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Butt-log Grade Distributions for Five Appalachian Hardwood Species

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Abstract

Tree quality is an important factor in determining the market value of hardwood timber stands, but many forest inventories do not include estimates of tree quality. Butt-log grade distributions were developed for northern red oak, black oak, white oak, chestnut oak, and yellow-poplar using USDA Forest Service log grades on more than 4,700 trees in West Virginia. Butt-log grade distributions indicate the probabilities associated with each grade for each species and d.b.h. class. These estimates are useful for predicting the value of timber stands for which stand tables are available.

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Introduction

Timber cruises usually involve the estimation of board-foot sawtimber volumes, cordwood volumes, and stand growth. One variable that is not commonly measured, but is important in estimating the actual value of a stand, is the stem quality of trees sampled in the cruise. Butt-log grade is a measure of stem quality that can be estimated from empirical equations relating butt-log grade to tree d.b.h. (Ernst and Marquis 1979). We developed equations and butt-log grade distributions for five Appalachian hardwood species. The distributions are useful for estimating average tree quality and stand value when stem quality data are not available.

Methods

Empirical grade equations were derived from Forest Survey point samples containing information on species, d.b.h. (D), and butt-log grade. The species included northern red oak, black oak, white oak, chestnut oak, and yellow-poplar. Data were from 4,781 sawtimber trees ranging from 10 to 25 inches d.b.h. on point samples placed throughout West Virginia.[1] USDA Forest Service log grades (Rast and others 1973) were used to grade the butt 16-foot log of each sample tree.

Three regression equations were developed for each species. The equations related the inverse of tree d.b.h. (D^{-1}) to:

(1) The proportion of sawtimber trees with a grade 1 butt log;

(2) The proportion of sawtimber trees with a grade 3 butt log;

(3) The proportion of sawtimber trees with a butt log below grade 3.

All regressions were weighted by the actual number of sawtimber trees in a diameter class times $1/D^2$, because trees were selected by point sampling. Analyses of covariance indicated that the following combinations of oak species were acceptable: red and black oak, and white and chestnut oak.

[1]Data were provided by the Forest Inventory and Analysis Research unit of the USDA Forest Service, Northeastern Forest Experiment Station, for the State of West Virginia.

Results

Butt-log grade distributions for yellow-poplar, red and black oak, and white and chestnut oak are presented in Tables 1-3. The grade distributions were predicted from the regression equations presented in Table 4. Coefficients of determination (R^2) ranged from 0.49 to 0.90. For each grade distribution, the percentage of sawtimber trees with butt logs in grade 1, 3, or "below grade" were predicted from the equations. The percentage of trees with grade 2 butt logs was found by subtraction.

For each species group and diameter class, the percentage of sawtimber trees with below-grade butt logs was computed first. Below-grade logs are not used to produce factory grade lumber. They include construction logs used for ties and timbers and local-use logs (Rast and others 1973). The predicted percentage of trees with below-grade butt logs decreased as d.b.h. increased in each species group (Tables 1-3).

From 10 to 11 inches d.b.h., the percentage of trees with grade 3 butt logs was determined by subtraction. In these diameter classes, grade 3 is the best possible grade due to size limits in the grading rules (Rast and others 1973). From 13 to 14 inches d.b.h., the percentage of trees with grade 3 butt logs was computed from the equations, and the percentage with grade 2 butt logs was determined by subtraction. In these diameter classes, the butt logs are too small to be grade 1. For trees 15 inches d.b.h. and larger, the percentage of trees with butt-log grades 1 and 3 were computed from the equations, and the percentage with butt-log grade 2 was determined by subtraction. Thus, the percentage of trees in each grade category for a particular diameter class totals 100.

Making Value Determinations

Forest Service tree grades (Hanks 1976) are useful for predicting lumber grade yields and the market value of individual sawtimber trees. Although tree grades and butt-log grades differ with respect to scaling diameter and allowable cull, surface requirements are the same in both grading systems. With some minor changes, the butt-log grade distributions presented here can be transposed to tree grades for estimating stumpage values.

The minimum diameters for *tree* grades 1, 2, and 3 are 10, 13, and 16 inches d.b.h., respectively (Hanks 1976). To approximate tree grade distributions from those presented in Tables 1-3, assume that no 12-inch trees are grade 2 and that no 15-inch trees are grade 1. This will increase the percentage of 12-inch trees that are grade 3 and the percentage of 15-inch trees that are grade 2. The total distribution in each diameter class equals 100 percent.

Table 1.—Butt-log grade distributions for yellow-poplar

D.b.h. (inches)	No. of trees	Grade 1	Grade 2	Grade 3	Below grade
		Percent			
10	123	—	—	74	26
11	99	—	—	78	22
12	112	—	9	71	20
13	123	—	24	59	17
14	108	—	37	48	15
15	85	29	19	39	13
16	82	36	20	32	12
17	73	41	23	25	11
18	46	47	25	19	9
19	28	51	28	13	8
20	34	56	29	8	7
21	23	59	31	4	6
22	18	63	30	1	6
23	7	66	29	1	5
24	6	69	26	1	4
25	9	72	23	1	4
Total	976				

Table 2.—Butt-log grade distributions for red and black oak

D.b.h. (inches)	No. of trees	Grade 1	Grade 2	Grade 3	Below grade
		Percent			
10	161	—	—	81	19
11	144	—	—	83	17
12	141	—	11	74	15
13	130	—	23	64	13
14	164	—	34	54	12
15	126	19	25	46	10
16	133	25	27	39	9
17	110	30	29	33	8
18	105	35	30	27	8
19	87	39	32	22	7
20	79	43	33	18	6
21	63	46	34	14	6
22	58	49	36	10	5
23	40	52	36	7	5
24	42	54	38	4	4
25	31	57	38	1	4
Total	1,614				

Table 3.—Butt-log grade distributions for white and chestnut oak

D.b.h. (inches)	No. of trees	Grade 1	Grade 2	Grade 3	Below grade
		Percent			
10	264	—	—	76	24
11	255	—	—	79	21
12	233	—	5	76	19
13	208	—	15	68	17
14	229	—	23	61	16
15	196	6	25	55	14
16	142	10	27	50	13
17	126	14	29	45	12
18	105	17	31	41	11
19	94	20	32	38	10
20	99	23	34	34	9
21	65	25	36	31	8
22	54	27	36	29	8
23	34	29	38	26	7
24	37	31	38	24	7
25	23	33	39	22	6
Total	2,164				

Table 4.—Regression statistics for dependent variable of percentage of trees in given grades

	Grade 1		Grade 3		Construction	
Species	Equation[a]	R^2	Equation[a]	R^2	Equation[a]	R^2
Yellow-poplar	$Y = 135.6 - 1601.4\ D^{-1}$	.62	$Y = -86.2 + 1885.5\ D^{-1}$	.90	$Y = -11.0 + 365.9\ D^{-1}$	.79
Red, black oaks	$Y = 112.7 - 1403.1\ D^{-1}$	.73	$Y = -67.4 + 1702.2\ D^{-1}$	.89	$Y = -6.4 + 252.6\ D^{-1}$	.49
White, chestnut oaks	$Y = 73.8 - 1021.4\ D^{-1}$	.61	$Y = -27.8 + 1241.0\ D^{-1}$	.83	$Y = -6.0 + 302.3\ D^{-1}$	.62

[a] Y = Percentage of trees by grade; D^1 = 1/d.b.h. (percentage of trees with grade 2 butt logs is found by subtraction.)

The adjusted grade distributions indicate how many trees in each diameter class are grade 1, 2, 3, or below grade for each species group. For example, a stand table reveals that a 50-acre stand contains 126 northern red oaks in the 18-inch diameter class. The grade distribution for the red oak-black oak group (Table 2) estimates the number of trees in each grade (Table 5). This procedure is repeated for each diameter class and for each species until all trees have been "graded."

Table 5.—Tree grade distribution of 126 northern red oaks on a 50-acre forest tract

Tree grade	Probability	Estimated no. of trees in each grade
1	0.35	44
2	0.30	38
3	0.27	34
4	0.08	10

The final step is estimating the market value of individual trees in each species group. Table 6 lists the average lumber yields and current lumber prices for a northern red oak, 18 inches d.b.h., with a grade 1 butt log and a merchantable height of 32 feet. The sum of current lumber prices (Lemsky 1985) applied to each lumber grade yield is the total value of lumber in the tree, $100.05. The value of lumber in a similar tree with a grade 2 butt log is $85.74. With a grade 3 butt log, the value drops to $65.32. The value of products in trees below grade 3 depends on local-use markets. For this example, we assumed the value of products in trees below grade was $40.

Table 6.—Value of lumber in a northern red oak, 18 inches d.b.h., with a grade 1 butt log and merchantable height of 32 feet

Lumber grade	Volume[a]	Lumber price[b] per M bf	Lumber value
	Board feet	------- *Dollars* -------	
FAS	35.9	$715	$ 25.67
1F	26.0	705	18.33
No. 1C	66.1	525	34.70
No. 2C	65.5	207	13.56
No. 3A	44.0	177	7.79
Total	237.5		100.05

[a] From Hanks 1976.
[b] From Lemsky 1985.

Stumpage prices can be obtained by subtracting conversion costs and a margin for profit and risk. In this example, the lumber grade yields (Hanks 1976) and current lumber prices (Lemsky 1985) for 126 northern red oaks resulted in an average lumber value of $361 per thousand board feet (M bf). If conversion costs and a margin for profit and risk equal $220 per M bf, the stumpage price for 18-inch red oaks is $141 per M bf. This could be expanded to include trees in all d.b.h. classes for red oak and result in one average stumpage price for the species. As lumber prices and conversion costs change, individual-tree values and average stumpage prices can be adjusted accordingly.

Discussion

Butt-log grade distributions can be used to estimate individual-tree and stand values when actual grade data are not available. Regression equations or grade distribution tables predict the percentage of trees in each grade for a particular species and diameter class. This information provides a basis for estimating lumber grade yields, total lumber value, and the residual stumpage value for any number of sawtimber trees. The user should first develop a stand table that indicates the number of trees by species and d.b.h., and an estimate of average merchantable height.

The regression equations can be used to incorporate grade distributions into stand value computer programs. An important advantage of using butt-log grades when estimating stand value is that dollar values include the effect of timber quality and current lumber prices. In cases involving timber trespass, for example, the grade distributions can be used to estimate the total value of losses based on the probable grade of the trees cut. Similarly, the distributions provide a basis for computing potential stand value from projections of individual-tree diameter growth and the accompanying changes in grade. In both examples, the value estimates include the effect of stem quality as well as species, tree size, and total volume.

Because butt-log grade data for this study were collected in unmanaged, central Appalachian hardwood stands throughout West Virginia, the distributions may have limited use outside the general study area. In addition, intensive timber management practices may result in grade distributions significantly different from those presented here. The user should be aware that such differences may occur and that additional grade distributions may be needed for some stands.

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