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Whole Stand Volume Tables for Quaking Aspen in the Rocky Mountains

Wayne D. Shepperd and H. Todd Mowrer[1]

Linear regression equations were developed to predict stand volumes for aspen given average stand basal area and average stand height. Tables constructed from these equations allow easy field estimation of gross merchantable cubic and board foot Scribner Rules per acre, and cubic meters per hectare using simple prism cruise data.

Keywords: *Populus tremuloides*, stand volume estimates, point-sampling

Introduction

Until recently, reliable, easy to use volume tables for quaking aspen (*Populus tremuloides* Michx.) in the central Rocky Mountains were not available. Foresters were limited to using crude tables derived in the early 1900's (Baker 1925), or tables which required field estimation of merchantable height (Peterson 1961). Edminster et al. (1981) simplified estimation of stem volumes by developing simple linear equations for aspen. The equations do not require estimation of merchantable height and provide volume/basal area ratio tables (Dilworth and Bell 1974) useful to estimate stem volumes from a diameter class cruise tally.

The tables and methodology presented here allow the direct estimation of gross stand volume per acre or hectare from average stand basal area and average stand height. The tables were developed from stand summaries computed with Edminster et al.'s (1981) equations and are applicable to even-aged aspen in Colorado and southern Wyoming. The merchantability limits for cubic, board feet Scribner, and metric tables are stems greater than 5 inches, 7 inches, and 10 cm, respectively.

[1]*The authors are Silviculturist and Associate Mensurationist, respectively, at the Rocky Mountain Forest and Range Experiment Station's headquarters in Fort Collins, in cooperation with Colorado State University.*

Methodology

Data from two independent studies were used. A yield study contributed individual stem data from 100 fixed area plots containing from 100 to 150 trees each. A classification study contributed 70 stands point sampled with a Basal Area Factor (BAF) 10 or 20 prism, and 23 stands sampled using fixed area plots containing from 20 to 30 stems each. Stand volumes for all 193 stands were estimated by calculating individual stem volumes using Edminster et al.'s (1981) equations and then summing on a per area basis. These volumes then served as the dependent variable in a least squares regression analysis, with the weighted average height of all stems included in the volume computation as the independent variable. Because minimum diameter for the independent variable coincided with minimum merchantability standards, the resultant equations can be used to estimate stand volumes by including only those stems meeting the merchantability criteria in the determination of average basal area and height.

Regressions were run independently on both data sets for gross merchantable cubic feet per acre to a 4-inch top, board feet per acre Scribner Rule to a 6-inch top, and gross merchantable cubic meters per hectare. In all cases, equations from the two data sets were quite similar. Volume estimates were predicted for average stand basal areas and heights of one data set using equations developed from the other data set. In all cases, there appeared to be reasonable agreement over the range of data between these estimates and the "actual" stand volumes estimated by Edminster et al.'s (1981) individual stem equations.

Next, the models derived from the two data sets for each volume table were tested for equality of coefficients by the method suggested by Graybill (1976). Good agreement between the two data sets was obtained for all volume equations with significance levels of 0.79, 0.22, and 0.48 for the cubic, board feet, and metric equations, respectively. Both data sets then were combined, and regressions were recomputed to derive the final equations used to construct the tables.

This technique and the resulting volume tables do not estimate actual stand volumes, but instead estimate the volumes which would be obtained from an individual stem cruise using Edminster et al.'s (1981) equations. Therefore, the statistics presented with these tables do not account for any error of estimation associated with Edminster et al.'s (1981) equations. The "smoothing" effect caused by this approach should be offset in general cruising applications by the greater sample intensities made possible with whole stand tables and their ease of use. Users requiring a higher degree of accuracy should continue to utilize individual stem cruising to estimate stand volumes.

Using the Tables

An estimate of average stand basal area and height can be obtained several ways. However, the quickest and easiest method would be a series of BAF variable radius points placed throughout the stand at which the cruiser counts "in" trees and multiplies by BAF to obtain a basal area estimate. A minimum sampling intensity of at least one point per acre using BAF of 10 or 20 is recommended for most aspen stands in the Rocky Mountains. Include only stems larger than 5 inches (10 cm) d.b.h. for cubic volume estimates, and only those larger than 7 inches d.b.h. for Scribner estimates. Additional diameter measurements or tallies are not needed. A stand height estimate should be taken at each point, and should be averaged to provide a height input for the tables. Metric basal area estimates can be obtained directly using a metric prism or wedge with a BAF of 2.5 to 5, or converted from English basal area estimates using:

$$\text{Square meters/ha} = \text{square feet/acre} * 0.229568.$$

The average stand basal areas and heights can then be used with the appropriate table to directly estimate stand volumes. No further computation or summaries are necessary. Procedures for converting these tables to hand-held calculator programs are available (Shepperd 1980). However, the valid application of any program written will be restricted to the range of data presented in the tables.

The growth characteristics of aspen in the Rocky Mountains make whole stand volume tables particularly useful to field situations where the volume of a large area encompassing a number of clones is being estimated. Because a clone is a genetic individual instead of a single tree, many more sample points per unit area are needed to adequately sample the natural genetic diversity within a stand. The cost of conventional individual tree cruises often prohibit sampling to these intensities. However, the ease of application of these whole stand volume tables allow the gathering of data from numerous sample points throughout a stand and will more adequately measure stocking variability resulting from clonal or microsite variation, provided that an appropriate sampling intensity is used.

Literature Cited

Baker, Frederick S. 1925. Aspen in the central Rocky Mountains region. U.S. Department of Agriculture, Technical Bulletin No. 1291, 45 p. Washington, D.C.

Dilworth, J. R. and J. F. Bell. 1974. Variable probability sampling—Variable plot and three-P. 130 p. Oregon State University Bookstore Inc. Corvallis, Oreg.

Edminster, Carlton B., H. Todd Mowrer, and Thomas E. Hinds. 1981. Volume tables and point-sampling factors for aspen in Colorado. USDA Forest Service Research Paper RM-232, 16 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Graybill, Franklin A. 1976. Theory and application for the linear model. 704 p. Duxbury Press, Belmont, Calif.

Peterson, Geraldine. 1961. Volume tables for aspen in Colorado. United States Department of Agriculture, Forest Service, Research Note 63, 4 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Shepperd, Wayne D. 1980. Hand-held-calculator programs for the field forester. USDA Forest Service General Technical Report RM-76, 17 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Table 1.—Aspen stand volume table in gross merchantable cunits per acre for even-aged aspen in Colorado and southern Wyoming. Includes stems greater than 5.0 inches d.b.h. to a 4-inch top d.i.b. Stump height 1 foot.

Basal area *(ft²/acre)*	**Average stand height** *(feet)*																
	20	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
10																	
20																	
30	0	0	1	2	2	3	3	4									
40	1	1	2	3	4	5	5	6	7								
50	1	2	3	4	5	6	7	8	9								
60	2	3	5	6	7	8	9	11	12	13							
70	3	4	6	7	9	10	11	13	14	16	17						
80			7	9	10	12	13	15	17	18	20	20					
90			8	10	12	14	15	17	19	21	22	24					
100			9	11	13	15	17	19	21	23	25	27					
110				13	15	17	19	22	24	26	28	30	32				
120				14	17	19	21	24	26	28	31	33	36	38			
130				16	18	21	23	26	28	31	34	36	39	41			
140				17	20	22	25	28	31	34	36	39	42	45			
150				18	21	24	27	30	33	36	39	42	45	48			
160				20	23	26	29	32	36	39	42	45	48	51			
170				21	24	28	31	35	38	41	45	48	51	55	58		
180				22	26	30	33	37	40	44	47	51	55	58	62		
190				24	28	31	35	39	43	46	50	54	58	62	65	69	
200				25	29	33	37	41	45	49	53	57	61	65	69	73	
210					31	35	39	43	47	52	56	60	64	68	72	77	81
220					32	37	41	46	50	54	59	63	67	72	76	80	85
230					34	39	43	48	52	57	61	66	70	75	80	84	89
240					36	40	45	50	55	59	64	69	74	78	83	88	93
250					37	42	47	52	57	62	67	72	77	82	87	92	97
260					39	44	49	54	59	65	70	75	80	85	90	95	
270					40	46	51	56	62	67	72	78	83	89	94	99	
280					42	47	53	59	64	70	75	81	86	92	97	103	
290					44	49	55	61	67	72	78	84	90	95	101	107	
300					45	51	57	63	69	75	81	87	93	99	105	111	
310					47	53	59	65	71	77	84	90	96	102			
320					48	55	61	67	74	80	86	93	99	105			
330					50	56	63	70	76	83	89	96	102	109			
340								72	78	85	92	99	105	112			
350									81	88	95	102	109	116			
360										90	97	105	112	119			
370											100	108	115	122			
380												111	118	126			
390												114	121	129			
400												117	124	132			
410												119	128	136			
420												122	131	139			
430												125	134	142			

*Cunits/acre = (0.39666673*BAHT - 249.0846)/100*
Where: BAHT = Average stand basal area in square feet/acre × average stand height in feet.
Standard error of estimate: 2.173 Cunits/acre.
Values underlined indicate extent of data.

Table 2.—Aspen stand volumes in thousand board feet, inside bark Scribner Rule, merchantable stems excluding stump and top, aspen in Colorado and southern Wyoming. Includes stems greater than 7 inches d.b.h. to a 6-inch d.i.b. Stump height 1 foot.

Basal area (*ft²/acre*)	**Average stand height (*feet*)**														
	30	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**	**80**	**85**	**90**	**95**	**100**
20	0	0	0	0	0	0	1	1	1						
40	1	1	1	1	2	2	2	3	3	3					
60	1	2	2	3	3	4	4	5	5	6	6				
80		3	4	4	5	5	6	7	7	8	9	9			
100		4	5	6	6	7	8	9	10	11	11	12	13		
120			6	7	8	9	10	11	12	13	14	15	16		
140			7	9	10	11	12	13	14	16	17	18	19	21	
160			9	10	11	13	14	15	17	18	20	21	23	24	26
180			10	12	13	15	16	18	19	21	23	24	26	28	29
200				13	15	16	18	20	22	24	26	27	29	31	33
220				15	16	18	20	22	24	26	29	31	33	35	37
240					18	20	23	25	27	29	32	34	36	39	41
260					20	22	25	27	30	32	35	37	40	43	46
280					22	24	27	30	32	35	38	41	44	47	50
300						26	29	32	35	38	41	44	48	51	
320						29	32	35	38	41	45	48	52	55	
340							34	37	41	44	48	52	56	59	
360								40	44	48	52	56	60	64	
380								43	47	51	55	59	64	68	
400										54	59	63	68	73	

*MBF Scribner/acre = −1232.6954 + 1.4756175*BAHT + 0.000012382661*BAHT*BAHT*
Where: BAHT = Average stand basal area in square feet/acre × average stand height in feet.
Standard error of estimate: 1.863 MBF/acre.
Values underlined indicate extent of data.

Table 3.—Aspen stand volumes in gross merchantable cubic meters per hectare for even-aged aspen in Colorado and southern Wyoming. Includes stems greater than 10cm d.b.h. which have a minimum top d.i.b. of 10cm. Stump height 0.3m.

Basal area (m^2/ha)	**Average stand height (*meters*)**													
	6	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**
2	0	0	0	0	2									
4	0	3	6	9	13									
6	5	9	14	19	23	28								
8	9	16	22	28	34	40								
10	14	22	30	37	45	53	61							
12	19	28	37	47	56	65	75	84						
14	23	34	45	56	67	78	89	99						
16	28	40	53	65	78	90	103	115						
18		47	61	75	89	103	116	130						
20		53	68	84	99	115	130	146	161					
22		59	76	93	110	127	144	161	179					
24		65	84	103	121	140	158	177	196	214				
26		71	92	112	132	152	172	193	213	233				
28		78	99	121	143	165	186	208	230	251				
30		84	107	130	154	177	200	224	247	270	293			
32		90	115	140	165	189	214	239	264	289	314	338		
34		96	123	149	175	202	228	255	281	307	334	360		
36		103	130	158	186	214	242	270	298	326	354	382	410	
38		109	138	168	197	227	256	286	315	345	374	404	433	
40			146	177	208	239	270	301	332	363	394	425	456	
42			154	186	219	251	284	317	349	382	414	447	480	
44			161	196	230	264	298	332	366	400	435	469	503	
46				205	241	276	312	348	383	419	455	490	526	
48				214	251	289	326	363	400	438	475	512	549	
50				224	262	301	340	379	417	456	495	534	573	
52					273	314	354	394	435	475	515	556	596	
54					284	326	368	410	452	494	535	577	619	
56					295	338	382	425	469	512	556	599	642	
58					306	351	396	441	486	531	576	621	666	
60					317	363	410	456	503	549	596	642	689	
62					327	376	424	472	520	568	616	664	712	
64						388	438	487	537	587	636	686	736	
66						400	452	503	554	605	656	708	759	
68						413	466	518	571	624	677	729	782	
70						425	480	534	588	642	697	751	805	
72						438	494	549	605	661	717	773	829	
74						450	507	565	622	680	737	795	852	
76						462	521	580	639	698	757	816	875	
78						475	535	596	656	717	777	838	898	
80						487	549	611	674	736	798	860	922	
82							563	627	691	754	818	881		
84							577	642	708	773	838	903		
86								658	725	791	858	925		
88									742	810	878			
90									759	829	898			
92									776	847	919			
94									793	866				
96									810	885				
98										903				
100										922				

*Cubic meters/hectare = 0.38791 * MBA * MHT − 9.21137*

Where: MBA = Average stand basal area in square meters/hectare and: MHT = Average stand height in meters.

Standard error of estimate: 1.47 cubic meters/hectare.

Values underlined indicate extent of data.