A Volume Table for Central Oklahoma Stream Bottom Hardwoods

David W. Robinson
David L. Weeks

Bulletin B-662
November, 1968

AGRICULTURAL RESEARCH
OKLAHOMA STATE UNIVERSITY

A Volume Table for Central Oklahoma Stream Bottom Hardwoods

David W. Robinson and David L. Weeks*

The emerging importance of the forest products industry in Oklahoma has indicated a demand for improved resource information. Before orderly use of any resource can be planned, inventory data must be available. Industry is not willing to invest in plant facilities without reasonable assurances of adequate supplies of available raw material.

In order to have such resource data availble it is necessry to develop the basic relationships which are peculiar to the local situation. Unmanaged, randomly exploited, stands of timber have many differences. In the case of the Central stream bottom hardwoods such factors as species mix, site, frequency of flooding, presence of grazing, past cutting practices, etc., all tend to render normally accepted, wide use, volume tables unusable.

In 1965 the Oklahoma Agricultural Experiment Station undertook a study to develop an aerial volume table for the hardwood stands along the major and secondary stream bottoms in central Oklahoma. One hundred fifty, one-acre circular plots were established on the six major drainages and their tributaries. Figure 1 shows the area of the study and lists the counties to which the volume tables apply. The development of these volume tables was a necessary first step for the project since it was found that none of the standard volume tables produced satisfactory results.

Procedures

The information obtained pertaining to the development of the tree volume table was: species, diameter breast height, double bark thickness at DBH, merchantable length expressed as 8-foot logs, and diameter outside bark at the small end of each log.

Many trees in the central Oklahoma stream-bottom forests do not contain a full standard 16-foot log. Based upon a suggestion by one of the State's hardwood sawmill operators[1] a decision was made to call the basic log length eight feet. These logs have been designated B-logs to differentiate from the standard log which is sixteen feet long. A

---

*Assistant Professor, Department of Forestry, and Professor, Department of Mathematics and Statistics, Oklahoma State University.

Research conducted under Oklahoma Agricultural Experiment Station project MS-1236.

[1] Mr. John C. Burwell, Burwell Lumber Company, Idabel, Oklahoma.

forty-foot fiber glass measuring pole was used to determine B-log length precisely on all trees. Using a prismatic dendrometer[2] the outside bark measurement was determined on every tree at the end of each B-log. In addition the diameter at the upper level of utilization was obtained.

Cubic volumes were determined for each B-log length and fraction thereof using the Smalian average diameter, cubic volume formula, and these volumes were summed for each tree.

A quadratic equation was fitted to the data for each diameter class expressing the mean volume as a function of B-log length. These equations appear in Appendix Table 1. The tabular estimates from the quadratic equations were then analyzed by cubic volume and diameter class within B-log length in order to regularize the values and eliminate inequities. The resulting volume table was plotted on 2-cycle logarithmic graph paper (Spurr, 1952; Meyer, 1953) to evaluate the reliability of the table.

In order to render the cubic volume table more useful, ratios were developed for converting cubic volume to International ¼-inch, Scribner, and Doyle sawlog volumes. Widely accepted published form class volume tables were used to develop these ratios for each of three form class levels considered to be expressions of high, medium, and low taper for the particular forests encountered in the study.[3]

Results

Table 1 gives the cubic volume of trees 12" DBH and larger by B-logs. These are ouside bark volumes and were arrived at by using the following regression equations:

1. For 1 B-log $\hat{Y} = -13.93 + 1.33X + .0125X^2$
2. For 2 B-logs $\hat{Y} = -4.87 + .69X + .0500X^2$
3. For 3 B-logs $\hat{Y} = -8.80 + 1.27X + .0600X^2$
4. For 4 B-logs $\hat{Y} = -1.30 + .62X + .1000X^2$
5. For 5 B-logs $\hat{Y} = 13.46 - .83X + .1600X^2$

where $\hat{Y}$ = the estimated volume in cubic feet

X = any selected level of DBH in inches

These formulas were developed using the cubic volume and diameters taken from the tabular values produced by the regression analysis. The calculated estimates and their associated standard errors are found in Appendix Table 2.

[2]Prismatic dendrometer developed and manufactured by P. R. Wheeler, Forestry Consultant, New Orleans, Louisiana.

[3] a. Mesavage, Clement. Tables for Estimating Cubic Foot Volumes of Timber. O.P. 111. Southern Forest Exper. Sta., USDA. 1947.

b. Mesavage, Clement and James W. Girard. Tables for Estimating Board Foot Volume of Timber. USDA Forest Service (out of print).

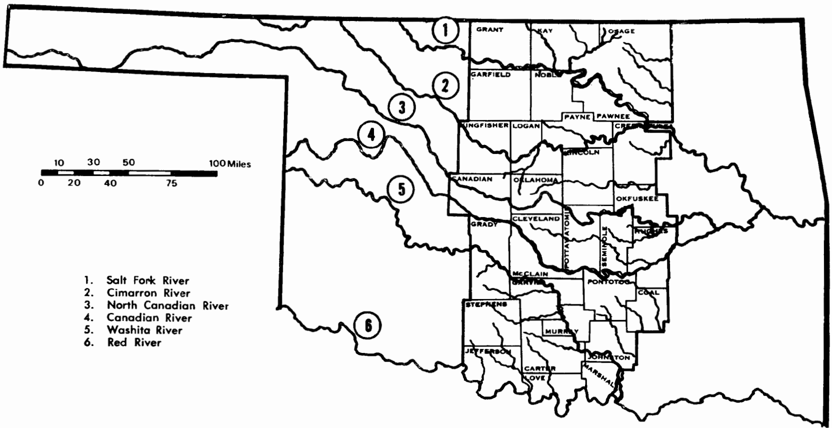

Figure 1. Central Oklahoma stream bottoms utilized for this study.

Table 1. Cubic Volumes For Central Oklahoma Stream Bottom Hardwoods by DBH and B-logs

DBH inches	1 B-log	2 B-logs	3 B-logs	4 B-logs	5 B-logs
12	3.82	10.61	15.08	20.30	26.54
13	5.47	12.55	17.85	23.40	29.71
14	7.14	14.59	20.74	26.70	33.20
15	8.83	16.73	23.75	30.20	37.01
16	10.55	18.97	26.88	33.90	41.14
17	12.29	21.31	30.13	37.80	45.59
18	14.06	23.75	33.50	41.90	50.36
19	15.85	26.29	36.99	46.20	55.45
20	17.67	28.93	40.60	50.70	60.86
21	19.51	31.67	44.33	55.40	66.59
22	21.38	34.51	48.18	60.30	72.64
23	23.27	37.45	52.15	65.40	79.01
24	25.19	40.49	56.24	70.70	85.70
25	27.13	43.63	60.45	76.20	92.71
26	29.10	46.87	64.78	81.90	100.04
27	31.09	50.21	69.23	87.80	107.69
28	33.11	53.65	73.80	93.90	115 66
29	35.15	57.19	78.49	101.50	123.95
30	37.22	60.83	83.30	106.70	132.56
31	39.31	64.57	88.23	113 40	141.49
32	41.43	68.41	93.28	120.30	150.74
33	43.57	72.35	98.45	127.40	160.31

The graphs for the equations appear in Figure 1 with the associated 95 percent confidence intervals listed in Appendix Table 3. It can be observed that one could have more confidence in estimates clustered about the mean diameter of 22-23 inches. However, on a percentage

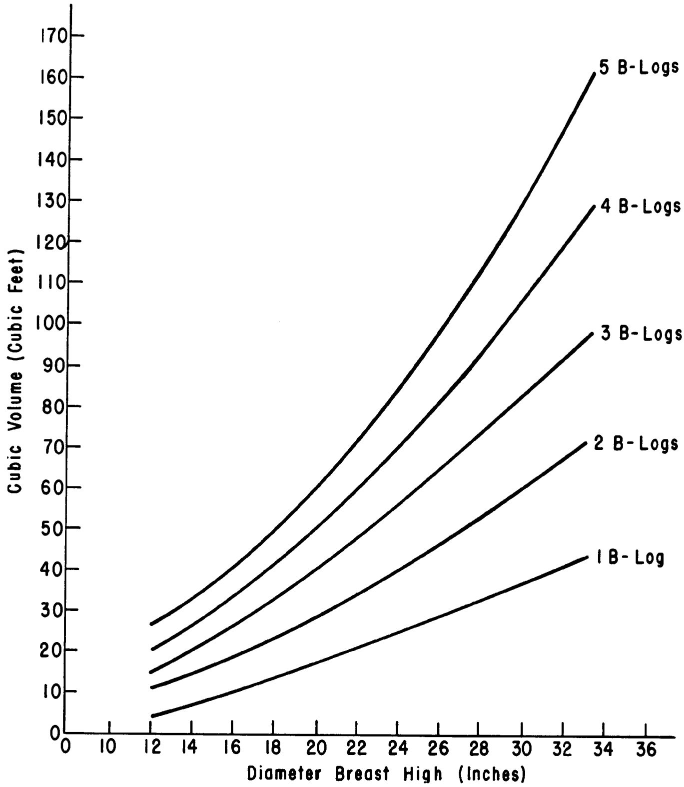

Figure 2. Relationship between cubic volume and diameter breast high within B-logs.

basis any estimates made using this volume table should be wholly acceptable particularly through the 4 B-log range. The increasing error at the extremes of the table and in the 5 B-log column is due to small numbers of trees in these classes.

Conversion to Usable Units

Board foot volumes for trees by DBH and B-logs in terms of the most generally used volume units is given in Table 2. These tables have been developed by applying board foot-cubic foot ratios to the cubic volume table developed from the study. The values can be used across almost all timber taper situations that might be encountered in the stream-bottom hardwood type in the sampled area. If the average

Table 2. Board foot volumes for trees by DBH and B-logs in terms of the most generally used volume units

	Doye Volume Table FC-65-751[1]					Scribner Volume Table FC-65-752[2]					International Volume Table FC-65-753[3]				
DBH inches	1 B-log	2 B-logs	3 B-logs	4 B-ogs	5 B-logs	1 B-log	2 B-logs	3 B-logs	4 B-logs	5 B-logs	1 B-log	2 B-logs	3 B-logs	4 B-logs	5 B-logs
12	18	51	72	97	127	22	62	87	118	154	25	69	98	132	172
13	26	60	86	112	143	32	73	104	136	172	36	82	116	152	193
14	34	70	100	128	159	41	85	120	155	193	46	95	135	174	216
15	42	80	114	145	178	51	97	138	175	215	57	108	154	196	241
16	51	91	129	163	197	61	110	156	197	239	69	123	175	220	267
17	59	102	145	181	219	71	124	175	219	264	80	138	196	246	296
18	67	114	161	201	242	82	138	194	243	292	91	154	218	272	327
19	76	126	178	222	266	92	152	215	268	322	103	171	240	300	360
20	85	139	195	243	292	102	168	235	294	353	115	188	264	330	396
21	94	152	213	266	320	113	184	257	321	386	127	206	288	360	433
22	103	166	231	289	349	124	200	279	350	421	139	224	313	392	472
23	112	180	250	314	379	135	217	302	379	458	151	243	339	425	514
24	121	194	270	339	411	146	235	326	410	497	164	263	366	460	557
25	130	209	290	366	445	157	253	351	442	538	176	284	393	495	603
26	140	225	311	393	480	169	272	376	475	580	189	305	421	532	650
27	149	241	332	421	517	180	291	402	509	625	202	326	450	571	700
28	159	258	354	451	555	192	311	428	545	671	215	349	480	610	752
29	169	275	377	487	595	204	332	455	589	719	228	372	510	660	806
30	179	292	400	512	636	216	353	483	619	769	242	395	541	694	862
31	189	310	424	544	679	228	375	512	658	821	256	420	573	737	920
32	199	328	448	577	724	240	397	541	698	874	269	445	606	782	980
33	209	347	473	612	769	253	420	571	739	930	283	470	640	828	1042

[1] Ratio: 4.8 board feet per cubic foot.
[2] Ratio: 5.8 board feet per cubic foot.
[3] Ratio: 6.5 board feet per cubic foot.

Girard form class[4] for a stand is less than 65 or greater than 75, the tabular values should be adjusted up or down accordingly. For each five points above or below these limits the tables should be adjusted 5 percent.

Doyle volume is the most commonly used unit of exchange in Oklahoma in spite of the fact that it is the most inaccurate estimator of the three tables presented. Estimates of mill production made on the average size tree in the central Oklahoma stream bottoms will be low. Users of this table or any other volume table should be aware of the inequities inherent to volume table use and assure themselves that the unit price of exchange is reflective of the real value.

Scribner volume is the basic unit of exchange used by the U. S. Forest Service. While it is some better than the Doyle rule, it will overrun[5] on most logs also. While there is not much prospect of this rule being used in the area covered by the study, there is a chance that an operator accustomed to dealing with public sales might want to use this rule in acquiring stumpage and it is therefore included.

The International ¼-inch volume table will produce the best estimate of mill production across all diameters and lengths of logs. It is not being used anywhere in the State to the author's knowledge, but due to its ability to predict mill scale it should be used as the standard. It will produce the most satisfactory results of any of the three.

Use of Tables

In order to determine the volume per acre of a particular tract of timber using these volume tables, one should design a field inventory procedure. Sample units such as horizontal points or fixed radius plots can be used depending upon the particular objective and the level of sampling knowledge of the user. From the cruise data one should develop the stand table information. A stand table is a table listing the numbers of trees by diameter and length class expressed on a per acre basis. Stand table categories should be chosen carefully so that classifications are not used that do not produce highly useful information.

Once the stand table is developed all that is necessary is to multiply the stand table entries by the appropriate tabular entries from the selected volume table and sum the totals in the desired combination of groups.

---

[4] Girard form class $\frac{\text{DIB @ 17.3}'}{\text{DBH}} \times 100$ with the decimal dropped.

[5] Overrun $= \frac{\text{Mill scale}}{\text{Log scale}} \times 100$

Summary

The general approach of this study, precise determination of tree volume by using cubic content and ratios to convert to usable terms, is a rather general standard for projects of this sort. It is a relatively simple matter to modify cubic estimates to any form desirable, even to cordwood volumes if needed. Cubic volume is by far the most stable of the units currently in use for timber estimation.

The volume tables here presented represent the best local standard volume values that can be used throughout the Central Oklahoma area. The field data was collected from a sufficiently large sample so the tables have broad general utility.

The greatest caution that needs to be exerted when using these tables is with their use in pure even aged stands, such as certain stands of cottonwood, which have developed on "new land." The use of these tables is inappropriate for this type stand. As long as the tables are applied to the mixed hardwood stands they will provide excellent results.

Bibliography

1. Meyer, Arthur H. *Forest Mensuration.* 1953
2. Spurr, Stephen H. *Forest Inventory,* Ronald Press. 1952.

APPENDIX TABLES

Appendix Table 1. Regression Formulas from Raw Data

DBH inches	Equations
12	$Y = 0.30338 + 0.65771X + 0.00195X^2$
14	$Y = 1.43922 + 0.80808X - 0.00076X^2$
15	$Y = 2.05042 + 0.92019X - 0.00148X^2$
16	$Y = 2.13015 + 1.07506X - 0.00370X^2$
17	$Y = 0.97466 + 1.37233X - 0.00784X^2$
18	$Y = 0.04267 + 1.62840X - 0.00979X^2$
19	$Y = 2.66420 + 1.51544X - 0.00394X^2$
20	$Y = 3.20257 + 1.73623X - 0.00862X^2$
21	$Y = 2.93824 + 1.93923X - 0.00955X^2$
22	$Y = 5.35306 + 1.87890X - 0.00496X^2$
23	$Y = 4.61582 + 2.13373X - 0.00590X^2$
24	$Y = 18.06672 + 0.99772X - 0.02310X^2$
25	$Y = 2.02214 + 3.19425X - 0.03072X^2$
26	$Y = -0.41633 + 3.66930X - 0.03686X^2$
27	$Y = 11.18786 + 2.41182X - 0.00549X^2$
28	$Y = 39.21337 + 0.41261X + 0.04407X^2$
29	$Y = 23.61395 + 1.13067X + 0.05519X^2$
30	$Y = 50.27165 - 0.11877X + 0.05400X^2$
31	$Y = -3.98524 + 5.56804X - 0.06357X^2$
32	$Y = 36.15796 + 0.71921X + 0.06956X^2$
33	$Y = 2.62179 + 4.57986X - 0.02708X^2$

Appendix Table 2. Cubic Volume with Associated Standard Errors for each DBH X B-log[1]

DBH inches	1 B-log		2 B-logs		3 B-logs		4 B-logs		5 B-logs	
	Volume	Std. Error	Volume	Std. Error	Volume	Std. Error	Volume	Std. Error	Volume	Std. Error
12	5.69	.043	11.32	.043	17.21	.136		.425		.883
13	6.66	.051	12.63	.048	18.60	.054	24.57	.068		.087
14	7.85	.145	14.17	.089	20.40	.106	26.52	.244	32.55	.584
15	9.32	.207	16.40	.105	23.28	.124	29.98	.253	36.49	.615
16	10.49	.300	18 39	.147	25.80	.183	32.75	.250	39.22	.548
17	11.45	.385	20 93	.197	29.40	.246	36.86	.336	43.32	.738
18	12.44	.555	23.59	.244	33.49	.284	42.13	.428	49.52	1.044
19	14.54	.661	25.90	.331	36.77	.375	47.13	.613	56.98	1.492
20	16.54	.839	28.78	.430	39.91	.485	49.93	.602	58.86	1.335
21	17.84	1.392	31.52	.643	43.98	.703	55.21	.748	65.22	1.655
22	20.07	1.300	34.15	.585	47.59	.680	60.40	.845	72.57	2.011
23	21.31	1.497	37.24	.896	52.43	.958	66.85	1.728	80.53	4.204
24	27.53	2.799	39.94	1.268	55.32	1.456	73.64	1.870	94.93	4.529
25	25.61	3.410	45.27	1.455	60.99	1.696	72.78	2.230	80.64	5.420
26	26.58	2.895	48.86	1.778	66.42	2.129	79.26	3.639		9.251
27	30.13	5.159	48.37	2.536	65.91	3.140	82.75	3.159	98.88	6.390
28		10.707	57.10	3.037	74.50	3.144	97.55	3.720	126.24	8.035
29	36.19	9.059	55.83	3.687	82.54	4.002	116.31	7.196		20.126
30		13.486	62.19	4.294	78.52	5.366	101.77	5.427	131.92	11.329
31	36.49	10.413	68.83	8.812	93.03	8.185	109.09	11.698		34.432
32	46.36	10.132	65.47	5.066	93.48	5.066	130.40	5.066	176.22	10.132
33	37.53	18.577	68.97	8.124	96.94	7.331	121.45	18.577		48.942

[1] The estimated standard errors of the "tabular" values predicted from the equations which appear in Appendix Table 1.

Appendix Table 3. Ninety-Five Percent Confidence Limits Associated with the Cubic Volume Table (± Cubic Feet for Each Diameter and B-log)

DBH inches	1 B-log	2 B-logs	3 B-logs	4 B-logs	5 B-logs
12	3.165	1.604	1.857	4.500	11.331
13	2.949	1.495	1.731	4.194	10.561
14	2.742	1.390	1.609	3.900	9.818
15	2.535	1.285	1.488	3.605	9.076
16	2.342	1.187	1.375	3.332	8.388
17	2.166	1.098	1.271	3.080	7.756
18	2.013	1.020	1.181	2.862	7.206
19	1.873	.950	1.100	2.665	6.710
20	1.758	.891	1.032	2.501	6.298
21	1.683	.853	.987	2.392	6.023
22	1.643	.833	.965	2.338	5.885
23	1.643	.833	.965	2.338	5.885
24	1.683	.853	.987	2.392	6.023
25	1.758	.891	1.032	2.501	6.298
26	1.873	.950	1.100	2.665	6.710
27	2.013	1.020	1.181	2.862	7.206
28	2.166	1.098	1.271	3.080	7.756
29	2.342	1.187	1.375	3.332	8.388
30	2.535	1.285	1.488	3.605	9.076
31	2.742	1.390	1.609	3.900	9.818
32	2.949	1.495	1.731	4.194	10.561
33	3.165	1.604	1.857	4.500	11.331