U. S. Forest Service
Research Paper RM-8

September 1964

Volume Tables and Point-Sampling Factors *for* Ponderosa Pine in the Black Hills

by Clifford A. Myers

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
RAYMOND PRICE, DIRECTOR FORT COLLINS, COLORADO
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

U. S. Forest Service Research Paper RM-8 September 1964

VOLUME TABLES AND POINT-SAMPLING FACTORS FOR PONDEROSA PINE IN THE BLACK HILLS

By

Clifford A. Myers, Research Forester
Rocky Mountain Forest and Range Experiment Station[1]

[1] Central headquarters maintained in cooperation with Colorado State University at Fort Collins.

LIST OF TABLES

(Ponderosa pines in the Black Hills of South Dakota and Wyoming)

Volume Tables and Point-Sampling Factors for Ponderosa Pine in the Black Hills

By

Clifford A. Myers

INTRODUCTION

The tables presented here give values needed to determine the volumes of ponderosa pine (Pinus ponderosa Laws.) in the Black Hills of South Dakota and Wyoming. They provide timber cruisers and growth estimators with the following:

1. Gross volumes in total and merchantable cubic feet.
2. Gross volumes in board feet, International 1/4-inch and Scribner log rules.
3. Point-sampling factors for merchantable cubic feet and board feet.
4. Distribution of board foot volume among the logs of a tree.

Volume on an area may be determined from: (1) measurements of tree diameters and heights, (2) measurements of diameters and of sufficient heights to convert the appropriate volume tables to local volume tables (Chapman and Meyer, 1949), or (3) tree counts obtained by point-sampling.

Sample trees were measured in all areas of commercial ponderosa pine in the Black Hills of South Dakota and Wyoming and the Bear Lodge Mountains of Wyoming.

DEFINITIONS AND STANDARDS

Variables used in the tables, and standards followed in field measurement and computations, are defined as follows:

Diameter breast high (d.b.h.).--Measured to 0.1 inch outside bark 4.5 feet above ground level.[2] Full-inch diameter classes, with class midpoints at the half-inch marks, were used in the tables (12.5, 13.5, etc.).

Scaling diameter of logs.--Average diameter inside bark to 0.1 inch, measured at the upper (small) end of logs or half-logs. Saw-log diameter classes followed conventional scaling practice, with the class midpoints at whole inches (8.0, 9.0, etc.).

Minimum top diameter of sawtimber trees.--Diameter inside bark 8 inches, which conforms to usual practice in the Black Hills. Logs with a scaling diameter less than 7.6 inches (8-inch class) usually were not included in saw-log volume. A few logs with a scaling diameter of 7 inches were included to satisfy requirements of the 4-foot rule described with the definition of height in logs, below. This also conforms to local practice.

Total height.--Measured to the nearest foot from ground level at the tree base upward to the tip. Forked, stag-topped, or other deformed trees were not included in the sample. Midpoints of the total height classes used in the tables were multiples of 10.0 feet, as 10.0, 20.0, etc.

[2] *Half the heights were measured from average ground level and half from the uphill side of the tree. Variations in positions of d.b.h. and scaling diameters were too small to make significant differences in volumes.*

Height in logs.--Measured from the top of a stump 1.0 foot high upward to the limit of saw log utilization. Each tree was divided into as many standard 16.3-foot-long logs as possible. An additional half-log, if present, was taken from the uppermost part of the merchantable length. Portions of the bole above the height of minimum top saw-log diameter were included in the uppermost saw log if the standard length of the log or half-log ended within 4.0 feet above this height. This "4-foot rule" was used to avoid biased negative error in volume (Chapman and Meyer, 1949).

EXPLANATION OF TABLES

The general definitions and standards given apply to all tables. Explanation of each type of table and suggestions for use are presented here.

Volume Tables

Headings and footnotes with each volume table (tables 1, 2, 4, 6, 8, 10) give the volume unit, type of height measurement, utilization standards, and volume equations used in its compilation. Ten-foot or half-log height classes and full-inch diameter classes were used in all tables.

The volume tables were derived from linear regressions in V and D^2H, of the form:
$V = a + b\ D^2H$,
where:
V = gross volume in the appropriate unit
D = diameter breast high outside bark
H = total height in feet or in standard logs and half-logs
a,b = regression constants

Two equations were used to derive each table; the relationship between V and D^2H could not be expressed by a single linear regression over the full range of the basic data. Correlation coefficients (r) of the 12 volume equations ranged from 0.891 (board feet with total height, small trees) to 0.993 (total cubic feet).

The number of logs in a tree shown in the tables is not necessarily the number that will actually be cut from it. Instead, it is the number of logs between the stump and the height where minimum top diameter is reached. To locate the minimum top, the 4-foot rule explained under the heading "height in logs" should be used.

Volume of nonmerchantable logs below the height of minimum top diameter should be deducted by estimation of scaling diameters, use of taper tables, or according to the percentages in table 13. Volume must not be reduced by tallying fewer logs in the tree. For example, assume that a sound tree 18 inches in diameter has a bole length of 65.2 feet (4 logs) between the stump and the height where diameter inside bark is 8 inches. The tree has a gross volume of 372 board feet Scribner Rule (table 6). The top log is too limby to send to the sawmill. This log contains 9 percent of the board feet in the tree (table 13) and the other logs contain 91 percent. When 9 percent or 33 board feet is deducted, the tree contains 339 board feet. If the tree were tallied as an 18-inch, 3-log tree, it would be incorrectly credited with a volume of 273 board feet.

Point-Sampling Factors

The first five tables of point-sampling factors (tables 3, 5, 7, 9, 11) give the factors for each of numerous combinations of tree diameter and height. Volumes per square foot of basal area were obtained from the equations in the table footnotes. These equations resulted from the division of each volume equation (tables 2, 4, 6, 8, 10) by $0.005454\ D^2$, a formula for basal area (B).

Table 12 was derived from the other tables of point-sampling factors. The factor for each height class is the weighted average of the factors in that class given in table 2, 4, 6, 8, or 10. Weights were obtained from random samples of heights and diameters in all areas of commercial ponderosa pine in the Black Hills.

Point-sample cruising for volume can be done in several ways: (1) Diameters and heights of trees counted through the prism or relascope may be measured, (2) diameters

may be estimated and heights measured, or (3) heights of the counted trees may be measured and no record made of tree diameters. The procedure selected will depend on the accuracy desired (relative accuracy usually in the order listed above) and the time and personnel available for the job. Point-sampling factors are provided for each alternative.

The diameter and height of each counted tree may be measured and a volume conversion factor selected for each combination of diameter and height (tables 3, 5, 7, 9, 11). Volume per acre is computed as follows:

1. Multiply the number of counted trees in each diameter-height class by the point-sampling factor for the class.
2. Total the products of step one.
3. Multiply this total by the basal area factor of the prism or other angle gauge used.
4. Divide the product of step three by the number of points sampled on the tract.

Time can often be saved if the heights of the counted trees are measured while diameters are estimated and tallied by broad diameter classes. Inspection of the tables shows that volumes per square foot of basal area often do not differ greatly among trees of a single height class. For example the merchantable volumes of trees 70 feet tall vary from 26.1 to 30.3 cubic feet per square foot as diameter increases from 7 to 27 inches (table 3). Board feet per square foot of basal area changes little with diameter when tree heights are measured in logs (tables 7, 11). Therefore, the increased time spent measuring diameters may not materially increase accuracy.

Measurement of heights with no record made of diameters is recommended when there is little change in volumes per square foot within a height class. Point-sampling factors in table 12, based on height only, will be most useful where the distributions of diameters within height classes approximate those used in preparation of the tables. Differences in the relationship between height and diameter due to differences in site quality or stand density may change the factor for each height class. These changes may be accounted for by computing new factors for each height class, using tables 3, 5, 7, 9, or 11 and almost the same procedure used to derive a local volume table from a standard table (Chapman and Meyer, 1949). Diameters are plotted over heights, since height will be retained as the measured variable.

The techniques of point sampling have been described in numerous publications. A good discussion of the method was presented by Bonnett (1959). Allen and Mogren (1960) described a simple procedure for determining the number of sampling points, and Afanasiev (1958) listed precautions on the use of point-sampling on small tracts. Basic American references were prepared by Grosenbaugh (1952, 1955, 1958).

Percentage of Tree Board-Foot Volume in Each Log

The board-foot volume in each log-quality class or the volume in cull logs can be determined with the percentages from table 13. Each line in the body of the table gives the distribution of volume among the logs of a tree of specified diameter and merchantable length. For example, in 18-inch, 3-log trees, the butt log contains 53 percent of the board feet, the middle log contains 34 percent, and the top log 13 percent.

Percentages for diameters that are not included in table 13 can be obtained by interpolation.

LITERATURE CITED

Afanasiev, M.
1958. Some results of the use of the Bitterlich method of cruising in an even-aged stand of longleaf pine. Jour. Forestry 56: 341-343.

Allen, R. H., Jr. and Mogren, E. W.
1960. Range-mean ratio of basal area as an indicator of Bitterlich sampling intensity in lodgepole pine.* Colo. State Univ. College of Forestry and Range Mangt. Res. Note 13, 2 pp. Fort Collins, Colo.

Bonnett, Howbert W.
1959. Guides for variable plot cruising.* 38 pp., illus. U. S. Forest Serv. Region 4, Ogden, Utah.

Chapman, Herman H. and Meyer, Walter H.
1949. Forest mensuration. 522 pp., illus., New York: McGraw-Hill Book Co., Inc.

Grosenbaugh, L. R.
1952. Plotless timber estimates -- new, fast, easy, Jour. Forestry 50: 32-37, illus.

_____
1955. Better diagnosis and prescription in southern forest management.* U.S. Forest Serv. Southern Forest Expt. Sta. Occ. Paper 145, 27 pp. New Orleans, La.

_____
1958. Point-sampling and line-sampling: Probability theory, geometric implications, synthesis.* U. S. Forest Serv. Southern Forest Expt. Sta. Occ. Paper 160, 34 pp. New Orleans, La.

*Address requests for copies to the originating office.

Table 1.--Gross volumes of entire stem in cubic feet, ponderosa pines in the Black Hills of South Dakota and Wyoming

Cubic feet inside bark
Entire stem including stump and top — Total height above ground

Diameter breast height outside bark (Inches)	Total height in feet: 10	20	30	40	50	60	70	80	90	100	110	Basis: Trees
	Volume in cubic feet											
1	0.08	0.13	0.18									1
2	0.17	0.31	0.45	0.58								13
3	0.30	0.57	0.84	1.11	1.39							22
4	0.48	0.93	1.37	1.82	2.27							25
5		1.37	2.04	2.71	3.38							26
6		1.90	2.84	3.77	4.71	5.64						25
7		2.52	3.76	5.01	6.25	7.50	8.74					30
8		3.23	4.83	6.43	8.02	9.62	11.2					30
9		4.02	6.02	8.02	10.0	12.0	14.1	16.3				29
10			7.35	9.79	12.2	14.8	17.5	20.3				29
11			8.81	11.7	14.8	18.1	21.3	24.6	27.9			36
12			10.4	13.9	17.8	21.6	25.5	29.4	33.2			35
13			12.1	16.5	21.0	25.5	30.0	34.5	39.0			43
14				19.2	24.5	29.7	34.9	40.1	45.3	50.5		28
15				22.2	28.2	34.1	40.0	46.0	51.9	57.9		36
16				25.4	32.1	38.9	45.6	52.3	59.1	65.8		20
17					36.3	43.9	51.5	59.1	66.6	74.2		15
18					40.8	49.2	57.7	66.2	74.6	83.1	91.6	12
19					45.5	54.9	64.3	73.7	83.1	92.5	102	12
20					50.4	60.8	71.2	81.6	92.0	102	113	8
21						67.1	78.5	89.9	101	113	124	7
22						73.6	86.1	98.6	111	124	136	3
23						80.4	94.1	108	121	135	149	3
24						87.5	102	117	132	147	162	4
25						95.0	111	127	143	159	175	1
26						103	120	137	155	172	190	2
27						111	129	148	167	186	204	2
Basis: No. trees	5	35	62	52	80	84	92	52	26	9	0	497

Block indicates extent of basic data.
Derived from: $V = 0.002213\ D^2H + 0.030288$, for D^2H to 6,000
$V = 0.002474\ D^2H - 1.557103$, for D^2H larger than 6,000
Standard errors of estimate: ± 9.04 percent; ± 11.63 percent
Diameter classes full-inch; e. g. 20-inch class includes 20.0 to 20.9

Table 2.--Gross merchantable volumes in cubic feet to a 4.0-inch top, ponderosa pines in the Black Hills of South Dakota and Wyoming

Cubic feet inside bark
Merchantable stem excluding stump and top

Top diameter 4.0 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet										Basis: Trees
	20	30	40	50	60	70	80	90	100	110	
	Volume in cubic feet										
5	0.36	1.05	1.75	2.44							26
6	0.91	1.88	2.85	3.82	4.79						25
7	1.55	2.84	4.14	5.43	6.72	8.01					30
8	2.29	3.95	5.61	7.27	8.93	10.6					30
9	3.11	5.19	7.26	9.33	11.4	13.5	15.1				29
10		6.57	9.10	11.6	14.2	16.3	19.0				29
11		8.08	11.1	14.2	16.8	20.0	23.2	26.4			36
12		9.73	13.3	16.5	20.3	24.1	27.8	31.6			35
13		11.5	15.3	19.7	24.1	28.4	32.8	37.2			43
14			18.0	23.0	28.1	33.2	38.2	43.3	48.3		28
15			20.9	26.7	32.4	38.2	44.0	49.8	55.6		36
16			24.0	30.5	37.1	43.6	50.2	56.7	63.3		20
17				34.6	42.0	49.3	56.7	64.1	71.5		15
18				38.9	47.2	55.4	63.6	71.9	80.1	88.4	12
19				43.5	52.7	61.8	71.0	80.1	89.3	98.4	12
20				48.3	58.4	68.6	78.7	88.8	98.9	109	8
21					64.5	75.6	86.8	97.9	109	120	7
22					70.9	83.0	95.2	107	120	132	3
23					77.5	90.8	104	117	131	144	3
24					84.4	98.9	113	128	142	157	4
25					91.7	107	123	139	154	170	1
26					99.2	116	133	150	167	184	2
27					107	125	143	162	180	198	2
Basis: No. trees	3	41	49	80	84	92	52	26	9	0	436

Block indicates extent of basic data.
Derived from $V = 0.002297\ D^2H - 1.032297$ for D^2H to 6,700
$V = 0.002407\ D^2H - 2.257724$ for D^2H larger than 6,700
Standard errors of estimate: $\pm$ 12.03 percent; $\pm$ 12.09 percent
Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 3.--Gross merchantable volumes in cubic feet per square foot of basal area, ponderosa pines in the Black Hills of South Dakota and Wyoming

Cubic feet inside bark — Top diameter 4.0 inches inside bark
Merchantable stem excluding stump and top — Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet									
	20	30	40	50	60	70	80	90	100	110
	Cubic feet									
5	2.2	6.4	10.6	14.8						
6	3.9	8.2	12.4	16.6	20.8					
7	5.1	9.3	13.5	17.7	21.9	26.1				
8	5.8	10.0	14.2	18.4	22.7	26.9				
9	6.3	10.5	14.8	19.0	23.2	27.4	30.7			
10		10.9	15.1	19.3	23.6	27.1	31.5			
11		11.2	15.4	19.6	23.3	27.8	32.2	36.6		
12		11.4	15.6	19.4	23.8	28.2	32.7	37.1		
13		11.6	15.4	19.8	24.2	28.6	33.0	37.4		
14			15.7	20.1	24.5	28.9	33.3	37.7	42.2	
15			15.9	20.3	24.8	29.2	33.6	38.0	42.4	
16			16.1	20.5	25.0	29.4	33.8	38.2	42.6	
17				20.7	25.1	29.5	34.0	38.4	42.8	
18				20.9	25.3	29.7	34.1	38.5	42.9	47.3
19				21.0	25.4	29.8	34.2	38.6	43.0	47.5
20				21.1	25.5	29.9	34.3	38.7	43.1	47.6
21					25.6	30.0	34.4	38.8	43.2	47.6
22					25.7	30.1	34.5	38.9	43.3	47.7
23					25.7	30.1	34.6	39.0	43.4	47.8
24					25.8	30.2	34.6	39.0	43.4	47.9
25					25.8	30.3	34.7	39.1	43.5	47.9
26					25.9	30.3	34.7	39.1	43.5	48.0
27					25.9	30.3	34.8	39.2	43.6	48.0

Derived from: $V/B = 0.4212\ H - 189.2734/D^2$, above dotted line.

$V/B = 0.4413\ H - 413.9575/D^2$, below dotted line.

Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9.

Table 4.--Gross volumes in board feet Scribner Rule, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark
Merchantable stem excluding stump and top

Top diameter 8 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet									Basis: Trees
	40	50	60	70	80	90	100	110	120	
	Volume in board feet									
10		34	47	61	75					30
11	31	47	64	80	96	113				52
12	43	62	81	101	120	139				64
13	56	78	101	123	146	168	198			86
14	70	95	121	147	175	210	244	278		60
15		114	144	175	214	254	293	332		67
16		134	167	212	256	301	345	389		41
17		155	201	251	301	351	401	450		44
18		180	236	292	348	403	459	515		31
19		211	273	335	397	459	521	583		28
20		244	312	381	449	518	587	655		23
21		278	353	429	504	580	655	731		14
22		314	396	479	562	644	727	809	892	12
23		351	441	532	622	712	802	892	982	11
24		391	488	586	684	782	880	978	1,076	12
25		431	537	644	750	856	962	1,068	1,174	9
26			588	703	818	932	1,047	1,161	1,276	10
27			641	765	888	1,011	1,135	1,258	1,382	12
28			696	829	961	1,094	1,226	1,359	1,491	5
29				895	1,037	1,179	1,321	1,463	1,605	5
30					1,115	1,267	1,419	1,571	1,722	1
Basis: No. trees	10	60	142	169	130	71	32	2	1	617

Block indicates extent of basic data.
Derived from $V = 0.012331\ D^2H - 34.167170$, for D^2H to 16,000
$V = 0.016318\ D^2H - 99.212720$, for D^2H larger than 16,000
Standard errors of estimate: ± 19.64 percent; 15.61 percent
Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 5.--Gross volumes in board feet Scribner Rule per square foot of basal area, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark
Merchantable stem excluding stump and top

Top diameter 8 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet								
	40	50	60	70	80	90	100	110	120
	Board feet								
10		56	79	101	124				
11	43	66	88	111	134	156			
12	50	73	96	118	141	163			
13	56	79	101	124	146	169	199		
14	61	83	106	128	153	183	213	243	
15		87	110	134	164	194	223	253	
16		90	113	143	173	202	232	262	
17		93	120	150	180	210	240	270	
18		96	126	156	186	216	246	276	
19		102	132	162	192	221	251	281	
20		106	136	166	196	226	256	286	
21		110	140	170	200	230	260	290	
22		114	144	174	203	233	263	293	323
23		117	147	176	206	236	266	296	326
24		119	149	179	209	239	269	299	329
25		122	152	181	211	241	271	301	331
26			154	184	213	243	273	303	333
27			155	185	215	245	275	305	335
28			157	187	217	247	277	307	337
29				189	218	248	278	308	338
30					220	250	280	310	339

Derived from: $V/B = 2.2609\ H - 6264.6076/D^2$, above dotted line

$V/B = 2.9919\ H - 18190.8177/D^2$, below dotted line

Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 6.--Gross volumes in board feet Scribner Rule, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark
Merchantable stem excluding stump and top

Top diameter 8 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Number of 16-foot logs to 8-inch top											Basis: Trees
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
	Volume in board feet											
10	31	45	60	75								30
11	37	54	72	89	107							52
12	43	64	84	105	126	146	167					64
13	50	74	98	122	146	170	194	218				86
14	57	85	113	141	168	196	224	252				60
15		97	129	160	192	224	256	287				67
16		110	146	182	218	254	290	327				41
17		123	164	204	245	285	327	375	423			44
18		137	183	228	273	318	372	425	479			31
19		152	203	253	303	360	419	479	538	598		28
20		168	224	279	338	404	469	535	601	666	732	23
21		185	246	307	377	450	522	594	666	739	811	14
22				340	419	498	577	656	735	814	893	12
23				375	462	548	634	721	807	893	980	11
24				413	507	601	694	788	882	976	1,070	12
25				452	554	655	757	859	960	1,062	1,164	9
26				493	602	712	822	932	1,042	1,151	1,261	10
27				535	653	771	890	1,008	1,126	1,244	1,362	12
28					706	833	960	1,087	1,214	1,341	1,468	5
29						896	1,032	1,168	1,304	1,440	1,576	5
30							1,107	1,253	1,398	1,543	1,689	1
Basis: No. trees	24	61	102	98	106	80	74	38	28	6	0	617

Block indicates extent of basic data.
Derived from: $V = 0.264267\ D^2H + 1.737800$, for D^2H to 1,200
$V = 0.312649\ D^2H - 56.188070$, for D^2H larger than 1,200
Standard errors of estimate: $\pm$ 13.22 percent; $\pm$ 11.58 percent
Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 7.--Gross volumes in board feet Scribner Rule per square foot of basal area, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark — Top diameter 8 inches inside bark
Merchantable stem excluding stump and top — Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Number of 16-foot logs to 8-inch top										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Board feet										
10	51	76	100	124							
11	51	75	99	124	148						
12	50	75	99	123	147	172	196				
13	50	74	99	123	147	171	196	220			
14	50	74	98	123	147	171	195	220			
15		74	98	122	147	171	195	219			
16		74	98	122	147	171	195	220			
17		74	98	122	146	171	196	224	253		
18		74	98	122	146	171	199	228	257		
19		74	98	122	146	174	202	231	260	288	
20		73	98	122	147	176	205	233	262	291	319
21		73	98	122	150	178	207	236	264	293	322
22				123	152	180	209	238	266	295	324
23				125	153	182	211	239	268	297	325
24				126	155	183	212	241	269	298	327
25				127	156	185	213	242	271	299	328
26				129	157	186	215	243	272	301	329
27				130	158	187	216	244	273	302	330
28					159	188	217	245	274	303	331
29						189	217	246	275	303	332
30							218	247	276	304	333

Derived from $V/B = 48.4538\ H + 318.6285/D^2$, above dotted line.

$V/B = 57.3247\ H - 10302.1764/D^2$, below dotted line.

Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 8.--Gross volumes in board feet International 1/4-inch Rule, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark
Merchantable stem excluding stump and top

Top diameter 8 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet									Basis: Trees
	40	50	60	70	80	90	100	110	120	
	Volume in board feet									
10		38	55	71	88					30
11	35	55	75	95	114	134				52
12	49	73	96	120	143	170				64
13	65	92	120	147	179	210	241			86
14	82	113	145	181	217	253	288	324		60
15		136	176	217	258	299	339	380		67
16		163	209	255	301	348	394	440		41
17		191	243	295	348	400	452	504		44
18		222	280	338	396	455	513	571		31
19		254	319	384	448	513	577	642		28
20		288	360	431	502	574	645	717		23
21		324	402	481	560	638	717	795		14
22		361	447	533	619	705	791	877	963	12
23		400	494	588	682	776	870	963	1,057	11
24		441	543	645	747	849	951	1,053	1,155	12
25		484	594	705	815	926	1,036	1,147	1,257	9
26			647	766	886	1,005	1,124	1,244	1,363	10
27			702	831	959	1,088	1,216	1,345	1,473	12
28			759	897	1,035	1,173	1,311	1,449	1,587	5
29				966	1,114	1,262	1,410	1,558	1,706	5
30					1,196	1,354	1,512	1,670	1,828	1
Basis: No. trees	10	60	142	169	130	71	32	2	1	617

Block indicates extent of basic data.
Derived from $V = 0.015011\ D^2H - 44.360460$, for D^2H to 13,000
$V = 0.016991\ D^2H - 68.750200$, for D^2H larger than 13,000
Standard errors of estimate: $\pm$ 19.95 percent; $\pm$ 14.17 percent
Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 9.--Gross volumes in board feet International 1/4-inch Rule per square foot of basal area, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark — Top diameter 8 inches inside bark
Merchantable stem excluding stump and top — Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Total height in feet								
	40	50	60	70	80	90	100	110	120
	Board feet								
10		64	91	119	146				
11	49	76	104	131	159	186			
12	58	86	113	141	168	200			
13	65	93	121	148	180	211	242		
14	71	99	126	158	189	220	252	283	
15		104	134	166	197	228	259	290	
16		109	141	172	203	234	265	296	
17		115	146	177	208	239	270	302	
18		119	150	181	212	244	275	306	
19		123	154	185	216	247	278	310	
20		126	157	188	219	250	282	313	
21		128	160	191	222	253	284	315	
22		131	162	193	224	255	287	318	349
23		133	164	195	226	258	289	320	351
24		135	166	197	228	259	291	322	353
25		136	168	199	230	261	292	323	354
26			169	200	231	262	294	325	356
27			170	201	233	264	295	326	357
28			171	203	234	265	296	327	358
29				204	235	266	297	328	359
30					236	267	298	329	360

Derived from $V/B = 2.7523\ H - 8133.5644/D^2$, above dotted line.

$V/B = 3.1153\ H - 12605.4639/D^2$, below dotted line.

Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 10.--Gross volumes in board feet International 1/4-inch Rule, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark
Merchantable stem excluding stump and top

Top diameter 8 inches inside bark
Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Number of 16-foot logs to 8-inch top											Basis: Trees
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	
	Volume in board feet											
10	37	54	71	89								30
11	44	64	85	106	126							52
12	51	76	100	124	149	173	198					64
13	59	88	116	145	173	202	230	259				86
14	68	101	134	167	200	232	265	298				60
15		115	153	190	228	265	303	340				67
16		130	173	215	258	300	343	384				41
17		146	194	242	290	337	384	433	482			44
18		163	216	270	323	376	430	485	539			31
19		181	240	300	358	418	479	539	600	661		28
20		199	265	331	396	463	530	597	664	731	798	23
21		219	291	362	436	510	583	657	731	804	878	14
22				397	478	559	639	720	801	881	962	12
23				434	522	610	698	786	874	962	1,050	11
24				472	568	664	759	855	950	1,046	1,142	12
25				512	616	719	823	927	1,030	1,134	1,237	9
26				554	665	777	889	1,001	1,113	1,225	1,337	10
27				597	717	838	958	1,079	1,199	1,320	1,440	12
28					771	900	1,029	1,159	1,288	1,418	1,547	5
29						965	1,103	1,242	1,381	1,519	1,658	5
30							1,180	1,328	1,476	1,624	1,773	1
Basis: No. trees	24	61	102	98	106	80	74	38	28	6	0	617

Block indicates extent of basic data.
Derived from: $V = 0.312621\ D^2H + 2.338510$, for D^2H to 1,100

$V = 0.318669\ D^2H - 5.939610$, for D^2H larger than 1,100

Standard errors of estimate: $\pm$ 13.18 percent; $\pm$ 10.28 percent
Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 11.--Gross volumes in board feet International 1/4-inch Rule per square foot of basal area, ponderosa pines in the Black Hills of South Dakota and Wyoming

Board feet inside bark — Top diameter 8 inches inside bark
Merchantable stem excluding stump and top — Stump height 1.0 foot

Diameter breast height outside bark (Inches)	Number of 16-foot logs to 8-inch top										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Board feet										
10	61	90	119								
11	61	89	118	147	175						
12	60	89	117	146	175	203	232				
13	60	88	117	146	174	203	232	260			
14		88	117	145	174	203	231	260			
15		88	116	145	174	202	231	260			
16		88	116	145	174	202	231	259			
17		87	116	145	173	202	230	259	289		
18		87	116	145	173	201	231	260	289		
19		87	116	144	172	202	231	260	289	318	
20		87	116	144	173	202	231	260	290	319	348
21		87	116	144	173	202	231	261	290	319	348
22				144	173	202	232	261	290	319	348
23				144	173	203	232	261	290	319	349
24				144	173	203	232	261	290	320	349
25				144	174	203	232	261	290	320	349
26					174	203	232	261	291	320	349
27					174	203	232	261	291	320	349
28					174	203	232	262	291	320	349
29						203	232	262	291	320	349
30							233	262	291	320	349
31							233	262	291	320	349

Derived from: $V/B = 57.3196\ H + 428.7697/D^2$, above dotted line.

$V/B = 58.4285\ H - 1089.0374/D^2$, below dotted line.

Diameter classes full-inch; e.g. 20-inch class includes 20.0 to 20.9

Table 12.--Gross tree volumes per square foot of basal area by tree height classes only,

Black Hills ponderosa pine

Tree height (feet)	Merchantable cubic feet	Board feet Scribner	Board feet International	Tree height (logs)	Board feet Scribner	Board feet International
20	2.4			1.0	51	61
30	7.9			1.5	75	89
40	13.4	49	56	2.0	99	117
50	18.9	73	86	2.5	123	145
60	23.9	103	122	3.0	147	174
70	28.8	136	160	3.5	173	202
80	33.7	175	203	4.0	202	231
90	38.6	222	247	4.5	238	261
100	43.2	262	286	5.0	269	290
110	47.7	298	322	5.5	298	319
120		333	356	6.0	328	349

Table 13.--Percentage of total board foot volume in each log of a tree,

Black Hills ponderosa pine

D.b.h. (inches) and tree height (logs)	Position of log in the tree										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
	Percent of total tree volume										
Trees 12 inches d.b.h.:											
1.0	100										
1.5	75	25									
2.0	62	--	38								
2.5	49	--	37	14							
3.0	42	--	35	--	23						
3.5	37	--	33	--	21	9					
Trees 18 inches d.b.h.:											
2.0	70	--	30								
2.5	62	--	30	8							
3.0	53	--	34	--	13						
3.5	45	--	32	--	18	5					
4.0	41	--	30	--	20	--	9				
4.5	37	--	27	--	22	--	10	4			
5.0	34	--	23	--	22	--	15	--	6		
Trees 24 inches d.b.h.:											
3.0	60	--	30	--	10						
3.5	50	--	31	--	16	3					
4.0	42	--	31	--	21	--	6				
4.5	38	--	30	--	20	--	10	2			
5.0	34	--	27	--	21	--	14	--	4		

Myers, Clifford A.
1964. Volume tables and point-sampling factors for ponderosa pine in the Black Hills. U. S. Forest Serv. Res. Paper RM-8, 16 pp. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$. Volumes per square foot of basal area are also included.

Myers, Clifford A.
1964. Volume tables and point-sampling factors for ponderosa pine in the Black Hills. U. S. Forest Serv. Res. Paper RM-8, 16 pp. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

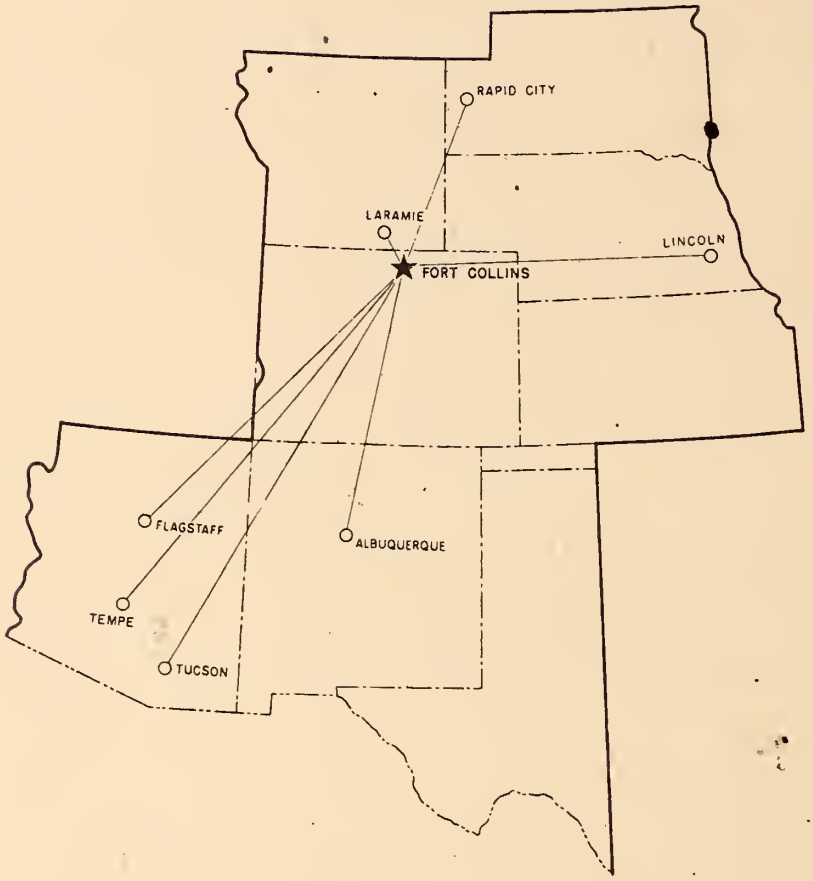
Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$. Volumes per square foot of basal area are also included.

Myers, Clifford A.
1964. Volume tables and point-sampling factors for ponderosa pine in the Black Hills. U. S. Forest Serv. Res. Paper RM-8, 16 pp. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$. Volumes per square foot of basal area are also included.

Myers, Clifford A.
1964. Volume tables and point-sampling factors for ponderosa pine in the Black Hills. U. S. Forest Serv. Res. Paper RM-8, 16 pp. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Volumes are in total cubic feet and cubic feet to a 4.0-inch top, board feet Scribner Rule to an 8-inch top, and board feet International 1/4-inch Rule to an 8-inch top. Tree heights are in feet and numbers of logs. Volume equations are of the form $V = a + bD^2H$. Volumes per square foot of basal area are also included.


RAPID CITY
LARAMIE
LINCOLN
FORT COLLINS
FLAGSTAFF
ALBUQUERQUE
TEMPE
TUCSON