



# Station Note

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## Volume Tables for Small Trees in Northern Idaho

Gerald M. Allen, David L. Adams, Geoffrey L. Houck  
and Charles R. Hatch

Sawmills which utilize logs formerly considered too small in diameter for lumber production have recently been introduced into northern Idaho. Most available volume tables do not include values for logs in the smaller diameter classes. This paper presents small-tree volume equations and tables for Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta* var. *latifolia*) and grand fir (*Abies grandis*), and a composite equation and table for the four species.

Trees from the Athol, Elk City, Orofino and Bovill areas of Idaho formed the data base. Each tree was felled and the following information was recorded: species, total tree height in feet, diameter in inches inside and outside bark at the top of a 1-foot stump, and diameter in inches outside bark at breast height and at the bottom and top of every even-numbered 8-foot section up the trunk. On a

subsample of these trees, inside bark diameter measurements were taken along with the outside bark diameter measurements.

This information and regression analysis were used to develop an equation to predict diameter inside bark at breast height and at the bottom and top of every even-numbered 8-foot section in the tree. Using Smalian's formula, inside bark total cubic foot volume above a 1-foot stump was computed for each tree. Board foot volumes above a 1-foot stump were derived for each tree by diagramming the small end of each 8-foot bolt into the maximum number of 2 x 2's, 2 x 3's and/or 2 x 4's that could be recovered. Separate diagrams were constructed for each 1-inch diameter class. A 3/16-inch sawkerf and 8-foot minimum board length were assumed. Green lumber dimensions were determined from standards set by the Western Wood Products Association.<sup>1</sup>

The authors are Assistant Professor, Professor, Research Technician and Associate Professor, respectively, University of Idaho.

<sup>1</sup> Western Wood Products Association. 1970. Grading rules for western lumber. Portland, Oregon. p. 52.

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Volume equations were developed using regression analysis and the following mathematical model:

$$V = a_0 + a_1 D^2 H$$

- Where  $a_0$  and  $a_1$  are least squares regression coefficients,  
 D is diameter (in inches) outside bark at breast height,  
 H is total tree height (in feet),  
 V is total cubic foot volume inside bark above a 1-foot stump or board foot volume inside bark above a 1-foot stump.

An examination of the residuals indicated unequal variances over the range of predicted volumes. Therefore, weighted least squares regression was used, with weights proportional to  $1/\sqrt{D^2 H}$ .

Volume equations are given with their associated volume tables (Tables 1 through 5). Table 5 also gives cubic foot-board foot and board foot-cubic foot conversion equations.

Table 1. DOUGLAS-FIR (*Pseudotsuga menziesii* var. *glauca*)

		Cubic-foot Volume										
		TOTAL TREE HEIGHT (in feet)										
		10	20	30	40	50	60	70	80	90		
DBH (inches)	2	0.24	0.31	0.38	0.46	0.53						14
	3	0.33	0.49	0.65	0.82	0.98						26
	4	0.46	0.74	1.03	1.32	1.61	1.89					27
	5	0.62	1.07	1.52	1.96	2.41	2.86					23
	6	0.82	1.46	2.11	2.75	3.40	4.05	4.69				17
	7			2.81	3.69	4.57	5.45	6.33				24
	8			3.62	4.76	5.91	7.06	8.21				13
	9				5.99	7.44	8.89	10.35				8
	10				7.35	9.14	10.94	12.73	14.53	16.32		1
	11					11.03	13.20	15.37	17.55	19.72		1
	12					13.09	15.68	18.26	20.85	23.43		1
	13						18.37	21.40	24.44	27.47		1
	14						21.28	24.80	28.32	31.83		0
			2	18	37	34	41	20	3	0	1	156
		BASIS (no. trees)										

Cubic foot volume =  $0.16949 + 0.001795D^2H$  ( $r^2 = 0.985$ )  
 Standard error of estimate = 0.2825 cu ft

		Board-foot Volume										
		TOTAL TREE HEIGHT (in feet)										
		20	30	40	50	60	70	80	90			
DBH (inches)	2	0.35	0.68	1.02	1.36							0
	3	1.19	1.94	2.70	3.45							7
	4	2.36	3.71	5.05	6.39	7.74						24
	5	3.87	5.97	8.07	10.17	12.27						23
	6		8.74	11.77	14.79	17.81	20.83					17
	7		12.02	16.13	20.24	24.36	28.47					24
	8		15.80	21.17	26.54	31.91	37.29					13
	9			26.88	33.68	40.48	47.28					8
	10			33.26	41.65	50.05	58.44	66.84	75.23			1
	11				50.47	60.62	70.78	80.94	91.10			1
	12				60.12	72.21	84.30	96.39	108.48			1
	13					84.80	98.99	113.18	127.36			1
	14					98.40	114.86	131.31	147.76			0
			0	24	31	41	20	3	0	1		120
		BASIS (no. trees)										

Board foot volume =  $-0.32308 + 0.008395D^2H$  ( $r^2 = 0.961$ )  
 Standard error of estimate = 2.4706 bd ft

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Table 2. LODGEPOLE PINE (*Pinus contorta* var. *latifolia*)

		Cubic-foot Volume									
		TOTAL TREE HEIGHT (in feet)									
		20	30	40	50	60	70	80	90		
DBH (inches)	2	0.33	0.42	0.51	0.61	0.70	0.79				7
	3	0.56	0.77	0.98	1.18	1.39	1.60	1.81	2.01		28
	4	0.88	1.25	1.62	1.99	2.36	2.73	3.10	3.47		42
	5	1.30	1.87	2.45	3.03	3.60	4.18	4.76	5.33		67
	6	1.81	2.64	3.47	4.30	5.13	5.96	6.79	7.62		60
	7	2.41	3.54	4.67	5.79	6.92	8.05	9.18	10.31		65
	8		4.57	6.05	7.52	9.00	10.48	11.95	13.43		41
	9			7.62	9.48	11.35	13.22	15.09	16.96		22
	10			9.37	11.68	13.98	16.29	18.59	20.90		11
	11			11.31	14.10	16.89	19.68	22.47	25.26		7
	12			13.43	16.75	20.07	23.39	26.71	30.03		1
	13					23.53	27.43	31.32	35.22		0
	14						31.78	36.30	40.82		0
	15								46.84		0
			8	79	58	80	69	59	34	24	351
		BASIS (no. trees)									

Cubic foot volume =  $0.14528 + 0.002306D^2H$  ( $r^2 = 0.982$ )

Standard error of estimate = 0.5752 cu ft

		Board-foot Volume									
		TOTAL TREE HEIGHT (in feet)									
		20	30	40	50	60	70	80	90		
DBH (inches)	2		0.33	0.77	1.21	1.66	2.10				0
	3	0.99	1.99	2.99	3.99	4.99	5.99	6.99	7.99		14
	4	2.55	4.32	6.10	7.88	9.65	11.43	13.21	14.98		42
	5	4.55	7.32	10.10	12.87	15.65	18.43	21.20	23.98		67
	6	6.99	10.99	14.98	18.98	22.98	26.98	30.97	34.97		60
	7	9.88	15.32	20.76	26.20	31.64	37.08	42.52	47.96		65
	8		20.31	27.42	34.53	41.63	48.74	55.85	62.95		41
	9			34.97	43.97	52.96	61.95	70.95	79.94		22
	10			43.41	54.51	65.62	76.72	87.83	98.93		11
	11			52.74	66.17	79.61	93.04	106.48	119.92		7
	12			62.95	78.94	94.93	110.92	126.91	142.90		1
	13					111.59	130.35	149.12	167.89		0
	14						151.34	173.10	194.87		0
	15								223.85		0
			2	11	52	79	69	59	34	24	330
		BASIS (no. trees)									

Board feet volume =  $-1.00612 + 0.011104D^2H$  ( $r^2 = 0.960$ )

Standard error of estimate = 4.2121 bd ft

Table 3. WESTERN LARCH (*Larix occidentalis*)

		Cubic-foot Volume								
		TOTAL TREE HEIGHT (in feet)								
		20	30	40	50	60	70	80		
DBH (inches)	2	0.24	0.32	0.40	0.47					1
	3	0.44	0.61	0.78	0.96	1.13				4
	4	0.71	1.01	1.32	1.63	1.94				9
	5	1.05	1.53	2.01	2.49	2.97	3.45			5
	6		2.17	2.86	3.55	4.24	4.93			9
	7		2.92	3.86	4.80	5.74	6.68			5
	8			5.01	6.24	7.47	8.70	9.93		5
	9				7.87	9.43	10.99	12.54		3
	10				9.70	11.62	13.54	15.47		0
	11					14.04	16.37	18.70		1
	12					16.70	19.46	22.23		0
	13							26.08		0
	14							30.23		0
			1	3	10	7	14	6	1	42
		BASIS (no. trees)								

Cubic foot volume =  $0.09023 + 0.001922D^2H$  ( $r^2 = 0.987$ )

Standard error of estimate = 0.3493 cu ft

		Board-foot Volume							
		TOTAL TREE HEIGHT (in feet)							
		30	40	50	60	70	80		
DBH (inches)	2		0.18	0.54					0
	3		1.99	2.80	3.61				1
	4	3.07	4.52	5.96	7.41				7
	5	5.51	7.77	10.03	12.29	14.55			5
	6	8.50	11.75	15.01	18.26	21.52			9
	7		16.45	20.88	25.31	29.75			5
	8		21.88	27.67	33.45	39.24	45.03		5
	9			35.35	42.68	50.00	57.32		3
	10			43.94	52.98	62.03	71.07		0
	11				64.38	75.32	86.26		1
	12				76.85	89.87	102.90		0
	13						120.98		0
	14						140.51		0
			0	8	7	14	6	1	36
		BASIS (no. trees)							

Board foot volume =  $-1.26871 + 0.009042D^2H$  ( $r^2 = 0.953$ )

Standard error of estimate = 3.3163 bd ft

Table 4. GRAND FIR (*Abies grandis*)

		Cubic-foot Volume							
		TOTAL TREE HEIGHT (in feet)							
		10	20	30	40	50	60	70	
DBH (inches)	2	0.08	0.17	0.26	0.34	0.43			44
	3	0.19	0.39	0.58	0.77	0.97			41
	4	0.34	0.69	1.03	1.38	1.72	2.07		32
	5	0.54	1.07	1.61	2.15	2.69	3.23	3.77	14
	6	0.77	1.55	2.32	3.10	3.87	4.65	5.42	5
	7		2.11	3.16	4.22	5.27	6.33	7.38	9
	8		2.75	4.13	5.51	6.89	8.27	9.64	9
	9			5.23	6.97	8.72	10.46	12.21	2
	10			6.46	8.61	10.76	12.92	15.07	0
	11				10.42	13.02	15.63	18.23	0
	12						18.60	21.70	0
			12	67	37	18	12	9	1

BASIS (no. trees)

Cubic foot volume =  $-0.00167 + 0.002153D^2H$  ( $r^2 = 0.985$ )  
 Standard error of estimate = 0.1537 cu ft

		Board-foot Volume						
		TOTAL TREE HEIGHT (in feet)						
		20	30	40	50	60	70	
DBH (inches)	2				0.13			0
	3		0.82	1.71	2.60			2
	4	1.31	2.89	4.48	6.06	7.64		24
	5	3.09	5.56	8.03	10.50	12.97	15.44	13
	6	5.27	8.82	12.38	15.94	19.49	23.05	5
	7	7.83	12.68	17.52	22.36	27.20	32.04	9
	8		17.12	23.45	29.77	36.09	42.42	9
	9		22.16	30.17	38.17	46.17	54.18	2
	10		27.79	37.68	47.56	57.44	67.32	0
	11			45.98	57.93	69.89	81.84	0
	12					83.52	97.75	0
			3	22	17	12	9	1

BASIS (no. trees)

Board foot volume =  $-1.84883 + 0.009881D^2H$  ( $r^2 = 0.939$ )  
 Standard error of estimate = 2.6323 bd ft

Table 5. ALL SPECIES

		Cubic-foot Volume									
		TOTAL TREE HEIGHT (in feet)									
		10	20	30	40	50	60	70	80	90	
DBH (inches)	2	0.12	0.21	0.30	0.39	0.47	0.56	0.65			66
	3	0.23	0.43	0.63	0.83	1.03	1.23	1.43	1.63	1.83	99
	4	0.39	0.74	1.10	1.45	1.80	2.16	2.51	2.87	3.22	110
	5	0.59	1.14	1.69	2.25	2.80	3.36	3.91	4.47	5.02	109
	6	0.83	1.63	2.43	3.22	4.02	4.82	5.62	6.42	7.21	91
	7		2.20	3.29	4.38	5.46	6.55	7.64	8.72	9.81	103
	8		2.87	4.29	5.71	7.13	8.54	9.96	11.38	12.80	68
	9			5.42	7.21	9.01	10.81	12.60	14.40	16.19	35
	10			6.68	8.90	11.12	13.33	15.55	17.77	19.98	12
	11				10.76	13.44	16.13	18.81	21.49	24.17	9
	12				12.80	15.99	19.19	22.38	25.57	28.76	2
	13						22.51	26.26	30.00	33.75	1
	14						26.10	30.45	34.79	39.14	0
	15							34.95	39.94	44.93	0
			14	94	96	120	140	112	69	35	25
		BASIS (no. trees)									

Cubic foot volume =  $0.03117 + 0.002217D^2H$  ( $r^2 = 0.976$ )

Standard error of estimate = 0.5112 cu ft

Conversion of cubic feet to board feet:  $bd\ ft = -1.637 + (4.7817 \times cu\ ft)$

		Board-foot Volume								
		TOTAL TREE HEIGHT (in feet)								
		20	30	40	50	60	70	80	90	
DBH (inches)	2			0.21	0.63	1.06	1.48			0
	3	0.42	1.37	2.33	3.28	4.24	5.19	6.14	7.10	24
	4	1.90	3.60	5.30	6.99	8.69	10.39	12.08	13.78	97
	5	3.81	6.46	9.11	11.76	14.41	17.06	19.71	22.36	108
	6	6.14	9.96	13.78	17.59	21.41	25.23	29.04	32.86	91
	7	8.90	14.10	19.29	24.48	29.68	34.87	40.07	45.26	103
	8		18.87	25.65	32.44	39.22	46.00	52.79	59.57	68
	9		24.27	32.86	41.45	50.03	58.62	67.21	75.79	35
	10		30.31	40.92	51.52	62.12	72.72	83.32	93.92	12
	11			49.82	62.65	75.48	88.30	101.13	113.96	9
	12			59.57	74.84	90.10	105.37	120.64	135.90	2
	13					106.01	123.92	141.84	159.75	1
	14					123.18	143.96	164.74	185.51	0
	15						165.48	189.33	213.18	0
			5	57	108	139	112	69	35	25
		BASIS (no. trees)								

Board foot volume =  $-1.48800 + 0.010601D^2H$  ( $r^2 = 0.943$ )

Standard error of estimate = 4.4081 bd ft

Conversion of board foot to cubic foot:  $cu\ ft = 0.3424 + (0.20913 \times bd\ ft)$