume with height within d.b.h. classes is too small to be of practical concern.

Figure 6. Variation in per cent bark volume in yellow poplar trees.

4. In trees larger than 6-8 inches d.b.h., variation in per cent bark volume with d.b.h. at all heights is negligible.
5. The effect of location of red oak bolts of a given diameter within and between trees on per cent bark volume is not practically significant. The bark volume of yellow-poplar bolts of a given diameter will be greater if they are removed from the butts of small trees rather than from the tops of larger trees.

Figure 7. Variation in per cent bark volume in red oak trees.

6. Because of the present low value of hardwood bark, it is doubtful whether variation in bark volume within-and-between-trees need be given consideration in volume estimation. Average values which may be multiplied by total cubic foot volumes to provide bark volumes of sufficient practical accuracy are given below:

Species	V_B/V_T
Yellow-poplar	0.17
Red oak and black oak	0.14
Scarlet oak	0.13
Red maple	0.08

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APPENDIX

Mean d/D values for height-d.b.h. combinations.

TABLE I

Mean d/D values for different height-d.b.h. combinations in yellow-poplar at Coopers Rock.

Hgt. above ground (feet)	D.b.h. class (inches)					Mean
	4-6	6-8	8-10	10-12	12-14	
58				.920	.915	.917
52				.922	.919	.918
46			.922	.923	.916	.919
40			.916	.925	.919	.920
34		.923	.916	.923	.921	.916
28		.918	.917	.921	.921	.917
22		.911	.914	.922	.923	.917
16	.899	.910	.911	.921	.921	.916
10	.894	.903	.910	.920	.920	.911
4.5	.881	.893	.905	.913	.919	.903
1.5	.875	.883	.897	.911	.901	.895
Mean	.887	.906	.912	.920	.918	.913

TABLE II

Mean d/D values for different height-d.b.h. combinations in red oak at Coopers Rock.

Hgt. above ground (feet)	D.b.h. class (inches)					Mean
	4-6	6-8	8-10	10-12	12-14	
52					.934	.934
46					.937	.937
40				.934	.932	.934
34			.922	.937	.926	.934
28		.935	.930	.938	.932	.936
22		.933	.925	.937	.929	.939
16	.930	.934	.923	.937	.922	.936
10	.927	.931	.922	.931	.926	.938
4.5	.919	.919	.920	.928	.923	.935
1.5	.911	.906	.909	.929	.920	.933
Mean	.922	.926	.922	.934	.926	.936

TABLE III

Mean d/D values for different height-d.b.h. combinations in black oak at Coopers Rock.

Hgt. above ground (feet)	4-6	D.b.h. class (inches)		Mean
		8-10	12-14	
34		.930	.934	.932
28		.936	.935	.936
22		.936	.937	.936
16	.937	.934	.932	.934
10	.932	.930	.934	.932
4.5	.910	.911	.926	.916
1.5	.896	.914	.926	.912
Mean	.919	.927	.932	.927

TABLE IV

Mean d/D values for different height-d.b.h. combinations in scarlet oak at Coopers Rock.

Hgt. above ground (feet)	4-6	D.b.h. class (inches)		Mean
		8-10	12-14	
40			.940	.940
34		.934	.942	.938
28		.929	.950	.940
22		.941	.944	.942
16	.944	.940	.944	.943
10	.929	.932	.944	.935
4.5	.911	.928	.942	.927
1.5	.898	.925	.938	.920
Mean	.920	.933	.943	.934

TABLE V

Mean d/D values for different height-d.b.h. combinations in red maple at Coopers Rock.

Hgt. above ground (feet)	4-6	D.b.h. class (inches)		Mean
		8-10	12-14	
46		.950	.950	.950
40		.954	.956	.955
34		.960	.954	.957
28		.956	.961	.958
22		.960	.960	.960
16	.959	.962	.963	.961
10	.957	.967	.961	.962
4.5	.959	.962	.959	.960
1.5	.954	.958	.961	.958
Mean	.957	.959	.958	.958