research notes

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Preliminary Site-class Volume Tables by Logs as an Aid to Grade-cruising Douglas Fir, Western Hemlock, and Western Red Cedar

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PRELIMINARY SITE-CLASS VOLUME TABLES BY LOGS

Introduction

For stumpage-appraisal purposes on timber sales, management officers desire an estimate of the proportions of the total volume occurring in each log grade. The requisites of the method of estimation to be employed are threefold.

1. The method need only proportionate stand volume among the various grades, without regard to the precision of the total-volume estimate. The total volumes of stands based on 10 per cent cruises and compiled by site-class volume tables are acceptable estimates of true volumes for present stumpage-appraisal purposes.

2. The method should be one of mechanical application with a minimum necessity for judgment by seasonally employed cruisers.

3. Any necessary tables should be based on available data.

Grade-cruising

Grade-cruising has usually been the duty of highly experienced cruisers who are thoroughly familiar with the following factors:

1. bark-thicknesses and tapers for various local conditions and species, or some sound basis for estimating log-length and top D.I.B. for application of the official Log Rule;

2. problems related to falling and bucking--stump and top utilization limits, breakage, and local company policies re bucking for scale, grade, or standards of transportation facilities;

3. defect deductions;

4. grades as specified by various local or regional Official Rules, supplemented by bush, boom, or mill experience with opened trees and logs;

5. selection of a representative sample within the cruised area from which grade proportions are determined for application to the total cruise; and,

6. problems common to any volume cruise such as strip-width and intensity of sampling.

The accuracy of grade-cruises is directly related to the ability of the cruiser to estimate these factors. The experienced cruiser apparently develops this ability as an art, and confidence in the results can not be built up by a scientific assessment of individual factors but only by comparison of results, over a long period of time, with the actual bush or water scales of the stands cruised. Such comparisons are impossible with the seasonally employed cruiser, hence the attempt to design an aid to grade-cruising based on average conditions.

Grade-cruising Tables

Essentially the tables are based on the premise that trees within the range of form and diameter classes found on the South Coast of British Columbia (of a single species and of the same merchantable length to similar standards of utilization) have for practical purposes the same percentage distribution of total tree volume according to log position in the tree. These percentages, applied to revised total-volume estimates for each diameter and height class listed in the site-class volume tables currently in use, provide a mechanical basis for estimating volumes in each log in each tree. A technical note on the details of table construction and a test of the practical utility of the above premise follows the tables.

Tables for Douglas fir, western red cedar, and western hemlock for each of the principal sites have been compiled.

Suggested Use of Tables

1. Thoroughly memorize the grade requirements specified in the Forest Act.

2. Thoroughly memorize the minimum scales acceptable in each grade. Specifically, all other requirements having been met, a 32-foot log must scale at least the following to be included in the grade indicated:

Fir	No. 1	1235	board	feet
	No. 2	125	"	"
Hemlock	No. 1	915	"	"
	No. 2	520	"	"
Cedar	No. 1	520	"	"
	No. 2	320	"	"

3. Determine the maximum height class of the stand being cruised. The maximum height is the average height of dominant trees only; no other trees need be estimated, since site-class volume tables automatically take care of the lesser heights of codominant and intermediate trees. Select the applicable table.

4. Measure the d.b.h. and record the d.b.h. and total volume of each tree.

5. Determine from the table the potential grades of the logs in the tree with respect to minimum sizes only. These are the best grades the logs may have. Degrade each log in the tree with respect to other requirements.

6. Using the table, record the volumes in No. 1 and No. 2 logs.

7. Summarize stand volumes, expressing the volumes in Grade 1 and Grade 2 as a percentage of the total volume. The balance of 100 per cent is ungraded volume.

Discussion of Tables

Volume-table methods of estimating stand volumes, as opposed to direct field estimations of log volumes in each individual tree, necessarily deal with average trees under average conditions. With reference to the factors listed as affecting the results of grade-cruises--volume tables dispense with the need for a sound knowledge of bark-thickness and tapers, necessary for estimating the top D.I.B. for various log lengths and species, in favour of easily measured factors of d.b.h., o.b., and total height; and they dispense with problems related to falling and bucking by setting a standard average log-length and fixed limits of utilization. Such a procedure causes gross differences in the estimation of volumes and grades in individual trees. For example, an average-sized tree bucked into 16-foot lengths will scale about 15 per cent more than the same tree bucked into 32-foot lengths. Whether or not there will be as many longer logs of the right sizes to compensate for shorter logs during actual utilization is usually unknown. Further, a 29-inch, 40-foot log scales 1,400 board feet. The top diameter is insufficient for a No. 1 and, if other requirements are met, its best possible grade is No. 2. By bucking at 32 feet, however, the diameter would be 30 inches and a potential Grade 1 log scaling 1,235 board feet is available, plus an 8-foot chunk which would account for approximately 330 board feet of the next 24-foot potential Grade 2 log. In this single log, bucking policy changes our estimate from 100 per cent No. 2 to 79 per cent No. 1 and 21 per cent No. 2 and increases scale by 9 per cent. Again, proof of whether or not such variations are compensating, when cruises to fixed standards of utilization are compared to scales of logs as utilized, is beyond the scope of this study. It is known, however, that to allow for inherent variation of individual trees in estimating board-foot volumes of stands, volume tables should be used only on tallies of not less than 50 trees if a tally-volume estimate within 6 per cent

(19 times out of 20) is to be expected. (This precision is dependent on careful field work and selection of the correct volume table; it should not be confused with the precision of total-stand estimates due to area-sampling intensity.) It is believed such a tally will contain enough individual logs to provide compensatory effects in the log-length and grade-proportion variations noted above.

Nothing can be added to the tables to supplement the individual's knowledge of the grade rules or to aid him in estimating hidden grade factors in standing trees, except in so far as stating minimum-sized logs in a grade. Hence, while the tables will provide a relative estimate, entirely compatible with the total-volume estimate, of the volumes in any run-of-log positions, the correct assignment of the logs to grade is dependent on the ability of the cruiser alone.

Based on experience from a 10 per cent cruise of approximately 7,000 acres on which every tree was graded, the field staff reports that no substantial gain in time would result from attempting selected sampling of the grade factor.

The suggested use and limitations of the tables supplied should be kept in mind by the estimator and by those using the final results.

PRELIMINARY SITE-CLASS VOLUME TABLES--MATURE DOUGLAS FIR
GROSS BOARD FEET, B. C. RULE

DBH	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Total Volume	Volume in Log Position 1	2	3	4	5	6	7
				Site 80 (Max. Ht. 116)							
16	85	0	0	0	0						
22	102	1	11	355	295	60					
28	112	2	2	725	465	250	10				
34	115	2	15	1130	640	410	80				
40	116	2	23	1560	850	590	120				

Footnote: Volumes scaled in 32-foot logs, 2-foot stump to 12-inch top D.I.B. In the above table, any log scaling 1,235 board feet or over is a potential No. 1; any log scaling 125 board feet or over is a potential No. 2; underlined volumes are for odd length top logs.

PRELIMINARY SITE-CLASS VOLUME TABLES--MATURE DOUGLAS FIR
GROSS BOARD FEET, B. C. RULE

DBH	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Top Log ft.	Total Volume	Volume in Log Position 1	2	3	4	5	6	7
				Site 100 (Max. Ht. 144)							
16	99	0	16	85	85						
22	121	1	26	465	330	135					
28	131	2	16	925	515	325	85				
34	142	3	3	1525	715	520	275	15			
40	144	3	11	2100	930	695	415	60			
46	144	3	18	2720	1175	880	570	95			
52	144	3	21	3400	1455	1100	735	110			
58	144	3	24	4090	1740	1320	905	125			
				Site 120 (Max. Ht. 174)							
16	112	0	24	125	125						
22	139	2	3	585	370	200	15				
28	158	3	3	1180	550	400	215	15			
34	170	3	24	1875	770	580	400	125			
40	174	4	3	2600	1020	775	545	245	15		
46	174	4	10	3380	1290	985	700	355	50		
52	174	4	14	4260	1610	1220	885	470	75		
58	174	4	18	5230	1960	1480	1090	605	95		
64	174	4	21	6230	2310	1770	1290	750	110		
70	174	4	22	7270	2710	2040	1520	885	115		

Footnote: Volumes scaled in 32-foot logs, 2-foot stump to 12-inch top D.I.B. In the above table, any log scaling 1,235 board feet or over is a potential No. 1; any log scaling 125 board feet or over is a potential No. 2; underlined volumes are for odd length top logs.

PRELIMINARY SITE-CLASS VOLUME TABLES--MATURE DOUGLAS FIR
GROSS BOARD FEET, B C. RULE

DBH	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Total Volume	Volume in Log Position 1	2	3	4	5	6	7
				Site 140 (Max. Ht. 206)							
16	126	1	0	170	170						
22	157	2	18	730	380	255	95				
28	181	3	21	1420	580	440	290	110			
34	197	4	13	2220	830	630	455	235	70		
40	205	4	26	3130	1130	860	630	375	135		
46	206	5	5	4110	1410	1090	820	525	240	25	
52	206	5	8	5150	1760	1340	1025	670	315	40	
58	206	5	13	6370	2120	1655	1260	840	425	70	
64	206	5	18	7680	2500	1960	1510	1050	565	95	
70	206	5	21	9030	2910	2300	1790	1240	680	110	
76	206	5	23	10460	3340	2650	2070	1465	815	120	
				Site 160 (Max. Ht. 241)							
16	140	1	10	285	235	50					
22	176	2	31	860	410	285	165				
28	204	4	5	1650	640	485	340	160	25		
34	224	5	0	2470	850	665	485	300	170		
40	236	5	20	3680	1180	925	715	495	260	105	
46	241	6	2	4890	1490	1190	940	685	405	170	10
52	241	6	8	6180	1850	1495	1185	865	525	220	40
58	241	6	11	7670	2290	1845	1460	1070	655	290	60
64	241	6	16	9140	2700	2200	1735	1270	785	365	85
70	241	6	20	10750	3160	2595	2040	1485	935	430	105
76	241	6	21	12450	3650	3010	2370	1710	1090	510	110
82	241	6	23	14260	4210	3450	2700	1940	1240	600	120

Footnote: Volumes scaled in 32-foot logs, 2-foot stump to 12-inch top D.I.B. In the above table, any log scaling 1,235 board feet or over is a potential No 1; any log scaling 125 board feet or over is a potential No 2; underlined volumes are for odd length top logs.

SITE-CLASS VOLUME TABLES--MATURE WESTERN HEMLOCK. GROSS BOARD FEET, B. C. RULE

DBH	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Tot. Vol.	Volume in Log Position 1	2	3	4	5	Stump Ht. Ft.	Top DIB In.
					Site 80 (Max. Ht. 110)						
10	67	1	1	45	45	0				2.0	6.5
16	92	1	28	215	160	55				2.0	7.8
22	106	2	11	500	330	140	30			2.0	9.0
28	110	2	16	810	530	220	60			2.5	10.2
34	110	2	16	1140	745	320	75			3.0	11.4
40	110	2	16	1490	980	415	95			3.5	12.6
					Site 100 (Max. Ht. 140)						
10	72	1	4	50	45	5				2.0	6.5
16	102	2	2	250	180	65	5			2.0	7.8
22	123	2	24	620	425	130	65			2.0	9.0
28	136	3	2	1095	605	345	140	5		2.5	10.2
34	140	3	6	1610	855	515	210	30		3.0	11.4
40	140	3	4	2120	1120	700	275	25		3.5	12.6
46	140	3	0	2600	1460	820	320			4.0	13.8
52	140	2	27	2990	1900	855	235			4.2	15.0
					Site 120 (Max. Ht. 175)						
10	74	1	5	50	45	5				2.0	6.5
16	107	2	6	270	190	70	10			2.0	7.8
22	134	3	0	690	385	220	85			2.0	9.0
28	154	3	15	1285	625	400	205	55		2.5	10.2
34	167	3	26	2025	930	630	345	120		3.0	11.4
40	174	3	29	2825	1300	875	480	170		3.5	12.6
46	175	3	25	3505	1655	1085	585	180		4.0	13.8
52	175	3	17	4100	2050	1290	610	150		4.2	15.0
58	175	3	8	4555	2400	1460	615	80		4.5	16.2

Footnote: In the above table, any log scaling 915 bd. ft. or over is a potential number 1; any log scaling 520 bd. ft. or over is a potential number 2; underlined volumes are for odd length top logs.

SITE-CLASS VOLUME TABLES--MATURE WESTERN HEMLOCK. GROSS BOARD FEET, B. C. RULE

DBH	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Tot. Vol.	Volume in Log Position 1	2	3	4	5	Stump Ht. Ft.	Top DIB In.
					Site 140 (Max. Ht. 210)						
10	72	1	4	50	45	5				2.0	6.5
16	106	2	5	265	185	70	10			2.0	7.8
22	135	3	0	695	390	220	85			2.0	9.0
28	159	3	19	1340	630	415	225	70		2.5	10.2
34	180	4	3	2220	940	685	400	180	15	3.0	11.4
40	194	4	12	3245	1290	960	615	310	70	3.5	12.6
46	204	4	13	4280	1710	1260	820	395	95	4.0	13.8
52	209	4	7	5165	2170	1600	930	405	60	4.2	15.0
58	210	3	29	5780	2730	1790	960	300		4.4	16.2
64	210	3	17	6360	3255	1990	910	205		4.5	17.4

Footnote: In the above table, any log scaling 915 bd. ft. or over is a potential number 1; any log scaling 520 bd. ft. or over is a potential number 2; underlined volumes are for odd length top logs.

SITE-CLASS VOLUME TABLES--MATURE WESTERN RED CEDAR, GROSS BOARD FEET, B. C. RULE

DBH Class	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Tot. Vol.	Volume in Log Position 1	2	3	4	5	6	Stump Ht. Ft.
				Max. Ht. Class 110							
16	67	-	16	85	85						
22	83	1	0	170	170						
28	95	1	20	595	490	105					
34	104	2	2	970	640	320	10				
40	108	2	9	1440	915	475	50				
46	110	2	14	2030	1285	670	75				
52	110	2	14	2850	1825	950	75				
58	110	2	14	3620	2335	1210	75				
64	110	2	14	4600	3000	1525	75				
				Max. Ht. Class 140							
16	80	-	25	130	130						
22	100	1	18	395	300	95					
28	117	2	5	710	450	235	25				
34	129	2	21	1170	690	370	110				
40	136	3	2	1780	965	545	260	10			
46	140	3	10	2560	1360	780	370	50			
52	140	3	10	3500	1870	1070	510	50			
58	140	3	10	4650	2510	1430	660	50			
64	140	3	10	6000	3250	1850	850	50			
70	140	3	10	7600	4120	2340	1090	50			

Footnote: Maximum Ht. Classes 110 and 200 based on insufficient data. Volumes scaled in 32-foot logs, variable stump to 12-inch top D.I.B. In the above table, any log scaling 520 bd. ft. or over is a potential No. 1; any log scaling 320 bd. ft. or over is a potential No. 2; underlined volumes are for odd length tops.

SITE-CLASS VOLUME TABLES--MATURE WESTERN RED CEDAR, GROSS BOARD FEET, B. C. RULE

DBH Class	Tot. Ht. Ft.	Merchantable Length 32.6' Logs	Merchantable Length Top Log ft.	Tol. Vol.	Volume in Log Position 1	2	3	4	5	6	Stump Ht. Ft.
				Max. Ht. Class 170							
16	93	1	5	180	180						
22	117	1	28	435	290	145					
28	137	2	21	830	465	255	110				
34	152	3	14	1380	645	430	230	75			
40	163	4	0	2100	925	630	375	170			
46	168	4	8	3000	1280	900	550	230	40		
52	170	4	10	4150	1770	1240	770	320	50		
58	170	4	10	5500	2360	1640	1010	440	50		
64	170	4	10	7150	3080	2130	1315	575	50		
70	170	4	10	9100	3910	2710	1670	760	50		
				Max. Ht. Class 200							
16	105	1	12	210	145	65					2.4
22	133	2	5	500	315	160	25				3.0
28	157	2	30	950	505	290	155				3.4
34	175	3	26	1580	685	475	285	135			3.9
40	189	4-	21	2420	915	675	470	250	110		4.4
46	197	5	2	3500	1310	990	650	395	145	10	4.9
52	200	5	8	4800	1800	1330	890	540	200	40	5.4
58	200	5	8	6400	2400	1780	1190	720	270	40	5.8
64	200	5	8	8300	3110	2320	1540	930	360	40	6.3
70	200	5	8	10600	3980	2980	1970	1200	430	40	6.8

Footnote: Maximum Ht. Classes 110 and 200 based on insufficient data. Volumes scaled in 32-foot logs, variable stump to 12-inch top D.I.B. In the above table, any log scaling 520 bd. ft. or over is a potential No. 1; any log scaling 320 bd. ft. or over is a potential No. 2; underlined volumes are for odd length tops.

Technical Note on Table Construction

1. Douglas Fir

(a) Tree Volume-Site Class Tables. The total height-d.b.h. relationships by site classes had previously been established in connection with Provincial inventory tables.(1) Total tree volumes were read from a base total-height volume table.(2) Total height-merchantable length relationships were extracted from work-sheets used in constructing base-log length and total-height tables.(3) Total-volume estimates cross-check in the two base tables.

The average deviation of individual values in the base tables is 15 per cent. Correctly applied to tallies of at least 50 trees, the total-volume estimate should be within approximately 6 per cent (19 times out of 20). When, however, the base-table values are used in site-class volume tables, there is the further possibility that an individual stand may vary by half a class from the nearest average site-table and a consistent under- or over-estimate of up to 10 per cent on individual tallies is thus possible. This latter non-sampling or method error is accepted by management for present purposes. (It should be remembered that this error may be included in, though it is distinct from, the 30 to 60 per cent coefficient of variation used for intensity of sampling determinations for old-growth Douglas Fir types.)

(b) Log Volume-Site Class Tables. The method employed in determining the proportion of the total cruised volume occurring in any run of logs, say, grouped by grade, within the trees must be compatible with the above errors. For example, if a particular total volume of a group of trees cruised is underestimated by 10 per cent, then the volume occurring in any group of logs within the trees must also be underestimated by 10 per cent. The absolute volume in the group of logs is only of importance relative to the total volume estimate.

The tree-measurement data used in constructing the base-volume table were reviewed and 273, or all those trees showing field measurements up to a 12-inch or less top, were selected. Within each tree the percentage of the total tree volume, 2-foot stump to 12-inch top, occurring in each 32.6-foot log and the odd-length top

(1) P. 12, Report of the Forest Service, 1948, King's Printer, Victoria.
(2) Table 7, Volume, Yield, and Stand Tables, B.C.F.S., 1936, Victoria (out of print).
(3) Tables 5 and 7, ibid.

was calculated. The data were sorted by half-log classes and averaged. Fig. 1 shows the plotted averages and the resulting, very well defined curves. Table 1 shows the curved percentages for each log or half-log in trees up to 7 logs.

TABLE 1

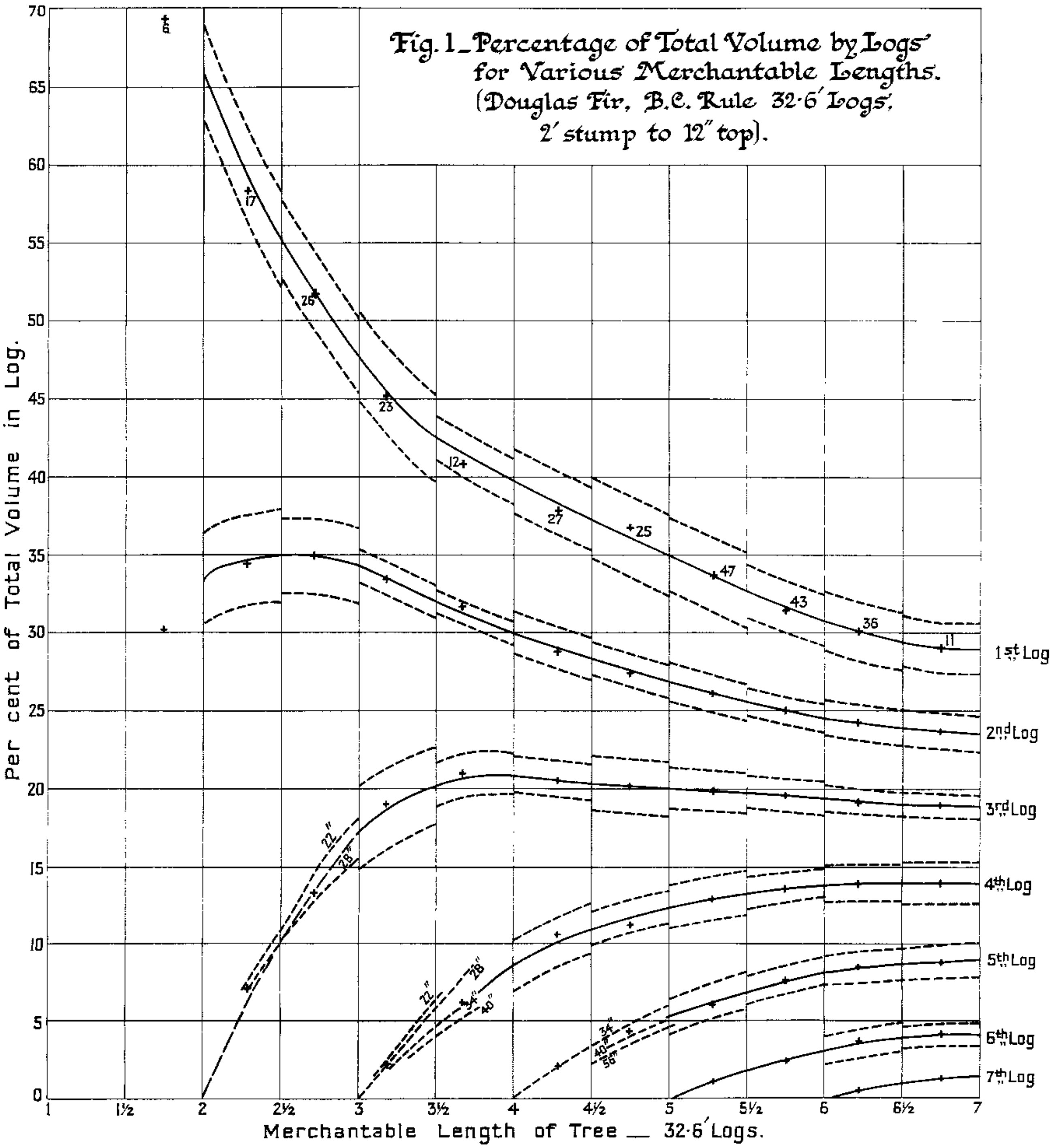
Average Percentage Distribution of Total Volume by

Logs for Various Merchantable Length Trees.

Douglas Fir, B. C. Rule 32.6' Logs, 2'Stump, 12" Top.

Number of Logs in Tree	Log Position in Tree 1	2	3	4	5	6	7
	Percentage of Total Volume						
1	100.0						
2	66.0	34.0					
2½	55.0	35.0	10.0				
3	48.1	34.3	17.6				
3½	42.5	32.1	20.2	5.2			
4	40.0	30.0	21.0	9.0			
4½	37.2	28.3	20.3	11.0	3.2		
5	35.0	27.0	20.0	12.6	5.4		
5½	32.7	25.6	19.7	13.4	6.9	1.7	
6	30.7	24.6	19.4	13.9	8.2	3.2	
6½	29.5	23.9	19.0	14.0	8.6	4.0	1.0
7	29.0	23.5	18.9	14.0	9.0	4.1	1.5

Underlined values are for half logs.



Basis: 1410 logs in 273 trees. Weights on first log curve apply to all points vertically below.

Broken lines are plotted at plus and minus one Standard Error of Estimate and enclose approximately two thirds of the individual observations.

The curved percentage values were next applied to the total tree volumes as determined in (a) above. The expected cross-check is that the calculated volume of the top log equals the scale of a 12-inch log of the top-log length. For example, a 40-inch tree on site 100, on the average, has a total volume of 2,100 board feet in three 32.6-foot logs and an 11-foot top log to a 12-inch top. The curved percentage in this log is 4 per cent (Fig. 1) equal to 84 board feet; the actual scale of a 12-inch 11-foot log is only 58 board feet or 2.8 per cent of the total tree volume. Near and beyond the limits of the basic data (Table 2) such discrepancies were of practical importance and are believed due to ignoring form.

In keeping with the requisites of the presented tables, a simple practical adjustment was sought. The basic data were resummarized by 6-inch diameter and half-log classes and plotted. Except for the parts of the curves in Fig. 1 which represent top logs (see top logs of 3-, 4-, and 5-log trees, Fig. 1), separate curves were too weak to use. In all cases, within the range of basic data, the 6-inch-class curved percentages agree with the actual percentages in top logs. The residual, or difference between the average curve and the adjusted top-log curve, could not be ignored. It was arbitrarily distributed over the remaining logs in the tree. For example, in a 40-inch, site 100 tree, averaging three 32.6-foot logs and in 11-foot top log, the curve percentages of the total volumes by logs are 44.0, 32.6, 19.4, and 4.0. The adjusted top-log percentage is 2.8 per cent. The residual 1.2 per cent (26 board feet) is added in 3 equal parts to the first 3 logs, resulting in adjusted percentages of 44.4, 33.0, 19.8, and 2.8. While theoretical objections to this procedure are entirely justifiable, the adjustments improve the answer sought for practical application. The tables must be considered preliminary and weak in the classes beyond the range of basic data (Table 2).

TABLE 2

Distribution of Basic Data by Site Classes --Douglas Fir

DBH Class	Site Class 80	100	120	140	160	Total
	Number of Trees					
16	1		1			2
22	2	8	12	3	2	27
28		16	17	8		41
34	1	6	11	17	6	41
40	1	3	13	22	14	53
46		1	8	21	21	51
52		1	1	11	13	26
58			1	3	10	14
64				3	8	11
70					4	4
76				1	1	2
82					1	1
Total	5	35	64	89	80	273

Solid block indicates extensions in application of basic data. The tree volumes are satisfactory but the log-volume breakdowns must be considered preliminary in extended classes.

Table 3 shows the standard errors of estimate of the basic data by half-log classes and log-position in tree. Since all top logs were adjusted to actual percentages, they show no errors. The standard errors of estimate are here a measure of the variation of individual values about the adjusted curve values. These absolute variations are difficult to interpret in view of the variable base values which will actually fall into groups in the field. Deviations of individual logs were, therefore, expressed as a per cent of the curve values, in this case per cent of percentages, and the standard error of estimate in per cent calculated. The standard error of estimate expressed as a per cent is a direct measure of the variation in board-foot volumes of the various logs.

TABLE 3

Variations in Basic Data--Douglas Fir

Log Class	Basis No. Trees	Log Position 1 SE	1 SE%	2 SE	2 SE%	3 SE	3 SE%	4 SE	4 SE%	5 SE	5 SE%	6 SE	6 SE%	7 SE	7 SE%
Less than 2 logs	6														
2 to $2\frac{1}{2}$	17	3.00	5.0	3.00	8.68	0	0								
$2\frac{1}{2}$ to 3	26	2.46	4.8	2.46	7.0	0	0								
3 to $3\frac{1}{2}$	23	2.82	6.3	1.03	3.1	2.53	13.13	0	0						
$3\frac{1}{2}$ to 4	12	1.47	3.6	.75	2.4	1.44	6.9	0	0						
4 to $4\frac{1}{2}$	27	2.02	5.2	1.40	4.8	1.20	5.8	1.63	16.07	0	0				
$4\frac{1}{2}$ to 5	25	2.57	7.1	1.09	4.0	1.83	9.1	1.19	10.1	0	0				
5 to $5\frac{1}{2}$	47	2.39	7.08	1.24	4.7	1.36	6.8	1.49	11.5	1.15	17.47	0	0		
$5\frac{1}{2}$ to 6	43	1.73	5.5	.90	3.6	1.13	5.8	1.00	7.3	.96	12.6	0	0		
6 to $6\frac{1}{2}$	36	1.88	6.3	1.06	4.4	.81	4.2	1.20	8.6	1.03	12.1	.90	25.58	0	0
$6\frac{1}{2}$ to 7	11	1.63	5.6	1.05	4.4	.79	4.2	1.33	9.5	1.04	11.8	.62	15.1	0	0
Total	273														

SE of Estimate is the absolute variation of the individual values about the adjusted curved percentage values. Top logs adjusted to zero variation.

SE of Estimate % is a cumbersome % of % and was only calculated in full for those log classes in each log position which showed the greatest relative dispersion. Those values shown to 1 decimal place are approximations only.

The actual precision of the estimate of the total volume occurring in any group of logs or grade can only be determined after the run of merchantable lengths of trees in the tally and the positions of logs falling in the various grades are known. However, it is possible to indicate in advance the maximum errors (poorest precisions) to expect if certain conservative assumptions are made:

(a) A minimum of 150 to 250 logs will occur in each tally in the type of stands for which grade proportions would be estimated. These numbers are based on recommended practice of including at least 50 trees in a tally for desirable total-volume estimates.

(b) A group of less than 10 logs would not be important enough to consider separately.

(c) Logs will be grouped by grades--Nos. 1, 2, and 3, as laid down in the Forest Act.

(d) Potential No. 1 logs only occur in the first or second log of $3\frac{1}{2}$-log or larger trees and occasionally in the third log of 5-log or larger trees. The greatest standard error of estimate associated with these classes is 7.1 per cent (Table 3).

(e) Potential No. 2 logs can occur in any log position except short tops. It is doubtful if they could be recognized above the fourth log (132 feet) in a standing tree. The largest standard error of estimate associated with these classes is 16.1 per cent (Table 2).

(f) No. 3 or ungraded logs make up the remainder of the total volume.

The precision of the grade breakdown of a stand will depend on the number of logs and the percentage of the total volume in the grade. For example, if 10 logs fall in grade 1 the maximum error in the board-foot-volume determination of grade 1 is $t \times \frac{SE}{\sqrt{n}} = 2.2 \times \frac{7.1}{\sqrt{10}} = 4.9\%$ (19 times out of 20). If these 10 logs represent 10 per cent of the total-stand volume, then the statement of precision would be: $10\% \pm (4.9\% \text{ of } 10\%)$ or $10\% \pm .49\%$ (19 times out of 20) of the estimated total volume is in Grade 1. If these 10 logs represent 30 per cent of the total-stand volume, then the statement of precision would be: $30\% \pm (4.9\% \text{ of } 30\%)$ or $30\% \pm 1.47\%$ of the total volume is in Grade 1. In practice it is doubtful that all the No. 1's will come from the class with the greatest variation (first logs of $4\frac{1}{2}$- to $5\frac{1}{2}$- log trees) and more precise estimates should prevail.

Table 4 shows the expected maximum errors in proportions of stand for various numbers of logs likely to occur in Grades 1 and 2. The maximum errors in Grade 3 or ungraded percentages cannot exceed the sum or be less than the difference of the maximum errors in Grades 1 and 2 since the total volume equals 100 per cent and the total error equals 0.

TABLE 4

Indicated Maximum Errors in Proportions of Stand for Various Numbers of Logs Likely to Occur in Grades 1 and 2. Douglas Fir.

Percent of Total Volume In Grade	Number of Grade 1 Logs					Number of Grade 2 Logs			
	10	20	30	40	50	50	100	150	200
	Maximum Error (.05 Level Probability)								
10	.49	.33	.26	.22	.20				
20	.98	.67	.52	.44	.40	.91	.64		
30	1.47	1.00	.78	.66	.60	1.36	.97	.79	.67
40			1.04	.88	.80	1.82	1.29	1.05	.91
50							1.61	1.31	1.14
60								1.58	1.37
70									1.60

Based on greatest variations associated with grades and minimum tally of 50 trees (150 - 250 logs).

Two points should be kept in mind when using Table 4 as a guide to expected precision:

(a) The tables are based on the largest variation associated with the potential grades and the smallest recommended tallies. In practice the maximum errors should be smaller than those shown in the tables.

(b) The errors are for logs as grouped and do not include the human error of incorrectly classifying logs by grade.

2. Western Red Cedar and Western Hemlock

A similar procedure was followed in constructing the tables for these species. The percentage of the total volume occurring in various logs for various merchantable lengths differed from that of Douglas fir (Fig. 1). The reasons, probably associated with bark-thicknesses, form, and slightly different standards of utilization, were not investigated. The maximum spreads of the individual observations did not exceed those for fir and were accepted without statistical test. The tables are considered preliminary, though suitable for the recommended use.