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PREDICTED CUBIC-FOOT YIELDS OF SAWMILL PRODUCTS FOR BLACK CHERRY TREES

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Abstract. Equations and tables for estimating the cubic-foot volumes of lumber, sawdust, and sawmill residue for black cherry trees are presented. Also included are cubic-foot and board-foot predictions for the sawlog portion of the trees.

The cubic foot is now the accepted unit of measure for U.S. Forest Service timber appraisals, and it is one of the primary units of measure used by forest industries. The cubic-foot unit can be used to measure not only lumber yields but other product yields as well. In a previous study I developed predicted cubic-foot yields of lumber, sawdust, and sawmill residue for 10 hardwood species (Hanks 1977). Cubic-foot volumes of the sawlog portion of these tree species also were presented. Comparable information for black cherry is now available for sawmills with either band or circular headsaws. I have also included board-foot volumes, lumber recovery factors (LRF), and lumber recovery ratios (LRR).

METHODS

A total of 192 black cherry trees from three locations were selected for this study. Diameter at breast height (dbh) and merchantable height were recorded prior to bucking. Merchantable height begins at the top of a 1-foot stump and ends where local-use material stops.[1]

[1] A local-use class log must scale at least 8 inches in diameter, inside bark (dib), by 8 feet long and it must be one-third sound.

The felled trees were bucked and log lengths ranged from 8 to 16 feet. Log length and both end diameters were recorded and later used to determine the cubic-foot volume of the bucked sections. The butt log was divided at breast height and treated as two sections. All sections were considered to be conoid in shape and volume was computed using the following equation:

Sectional cubic-foot volume = .001818 $(D^2 + Dd + d^2)L$

D = inside bark diameter of large end

d = inside bark diameter of small end

L = log length

Sectional volumes were summed to obtain the cubic-foot volume for the sawlog portion of each tree (gross tree volume).

Logs from 69 trees were sawed at a band mill, and logs from the remaining 123 trees were sawed at two circular mills. Nominal length, width, and thickness of each board were recorded and adjusted to industry averages developed in the previous study. The adjusted lumber dimensions were used to compute the cubic-foot volume of each board, and board volumes were summed by tree.

For each tree, we computed the cubic-foot volume of solid wood that was converted to sawdust. Saw kerfs of 10/64 and 17/64 were used for band and circular mills, respectively.

Sawmill residue volume—slabs, edgings, and end trims—was obtained for each tree by subtracting the volumes of lumber and sawdust from the volume of sawlogs.

During the sawing process a board-foot tally was maintained, and this provided actual total board-foot volume by tree.

RESULTS

Prediction equations

Standard regression procedures were used to calculate prediction equations of the following form:

volume = a + b $(\text{dbh})^2$ + c (merchantable height) + d (dbh^2 x merchantable height)

Dependent variables include cubic-foot volume of lumber, sawdust, sawmill residue, and the gross tree, and board-foot volume of lumber.

Regression coefficients and related data are presented in Table 1. Gross tree volume was not related to mill type. All other dependent variables were, however, and this is a reflection of saw kerf and perhaps sawing procedures. Therefore, except for gross tree volume, separate equations are presented for band and circular mills.

Cubic-foot yields

Table 2 contains the predicted cubic-foot volumes of lumber, sawdust, sawmill residue, and the gross tree for black cherry trees measured to the nearest 1/2 log. For greater accuracy, measure the trees to the nearest foot and use the equations in Table 1. The boxed areas indicate the size classes included in the tree sample. These volumes were obtained by solving the regression equations for various tree sizes.

Board-foot yields, LRF, LRR

Solutions to the board-foot equations are presented in Table 3 along with lumber recovery factors (LRF), and lumber recovery ratios (LRR). The terms LRF and LRR have become familiar in recent years. LRF represents the board feet of lumber recovered per cubic foot of logs sawed and has been described by Fahey and Woodfin (1976) as a substitute for overrun. LRR equals the cubic volume of lumber recovered per cubic volume of logs sawed.

The product of LRF and cubic-foot volume of logs represents the predicted board-foot volume of lumber. The cubic-foot volume of logs may be obtained from Table 2 by summing the volumes of lumber, sawdust, and sawmill residue. A tree's log volume differs from its gross tree volume and must be obtained by summation. Gross tree volume includes the volume of cull sections bucked from the sawlog portion of a tree and left in the woods. Therefore, we expect gross tree volume to be greater than the summed volume of lumber, sawdust, and sawmill residue.

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Table 1.—Regression coefficients and related statistics

Volume of:	Unit of measure	Independent variable							Means		
		Constant	Dbh^2	Merchantable height	Dbh^2 x merchantable height	Number of trees	SE[a]	R^2	Dbh (inches)	Merchantable height (feet)	Volume
Gross tree	cubic foot	0.5967	0.032981	-0.0065	0.002695	192	3.7	0.97	17.4	35.7	42.3
Lumber											
band	cubic foot	-.1569	.029332	-.0895	.001867	69	3.1	.97	17.0	37.5	28.1
circular	cubic foot	2.0629	.016514	-.1650	.001881	123	2.7	.95	17.6	34.7	23.3
band	board foot	-5.4792	.320763	-.9044	.019239	69	31.7	.97	17.0	37.5	290.5
circular	board foot	20.8308	.177764	-1.7420	.019574	123	29.6	.94	17.6	34.7	242.5
Sawdust											
band	cubic foot	-.4561	.005474	.0187	.000209	69	.5	.95	17.0	37.5	4.4
circular	cubic foot	1.3147	.001420	-.0530	.000584	123	.7	.95	17.6	34.7	6.6
Sawmill residue											
band	cubic foot	-.7673	.006312	.1133	.000374	69	2.2	.80	17.0	37.5	9.9
circular	cubic foot	-2.6851	.017791	.2183	.000089	123	2.6	.67	17.6	34.7	11.7

[a]Standard error of the estimate.

Table 2.—Predicted yields of sawmill products from black cherry trees, in cubic feet

Dbh (inches)	Product	Band mill 16	Band mill 24	Band mill 32	Band mill 40	Band mill 48	Band mill 56	Circular mill 16	Circular mill 24	Circular mill 32	Circular mill 40	Circular mill 48	Circular mill 56
		Merchantable height (feet)											
10	Lumber	4.3	5.1	5.9	6.7	7.4	8.2	4.1	4.3	4.5	4.6	4.8	5.0
	Sawdust	.7	1.0	1.4	1.7	2.0	2.3	1.5	1.6	1.6	1.7	1.7	1.8
	Residue	2.3	3.5	4.7	5.9	7.1	8.3	2.7	4.5	6.4	8.2	10.0	11.8
	Gross tree	8.1	10.2	12.3	14.4	16.5	18.6	8.1	10.2	12.3	14.4	16.5	18.6
11	Lumber	5.6	6.7	7.8	8.8	9.9	11.0	5.1	5.6	6.1	6.6	7.1	7.6
	Sawdust	.9	1.3	1.6	2.0	2.3	2.7	1.8	1.9	2.1	2.2	2.3	2.5
	Residue	2.5	3.8	5.1	6.3	7.6	8.9	3.1	5.0	6.8	8.6	10.5	12.3
	Gross tree	9.7	12.3	14.8	17.4	19.9	22.5	9.7	12.3	14.8	17.4	19.9	22.5
12	Lumber	6.9	8.4	9.8	11.2	12.7	14.1	6.1	7.0	7.8	8.7	9.5	10.5
	Sawdust	1.1	1.5	1.9	2.3	2.7	3.1	2.0	2.3	2.5	2.8	3.0	3.3
	Residue	2.8	4.2	5.5	6.8	8.2	9.5	3.6	5.4	7.3	9.1	11.0	12.8
	Gross tree	11.5	14.5	17.6	20.6	23.7	26.7	11.5	14.5	17.6	20.6	23.7	26.7
13	Lumber	8.4	10.2	12.0	13.8	15.6	17.5	7.3	8.5	9.7	11.0	12.2	13.4
	Sawdust	1.3	1.8	2.2	2.6	3.1	3.5	2.3	2.7	3.0	3.4	3.7	4.1
	Residue	3.1	4.5	5.9	7.4	8.8	10.2	4.1	5.9	7.8	9.7	11.5	13.4
	Gross tree	13.4	16.9	20.5	24.1	27.7	31.3	13.4	16.9	20.5	24.1	27.7	31.3
14	Lumber	10.0	12.2	14.4	16.6	18.9	21.1	8.6	10.2	11.8	13.4	15.1	16.7
	Sawdust	1.6	2.0	2.5	3.0	3.5	4.0	2.6	3.1	3.6	4.1	4.5	5.0
	Residue	3.5	4.9	6.4	7.9	9.4	10.9	4.6	6.5	8.3	10.2	12.1	14.0
	Gross tree	15.4	19.6	23.8	27.9	32.1	36.3	15.4	19.6	23.8	27.9	32.1	36.3
15	Lumber	11.7	14.4	17.0	19.7	22.3	25.0	9.9	12.0	14.0	16.1	18.2	20.2
	Sawdust	1.8	2.4	2.9	3.4	3.9	4.5	2.9	3.5	4.1	4.8	5.4	6.0
	Residue	3.8	5.4	7.0	8.6	10.1	11.7	5.1	7.0	8.9	10.9	12.8	14.7
	Gross tree	17.6	22.4	27.2	32.0	36.8	41.6	17.6	22.4	27.2	32.0	36.8	41.6
16	Lumber	13.6	16.7	19.8	22.9	26.0	29.1	11.4	13.9	16.4	19.0	21.5	24.0
	Sawdust	2.1	2.7	3.3	3.8	4.4	5.0	3.2	4.0	4.8	5.5	6.3	7.1
	Residue	4.2	5.9	7.5	9.2	10.9	12.6	5.7	7.7	9.6	11.5	13.4	15.4
	Gross tree	20.0	25.4	30.9	36.7	41.8	47.3	20.0	25.4	30.9	36.7	41.8	47.3
17	Lumber	15.5	19.1	22.7	26.3	29.9	33.5	12.9	15.9	19.0	22.0	25.0	28.0
	Sawdust	2.4	3.0	3.7	4.3	4.9	5.6	3.6	4.5	5.4	6.4	7.3	8.2
	Residue	4.6	6.4	8.1	9.9	11.7	13.5	6.4	8.3	10.3	12.2	14.2	16.1
	Gross tree	22.5	28.7	34.8	41.0	47.2	53.4	22.5	28.7	34.8	41.0	47.0	53.4

18	Lumber	17.6	21.7	25.8	30.0	34.1	38.2	14.5	18.1	21.6	25.2	28.7	32.3
	Sawdust	2.7	3.4	4.1	4.8	5.5	6.2	4.0	5.0	6.1	7.2	8.3	9.4
	Residue	5.0	6.9	8.8	10.7	12.5	14.4	7.0	9.0	11.0	13.0	14.9	16.9
	Gross tree	25.1	32.1	39.0	45.9	52.9	59.8	25.1	32.1	39.0	45.9	52.9	59.8
19	Lumber	19.8	24.5	29.1	33.8	38.5	43.2	16.2	20.4	24.5	28.6	32.7	36.8
	Sawdust	3.0	3.8	4.5	5.3	6.0	6.8	4.4	5.6	6.9	8.1	9.4	10.7
	Residue	5.5	7.5	9.5	11.4	13.4	15.4	7.7	9.7	11.8	13.8	15.8	17.8
	Gross tree	28.0	35.7	43.4	51.2	58.9	66.6	28.0	35.7	43.4	51.2	58.9	66.6
20	Lumber	22.1	27.4	32.6	37.9	43.1	48.4	18.1	22.8	27.5	32.2	36.9	41.6
	Sawdust	3.4	4.2	5.0	5.8	6.6	7.5	4.8	6.2	7.7	9.1	10.6	12.0
	Residue	6.0	8.1	10.2	12.3	14.4	16.5	8.5	10.5	12.6	14.6	16.6	18.6
	Gross tree	30.9	39.5	48.1	56.6	65.2	73.8	30.9	39.5	48.1	56.6	65.2	73.8
21	Lumber	24.5	30.4	36.3	42.1	48.0	53.9	20.0	25.3	30.6	35.9	41.2	46.6
	Sawdust	3.7	4.6	5.5	6.4	7.3	8.2	5.2	6.8	8.5	10.1	11.8	13.4
	Residue	6.5	8.7	10.9	13.1	15.4	17.6	9.3	11.3	13.4	15.5	17.5	19.6
	Gross tree	34.1	43.5	53.0	62.4	71.9	81.3	34.1	43.5	53.0	62.4	71.9	81.3
22	Lumber	27.1	33.6	40.1	46.6	53.1	59.6	22.0	27.9	33.9	39.9	45.8	51.8
	Sawdust	4.1	5.1	6.0	7.0	7.9	8.9	5.7	7.5	9.4	11.2	13.0	14.9
	Residue	7.0	9.4	11.7	14.1	16.4	18.8	10.1	12.2	14.3	16.4	18.5	20.6
	Gross tree	37.3	47.7	58.1	68.5	78.9	89.2	37.3	47.7	58.1	68.5	78.9	89.2
23	Lumber	29.7	36.9	44.1	51.3	58.5	65.7	24.1	30.7	37.4	44.0	50.6	57.3
	Sawdust	4.5	5.5	6.6	7.6	8.6	9.7	6.2	8.2	10.3	12.3	14.4	16.4
	Residue	7.6	10.0	12.5	15.0	17.5	20.0	11.0	13.1	15.2	17.3	19.5	21.6
	Gross tree	40.8	52.1	63.5	74.8	86.2	97.5	40.8	52.1	63.5	74.8	86.2	97.5
24	Lumber	32.5	40.4	48.3	56.2	64.1	71.9	26.3	33.6	41.0	48.3	55.7	63.0
	Sawdust	4.9	6.0	7.1	8.3	9.4	10.5	6.7	8.9	11.2	13.5	15.7	18.0
	Residue	8.1	10.8	13.4	16.0	18.6	21.3	11.9	14.0	16.2	18.3	20.5	22.7
	Gross tree	44.3	56.7	69.1	81.4	93.8	106.2	44.3	56.7	69.1	81.4	93.8	106.2

Table 3.—Predicted lumber yields, in board feet, and lumber recovery factors (LRF) and ratios (LRR)

Dbh (inches)	Item	Merchantable height (feet)											
		16	24	32	40	48	56	16	24	32	40	48	56
		BAND MILL						CIRCULAR MILL					
10	Lumber	43	51	59	67	76	84	42	44	46	47	49	51
	LRF	5.9	5.3	4.9	4.7	4.6	4.5	5.1	4.2	3.7	3.2	3.0	2.7
	LRR	.59	.53	.49	.47	.45	.44	.49	.41	.36	.32	.29	.27
11	Lumber	56	67	79	90	102	113	52	57	62	67	72	77
	LRF	6.2	5.7	5.4	5.3	5.2	5.0	5.2	4.6	4.1	3.9	3.6	3.4
	LRR	.62	.57	.54	.51	.50	.49	.51	.45	.41	.38	.36	.34
12	Lumber	71	85	100	115	130	145	64	72	81	89	98	107
	LRF	6.6	6.0	5.8	5.7	5.5	5.4	5.5	4.9	4.6	4.3	4.2	4.0
	LRR	.64	.60	.57	.55	.54	.53	.52	.48	.44	.42	.40	.39
13	Lumber	86	105	124	143	161	180	76	88	101	114	126	139
	LRF	6.7	6.4	6.2	6.0	5.9	5.8	5.5	5.1	4.9	4.7	4.6	4.5
	LRR	.66	.62	.60	.58	.57	.56	.53	.50	.47	.46	.45	.43
14	Lumber	103	126	149	172	195	218	89	106	123	139	156	173
	LRF	6.8	6.6	6.4	6.3	6.1	6.1	5.6	5.4	5.2	5.0	4.9	4.8
	LRR	.66	.14	.62	.60	.59	.59	.54	.52	.50	.48	.48	.47
15	Lumber	121	149	176	204	231	258	103	125	146	167	189	210
	LRF	7.0	6.7	6.5	6.4	6.4	6.3	5.8	5.6	5.4	5.3	5.2	5.1
	LRR	.68	.65	.63	.62	.61	.61	.55	.53	.52	.51	.50	.49
16	Lumber	141	173	205	237	270	302	119	145	171	197	223	249
	LRF	7.1	6.8	6.7	6.6	6.5	6.5	5.9	5.7	5.6	5.5	5.4	5.4
	LRR	.68	.66	.65	.64	.63	.62	.56	.54	.53	.53	.52	.52

17	Lumber	162	199	236	273	311	348	135	166	197	229	260	291
	LRF	7.2	7.0	6.8	6.7	6.7	6.6	5.9	5.8	5.7	5.6	5.6	5.6
	LRR	.69	.67	.66	.65	.64	.64	.56	.55	.55	.54	.54	.54
18	Lumber	184	226	269	312	354	397	152	189	226	262	299	336
	LRF	7.3	7.1	7.0	6.9	6.8	6.8	6.0	5.9	5.8	5.8	5.8	5.7
	LRR	.70	.68	.67	.66	.65	.65	.57	.56	.56	.56	.55	.55
19	Lumber	207	255	304	352	400	449	170	213	255	298	341	383
	LRF	7.3	7.1	7.1	7.0	6.9	6.9	6.0	6.0	5.9	5.9	5.9	5.9
	LRR	.70	.68	.68	.67	.66	.66	.57	.57	.57	.57	.56	.56
20	Lumber	231	286	340	394	449	503	189	238	287	335	384	433
	LRF	7.3	7.2	7.1	7.0	7.0	6.9	6.0	6.0	6.0	6.0	6.0	6.0
	LRR	.70	.69	.68	.68	.67	.67	.58	.58	.58	.58	.58	.58
21	Lumber	257	318	379	439	500	560	209	265	320	375	430	485
	LRF	7.4	7.3	7.2	7.1	7.1	7.0	6.1	6.1	6.1	6.1	6.1	6.1
	LRR	.71	.70	.69	.68	.68	.68	.58	.58	.58	.58	.58	.59
22	Lumber	284	352	419	486	553	621	231	292	354	416	478	540
	LRF	7.4	7.3	7.2	7.2	7.1	7.1	6.1	6.1	6.1	6.2	6.2	6.2
	LRR	.71	.70	.69	.69	.69	.68	.58	.59	.59	.59	.59	.59
23	Lumber	313	387	461	535	609	683	253	322	390	459	528	597
	LRF	7.5	7.4	7.3	7.3	7.2	7.2	6.1	6.2	6.2	6.2	6.2	6.3
	LRR	.71	.70	.70	.69	.69	.69	.58	.59	.59	.60	.60	.60
24	Lumber	342	424	505	586	668	749	276	352	428	505	581	657
	LRF	7.5	7.4	7.3	7.3	7.3	7.2	6.1	6.2	6.3	6.3	6.3	6.3
	LRR	.71	.71	.70	.70	.70	.69	.59	.59	.60	.60	.61	.61

Gross tree volume is less than the summed log volume for several dbh and height classes in Table 2. This occurred because of small differences between the actual gross tree volumes of the trees sawed at the band mill and those sawed at the circular mills.

Note that LRF and LRR differ by a factor of about 10. This indicates that about 10 board feet of lumber were sawed from each cubic foot of actual lumber.

DISCUSSION

Sawtimber has traditionally been sold using the board-foot measure. At first look, this is logical because most sawlogs have been converted to lumber which has been and still is measured and sold in board-foot units. The Forest Service is in the process of converting all timber sales to cubic feet from board feet. Cubic-foot measure is more consistent than board-foot measure for relating volume of round material to volume of end products.

In the earlier report (Hanks 1977), I found that the volume of sawmill residue was unaffected by type of headsaw. However, the circular mills selected to saw the black cherry logs produced more sawmill residue than the band mills. Therefore, separate equations were developed for predicting sawmill residue. Possible reasons for differences in the amount of sawmill residue can only be hypothesized, and they include the following:

- The saw kerf at the band mill was less than 10/64-inch.
- The saw kerf at the circular mills was greater than 17/64-inch.
- The band mill was more efficient.

Two circular mills were used and both were chosen because they demonstrated good practices. The band mill represented here was more efficient than the circular mills and should be considered "better than average."

In the future it may be possible to predict yields of sawmill products for various combinations of saw kerf, lumber thickness, log size, and taper. Until more work is completed, we believe that these tables provide a reasonable estimate of yields from band and circular mills.

Results of field trials indicate that real differences between the predicted and actual volumes will occur (Hanks 1980). However, if lumber is sized and edged properly, actual lumber volume will equal or exceed predicted volume and sawmill residue volume will be minimized.

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