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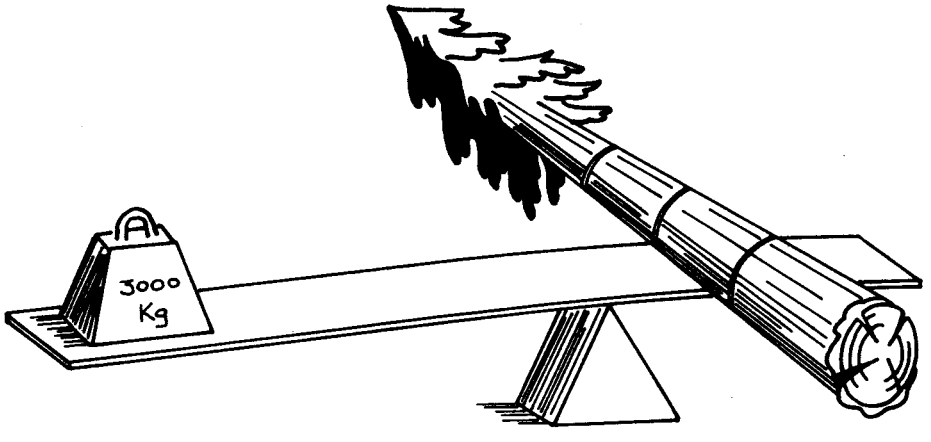
FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

ENGINEERING CHARACTERISTICS OF CANADIAN TREES: DOUGLAS-FIR AND WESTERN HEMLOCK IN INTERIOR BRITISH COLUMBIA

L.L. Adamovich
Faculty of Forestry
University of British Columbia

Technical Note No. TN-27
July 1979



201 - 2112 West Broadway, Vancouver, B.C., Canada V6K 2C8
143 Place Frontenac, Pointe Claire, Québec, Canada H9R 4Z7

FOREWORD

This is the third in a series of reports dealing with engineering characteristics of the commercially important tree species of Interior British Columbia. Investigations began in 1972 with the support of the Forest Management Institute, Canadian Forestry Service. The current study is a continuation of this work, carried out under contract to the Forest Engineering Research Institute of Canada, Western Division.

In the course of this project, theoretical models and field procedures have been developed and simplified. Although necessarily limited in scope, the data have proven useful to engineers concerned with the development of tree-felling heads, loaders and processors. The tree weight and centre-of-gravity tabulations can also be used to predict--or at least explain--the limitations of currently available logging machines for harvesting Interior British Columbia trees and stands.

The author gratefully acknowledges the advice of Mr. G.V. Wellburn in helping to select representative stands for this study. Personnel of the British Columbia Forest Service and of logging companies in the study areas (Weldwood of Canada Ltd., 100 Mile House and Likely; Canadian Cellulose Ltd., Revelstoke) provided valuable assistance during the field work.

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SUMMARY

The purpose of this study was to give a basis for estimating the engineering characteristics of trees of Western hemlock and of two forms of Douglas-fir in the Interior of British Columbia. Other common Interior species are covered similarly in previous publications by the author.

Tables of green weight, weight distribution, center of gravity and weight/volume ratios are derived from sample trees cut near 100 Mile House (dry-Interior Douglas-fir), Likely (wet-Interior Douglas-fir) and Revelstoke (Interior Western hemlock). With these tables, green weights, their distribution and their relation to length and volume can be predicted for portions of the tree above ground, with or without stem wood, bark, top or branches.

These predicted values should be useful for determining the dimensions, material strengths and power requirements of machines to fell, skid, lift or process trees.

INTRODUCTION

Tree harvesting is a special application of materials-handling technology requiring the development of specialized methods and equipment. With increasing mechanization in logging, it becomes imperative that the engineering characteristics of the trees be known. Study of the basic parameters (green weight, centre-of-gravity position) of the important commercial tree species of Interior B. C. began in 1973 (Adamovich, 1975 a, b), with the aim of helping logging equipment designers and users to produce or select machines of appropriate capabilities.

Work on the various species was scheduled in the approximate order of total volume cut per year. The first investigations dealt with Western white spruce (Picea glauca (Moench) Voss var. albertiana (S. Brown) Sarg.), lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm., alpine fir (Abies lasio-carpa Engelm.), and the major broad-leafed species, trembling aspen (Populus tremuloides Michx.).

The present study deals with the two varieties of Douglas-fir--the wet-belt or "green" variety (Pseudotsuga mensiesii (Mirb.) Franco) and the dry-belt, or "blue" variety (Pseudotsuga glauca (Beisn.)), and Western hemlock (Tsuga heterophylla (Raf.) Sarg.). Dry-belt Douglas-fir frequently exhibits a swept, heavily-tapered bole, and a long crown with large branches. The wet-belt variety commonly has a straight bole, moderate taper, finer branches and a crown length to total height ratio of less than 40%. Western hemlock grows only in the wet belt. In some areas mature trees are decadent, causing problems in log production and handling. The present study, however, deals only with sound trees.

The following sections outline briefly the sample locations and characteristics and the field methods and anlyses performed. The principal results appear in tabulations in the appendices and are generally parallel to those of the earlier reports on this long-term project. Since most of the original measurements were in metric (SI) units, results are reported in metric units. A table of conversion factors to Imperial units appears in Appendix I.

PROCEDURE

Field procedures for weighing and balancing trees and sections of trees have already been fully described (Adamovich, 1975 a, b). These methods were applied in three sample locations: i) dry-belt Douglas-fir, west of 100-Mile House, B. C.; ii) wet-belt Douglas-fir, near Likely, B. C., and iii) wet-belt Western hemlock near Revelstoke, B. C. The stands sampled are illustrated in Figures 1, 2, and 3. Site characteristics are summarized in Table 1.

FIGURE 1. Dry-Interior Type Douglas-Fir Stand West of 100-Mile House, B. C.

FIGURE 2. Wet-Interior Type Douglas-Fir Stand, North of Likely, B. C.

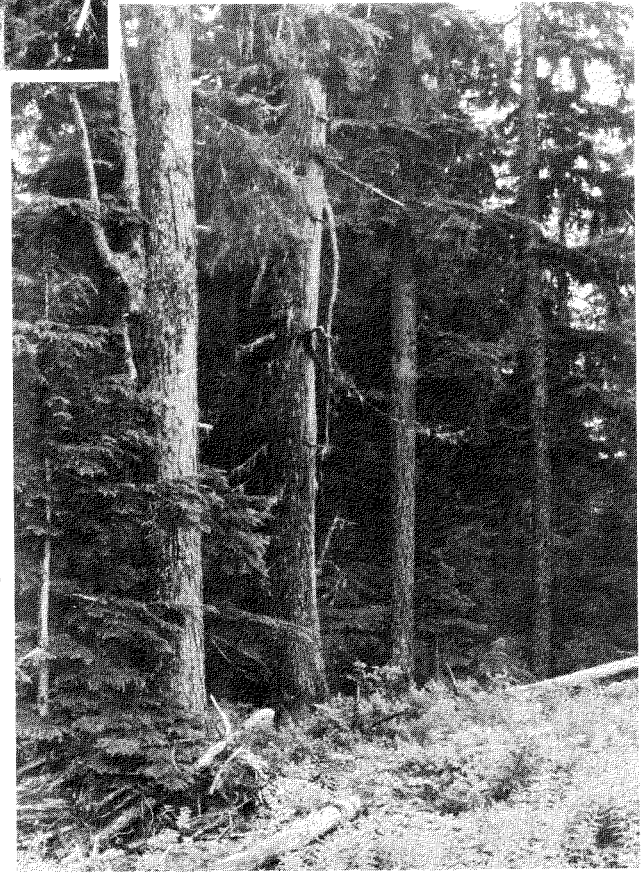


FIGURE 3. Interior Western Hemlock Stand, Northeast of Revelstoke, B.C.

Table 1. Characteristics of Stands Sampled

Type	Elevation Above Sea Level (m)	Av. Annual Rainfall (mm)	Soil Type	Stand Characteristics
Dry Interior Douglas-fir	1 140	450	Glacial till; gravelly; thin humus.	Patchy, variety of age classes; mixed with lodgepole pine.
Wet Interior Douglas-fir	840	900	Alluvial; gravelly sand; thin to moderate humus.	Even-aged, closed stand, mixed with white spruce, hemlock & lodgepole pine.
Interior Western hemlock	3 600	1 050	Deep podzol; very thick, raw humus.	Decadent stand; mixed with Western red cedar.

Sound trees were systematically selected to represent the full range of breast height diameters (dbh) locally available. In addition to weights of the tree, stem, bark-free bole, branches and bark samples, the following were recorded: centre-of-gravity position of the tree, stem or smaller sections, age, crown type and length; maximum branch length; and stump height. The field form is shown in Appendix II.

Data were keypunched directly from field forms for computer analysis. The computer program calculated: centre of gravity of whole tree and stem; total weight of whole tree, stem and bole; total weight of branches and bark, and the weight of each of these components for deciles (one-tenth) of tree height.

Bark volume was calculated for sectioned trees using the average end-area formula:

$$V = \frac{h\ (A_b + A_t)}{2}$$

where: V = volume of bark for a log section
h = length of log section
A_b = cross-sectional area of bark at the base of log section
A_t = cross-sectional area of bark at the top of the log section

Bark weight per unit volume (from a smaller bark sample), multiplied by the bark volume for the log section gave an estimate of bark weight for the section. These were summed to give bark weight for the tree.

Regression analyses determined for each species sampled:

i) tree height as a function of dbh;
ii) tree centre of gravity (absolute and relative) as a function of dbh and height;
iii) the green weight of tree components (stem, debarked bole, bark, branches) as function of dbh and height.

Green weight and centre-of-gravity position for deciles of tree height, for the merchantable stem (tree lengths) and for standard log lengths were determined by methods previously described (Adamovich, 1975 a).

RESULTS

Dry-Interior Douglas-Fir

The height-diameter relationship for the 24 trees in this sample is illustrated in Figure 4. The curve fitted through the plotted points was calculated from the regression equation shown.

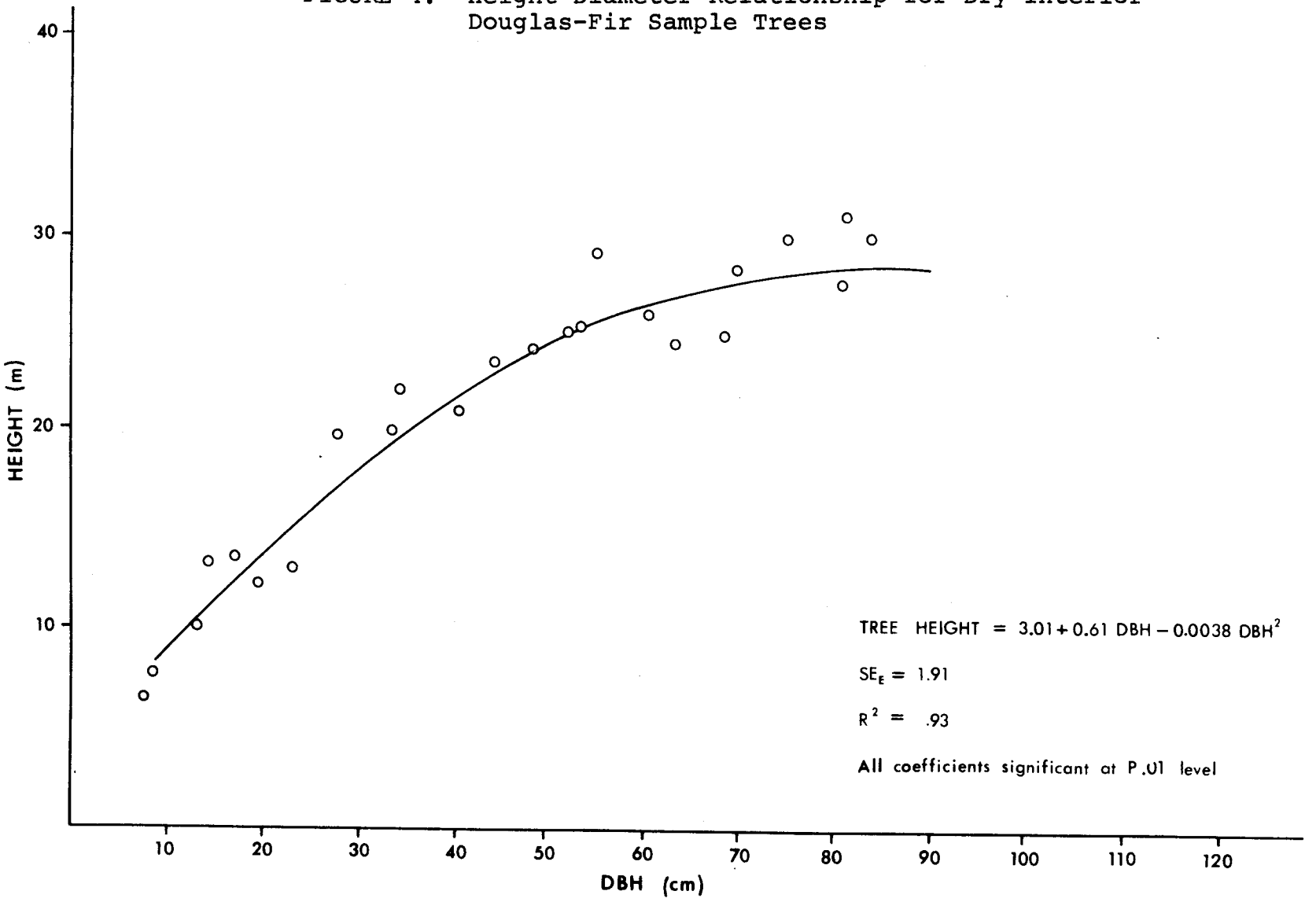
Other basic statistics for the sample trees (age, green weight, centre-of-gravity position, crown dimensions) are shown in Appendix III Table III-1. Tree weights varied from 25 kg to 4 578 kg, averaging 1 440 kg. The centre-of-gravity position of the trees ranged from 32% to 43% of total tree height, and averaged 37%.

Appendix III Table III-2 shows the green weight distribution for dry-Interior Douglas-fir trees, by deciles of tree height. These values are graphed in Figure 5 to illustrate the percent distribution of green weight within the tree. Comparison with similar graphs for wet-Interior Douglas-fir (Figure 7) and Western hemlock (Figure 9) indicates differences in stem form, branching characteristics and centre-of-gravity position.

Centre-of-gravity positions for the whole tree and stem, (as related to tree height and diameter) are shown in Appendix III Table III-3. Green weights of the whole tree, stem, bark, bark-free bole, and branches appear in Appendix III Tables III-4 to III-8. Weight and centre-of-gravity position of the merchantable stem to a 10-cm top diameter inside bark are shown together in Appendix III Table III-9. Similar tabulations are given in subsequent appendices for each of the species investigated. For ease of comparison, the tables parallel those issued in earlier reports on this project.

The ratio between bole, stem or whole-tree weight and merchantable wood volume was also derived for representative tree sizes, using data from Tables III-4, III-5 and III-7 in conjunction with standard volume tables. Table III-10 shows the results for two typical tree sizes, expressed in kg (lb) per m^3 (ft^3) of bole volume between ground level and a 10-cm (4-inch) top inside bark. For the smaller-sized tree (30 cm) the bark-free bole weighs about 80% of the stem including bark, and the whole tree including bark and branches weighs about 125%. The respective values for the larger (60 cm) tree are 78 and 120 percent.

FIGURE 4. Height-Diameter Relationship for Dry-Interior Douglas-Fir Sample Trees



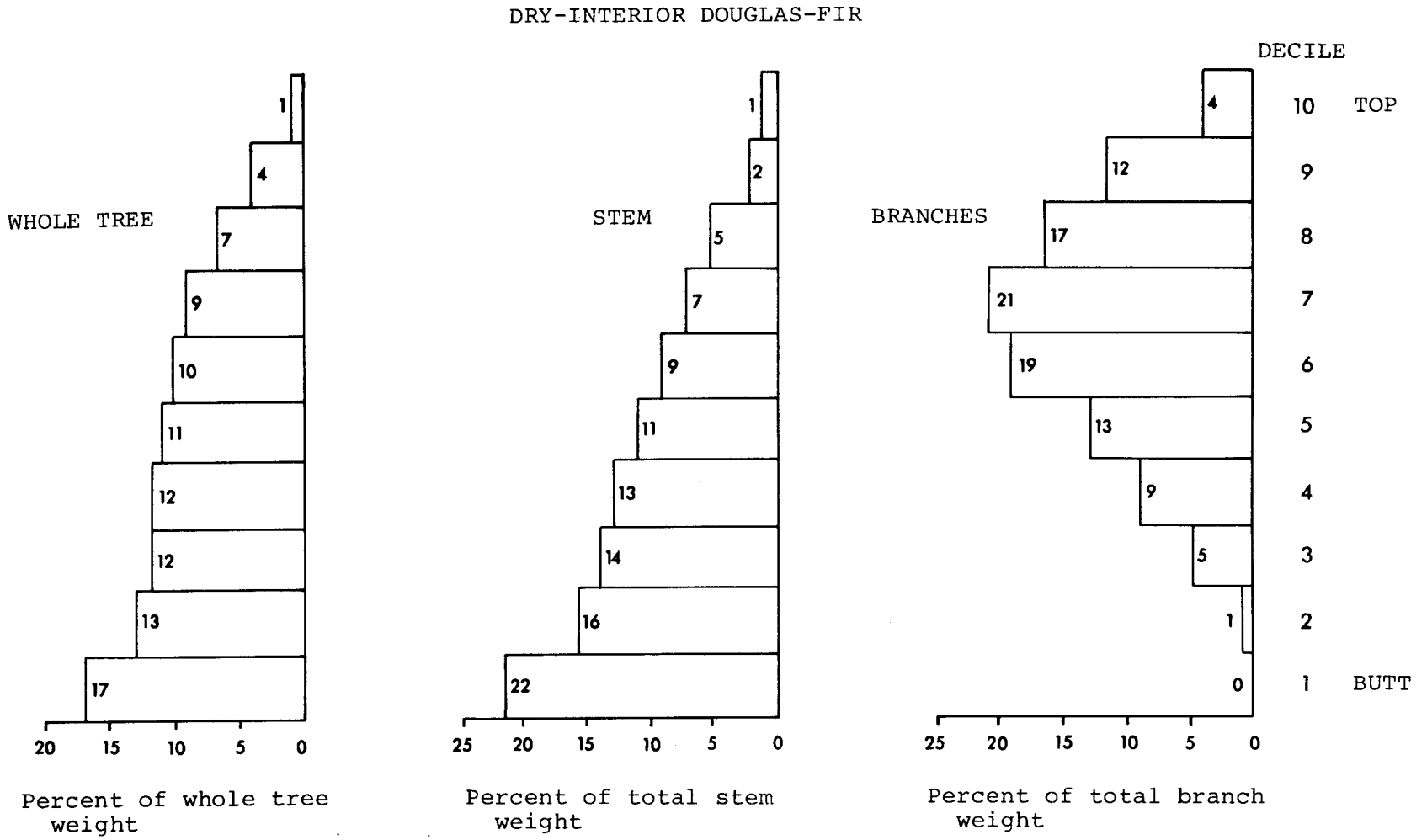


FIGURE 5. Green-Weight Distribution for Deciles of Tree Height, Dry-Interior Douglas-Fir (from Table III-2.)

Wet-Interior Douglas-Fir

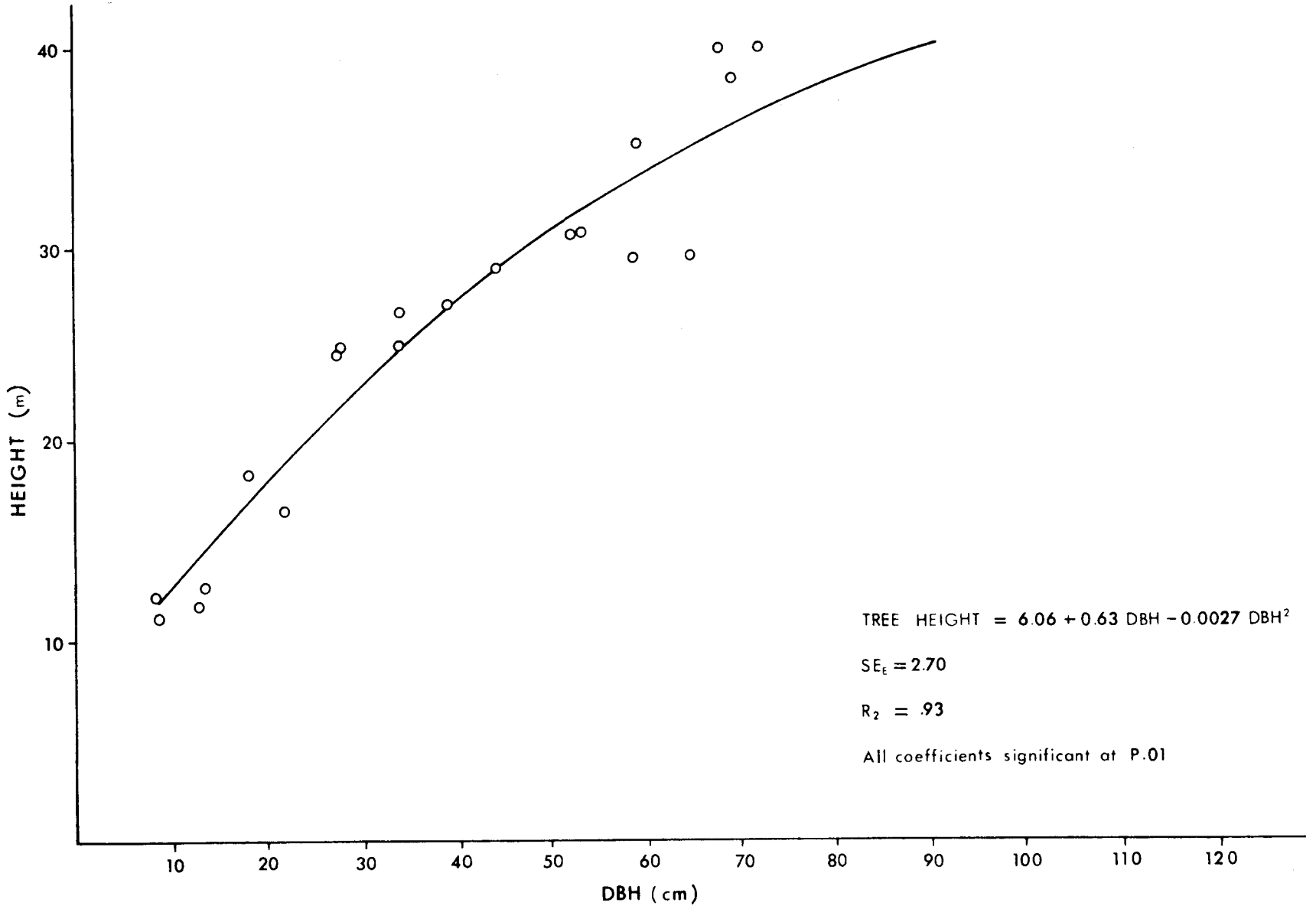
Figure 6 presents the height-diameter relationship for the 20 trees in this sample. Wet-Interior Douglas-fir were, on the average, 5 m taller than dry-Interior fir at 50 cm dbh. This difference in height increased with increasing tree diameter.

Tabulations for wet-Interior Douglas-fir, analogous to those described for the dry-Interior variety, appear in Appendix IV, Tables IV-1 to IV-10. Tree weights varied from 29 kg to 4 923 kg, and averaged 1 513 kg. Centre-of-gravity positions for these trees fell between 29% and 43% of total tree height, averaging 38%.

Table IV-10 shows slightly less density in the bole wood and less proportional weight in bark and branches than for dry-Interior Douglas-fir. Bole weights are 86 to 89 percent of stem weight, and whole-tree weights 114 to 116 percent.

Figure 7 shows the percent distribution of green weight within the tree. Comparing these profiles with those of Figure 5 reveals differences in tree form and branching habit between wet-Interior and dry-Interior Douglas-fir.

FIGURE 6. Height-Diameter Relationship for Wet-Interior Douglas-Fir Sample Trees



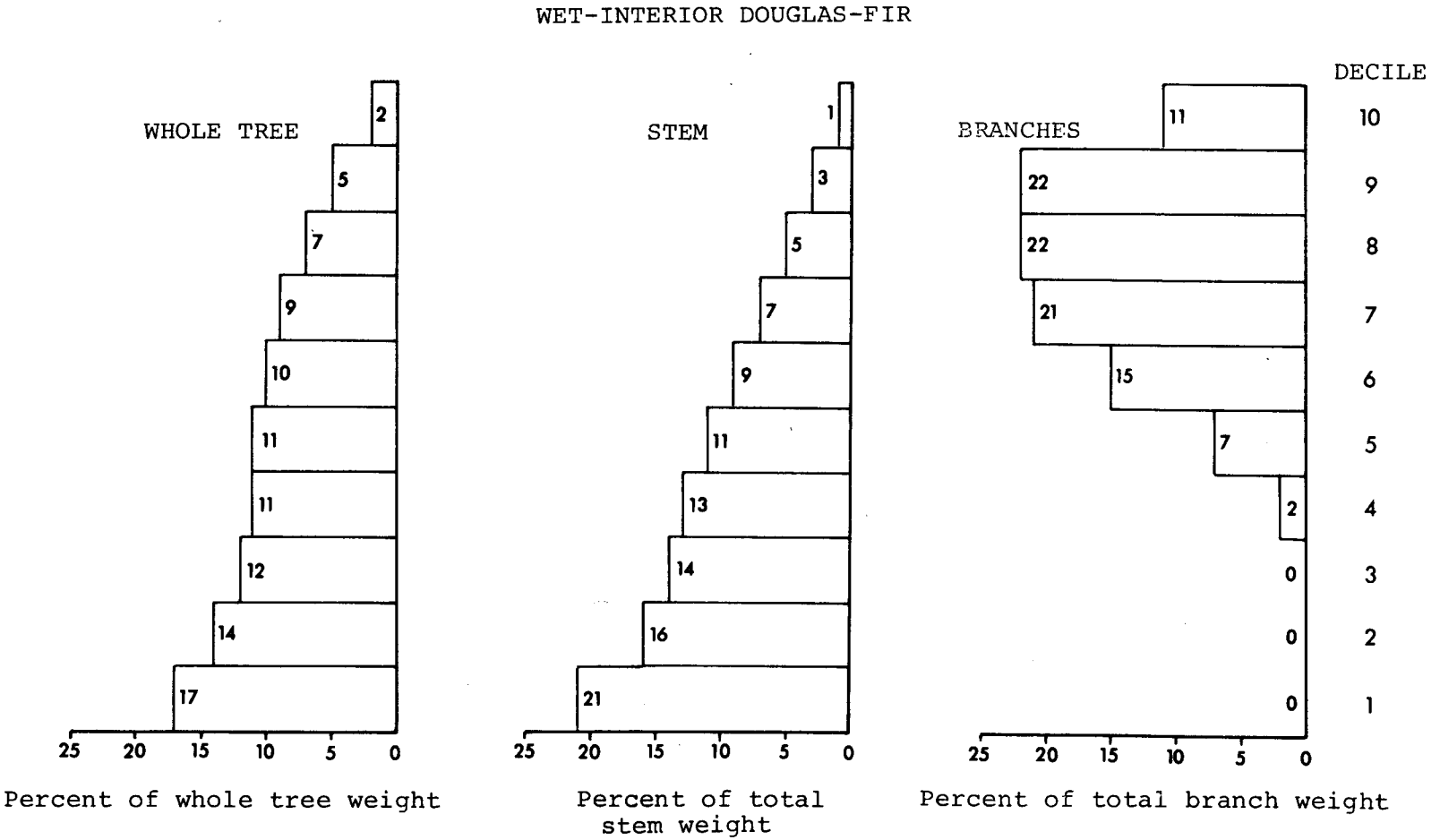


FIGURE 7. Green-Weight Distribution for Deciles of Tree Height, Wet-Interior Douglas-Fir (from Table IV-2.)

Interior Western Hemlock

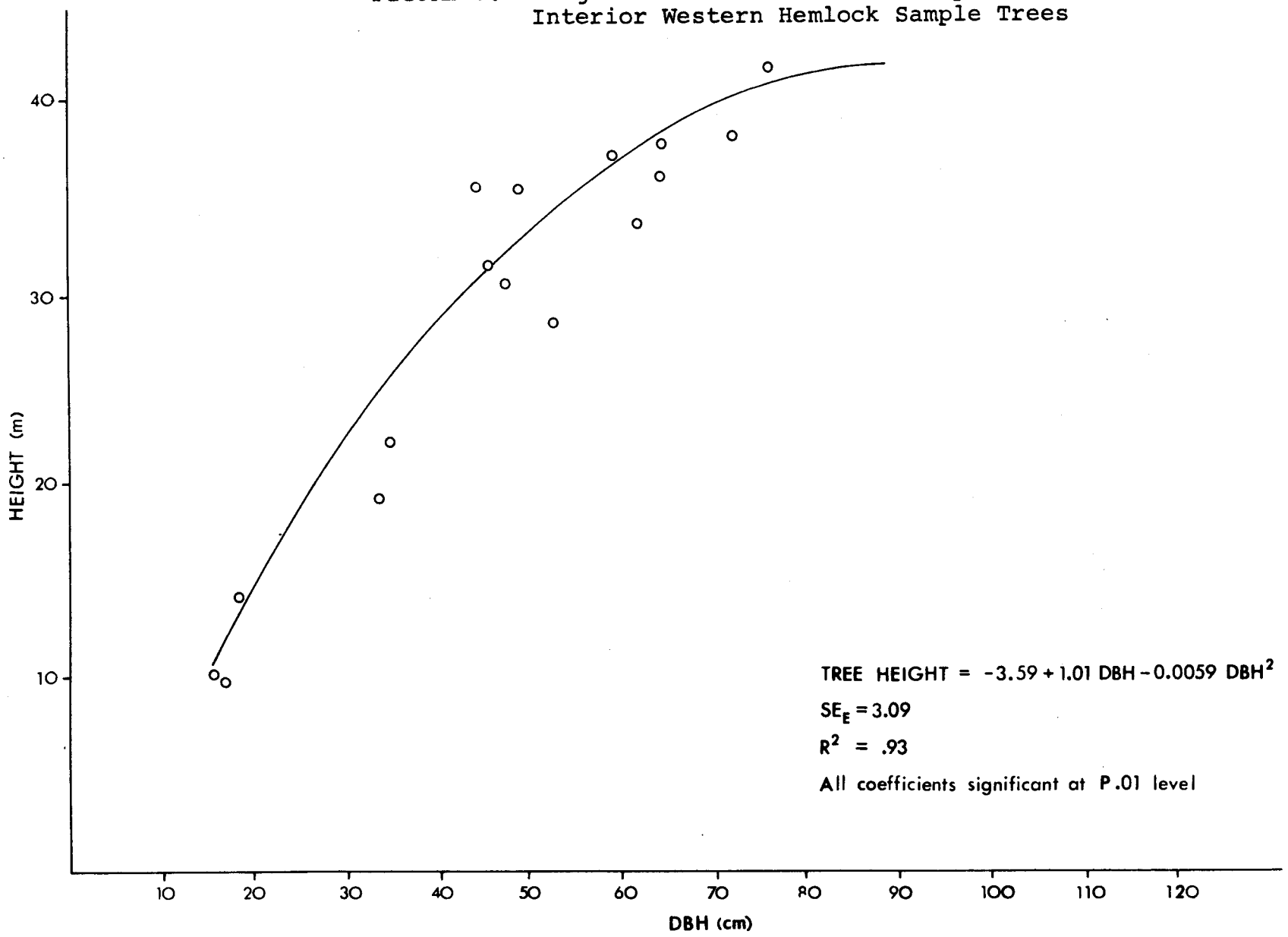
The height-diameter relationship, based on 15 sample Western hemlock trees, is shown in Figure 8.

Tabulations analogous to those presented for Douglas-fir are given for Western hemlock in Appendix V, Tables V-1 to V-9. Sample trees varied in weight from 17 kg to 6 580 kg, averaging 2 428 kg. Centre-of-gravity position for Western hemlock trees varied from 30% to 46% of total tree height, and averaged 37%.

Table V-10 in the Appendix again illustrates the weight of bole, stem and whole tree for 30 cm and 60 cm trees, expressed in kg (lb) per m^3 (ft^3) of bole wood. Debarked boles weigh 94 percent of the stem weight for 30-cm trees, and 85 percent of stem weight for 60-cm trees (hemlock bark is thinner than Douglas-fir bark). Whole trees weigh 122 percent of stem weight for 30-cm trees and 111 percent of stem weight for 60-cm trees. These figures suggest heavy tops on smaller trees and proportionately smaller top weights in the larger trees.

Figure 9 shows the percent distribution of green weight within the tree, for deciles of tree height.

FIGURE 8. Height - Diameter Relationship for Interior Western Hemlock Sample Trees



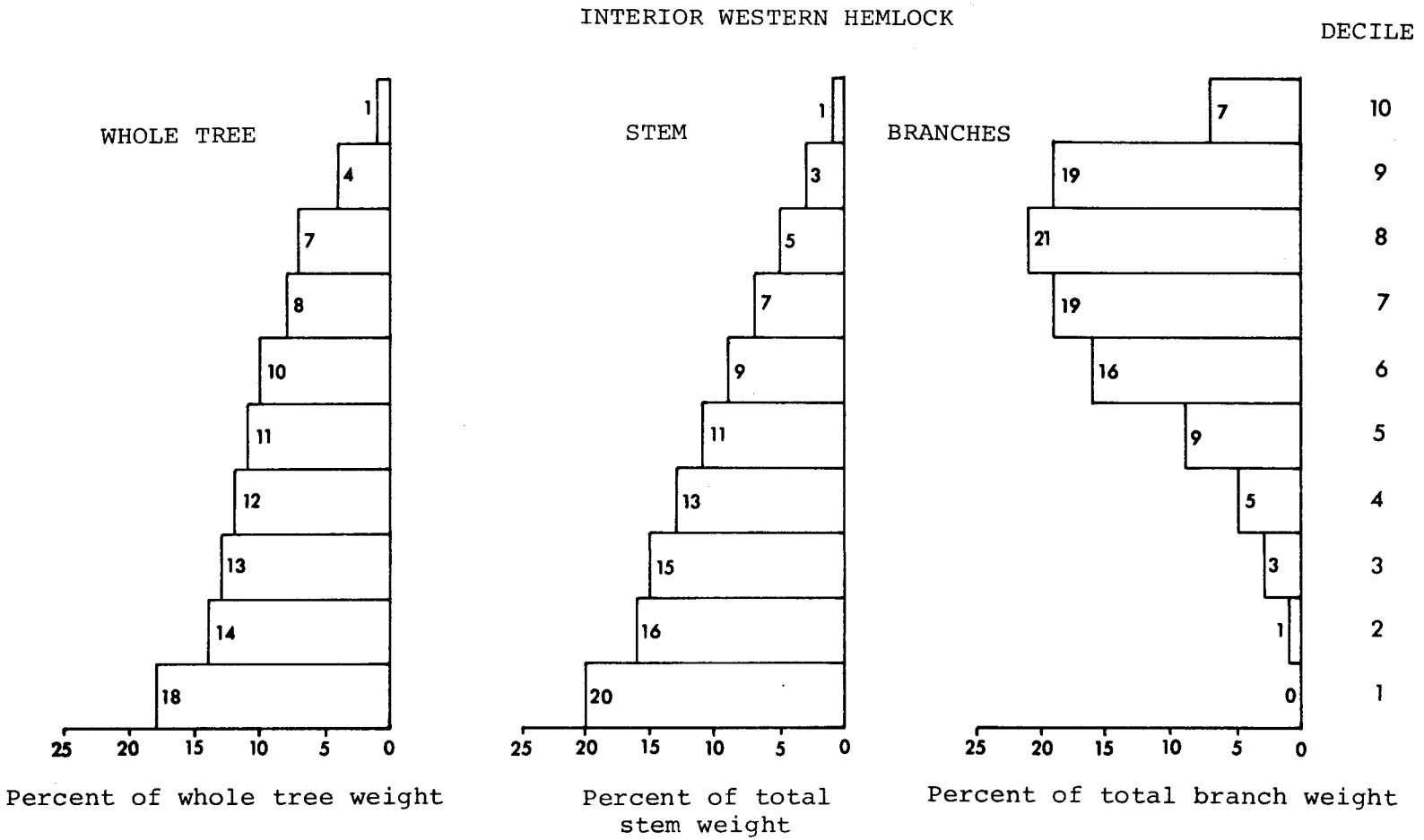


FIGURE 9. Green-Weight Distribution for Deciles of Tree Height, Interior Western Hemlock (from Table IV-2.)

CONCLUSION

This report completes the investigation of two basic engineering parameters--green weight and centre of gravity--for the most important coniferous trees of Interior British Columbia. Other publications in this series have presented results for white spruce, lodgepole pine and alpine fir (as well as one deciduous species--trembling aspen) on both good and poor growing sites. Similar tabulations for the wet-Interior and dry-Interior varieties of Douglas-fir and for Western hemlock are offered here.

The analyses showed distinct differences between wet-Interior and dry-Interior Douglas-fir. The former tended to have a higher centre-of-gravity position and greater weight for a given diameter and height. Graphs of component weights by deciles of tree height showed that weight of both stem and branch material in the upper part of the tree was markedly greater in the wet-Interior variety. Yet, dry-Interior Douglas-fir trees had heavier bark and branches for given diameter and height.

Western hemlock trees were heavier than either variety of Douglas-fir of similar dimension; however, centre-of-gravity position for hemlock fell between values established for wet-and dry-Interior Douglas-fir.

The engineering characteristics of Interior tree species, presented in this and earlier reports, should be sufficient for most logging equipment design purposes. Future investigations in this field could: i) broaden the sampling basis for the species already reported; ii) determine the effect of the presence of decay on engineering parameters of decadent Western hemlock and Western red cedar trees; and iii) examine engineering characteristics of coastal trees to provide data for designing aerial logging systems and possibly for mechanized harvesting in second-growth stands.

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APPENDIX I. English-Metric Equivalents

Length

1 inch	=	2.54 centimetre
1 foot	=	30.48 centimetre
1 mile	=	1.609 kilometre

Area

1 acre	=	0.405 hectare
1 square mile	=	2.59 square kilometre

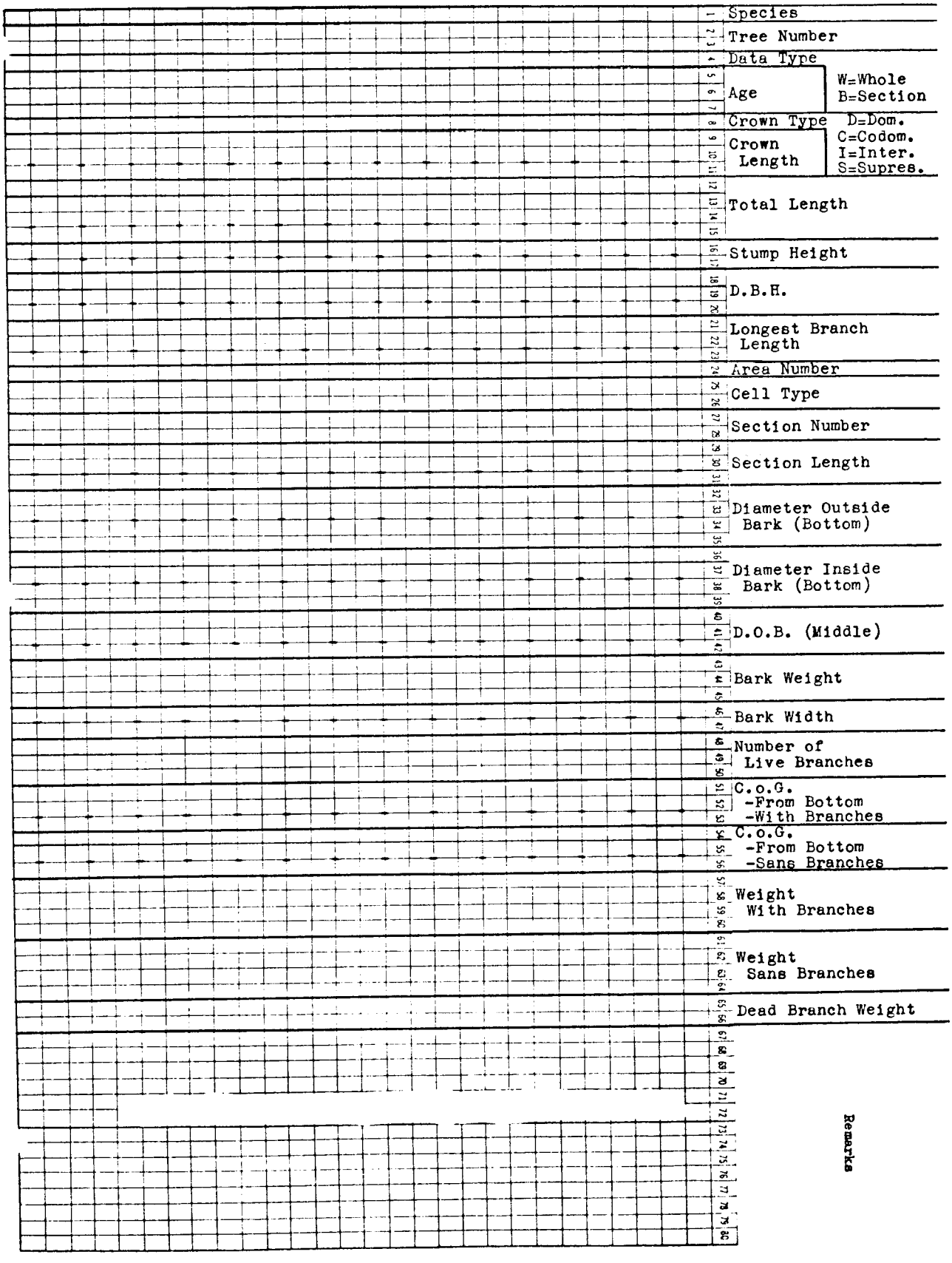
Volume

1 cubic foot	=	0.028 3 cubic metre
1 cunit	=	2.832 cubic metre
1 cubic foot per acre	=	0.07 cubic metre per hectare
1 cunit per acre	=	7.0 cubic metre per hectare

Weight

1 pound	=	o.453 59 kilogram

APPENDIX II. Field Data Form for Recording Tree Weight and Center of Gravity Information



APPENDIX III. Green-Weight and Centre of Gravity: Dry-Interior Douglas-Fir

TABLE III-1. Basic Statistics of Dry-Interior Douglas-Fir Sample Trees

Factors	Units	n	Mean	Minimum	Maximum
Age	yr	24	184	34	465
Breast height diameter (DBH)	cm	24	44	8	85
Tree height (TH)	m	24	20.5	6.1	30.5
Crown length (CL)	m	24	11.8	4.7	18.9
Crown ratio (CL/TH x 100)	%	24	59	28	85
Weight of tree (TW)	kg	24	1440	26	4578
Weight of stem (SW)	kg	24	1194	14	3796
Weight of bole (BW)	kg	15	914	18	2612
Weight of bark (BaW)	kg	15	204	4	674
Weight of branches (BrW)	kg	24	246	9	782
Tree center (TC)	m	24	7.4	2.3	10.1
Stem center (SC)	m	24	6.4	1.9	9.1
Tree center (TC/TH x 100)	%	24	37	32	43
Stem center (SC/TH x 100)	%	24	31	27	37
Crown center (CC/CL x 100)	%	15	36	31	42

TABLE III-2. Green Weight Distribution Patterns for Dry-Interior Douglas-Fir for Deciles of Tree Height

	Decile	Tree Weight %	SD	Stem Weight %	SD	Bole Weight %	SD	Bark Weight %	SD	Branch Weight %	SD
(Butt)	1	17.58	2.87	21.59	2.57	20.55	3.16	26.20	2.84	0.0	0.0
	2	13.46	1.72	16.50	2.15	16.54	2.64	16.44	1.84	0.60	1.61
	3	12.70	1.01	14.42	0.89	14.66	1.20	13.50	1.43	4.81	5.65
	4	12.29	1.81	13.04	0.93	13.43	1.07	11.34	1.03	8.91	6.66
	5	11.46	1.78	11.02	0.61	11.34	0.68	9.57	1.08	13.51	7.00
	6	10.85	1.39	8.93	1.05	9.04	1.24	8.40	1.05	18.77	4.71
	7	9.37	1.84	6.72	1.27	6.71	1.66	6.74	0.96	20.60	7.57
	8	6.84	2.16	4.61	1.32	4.63	1.64	4.41	0.94	16.86	8.79
	9	3.97	1.70	2.26	1.06	2.20	1.23	2,49	0.95	11.56	5.12
(Top)	10	1.49	0.85	0.91	0.72	0.89	0.79	0.91	0.54	4.36	2.52

TABLE III-3. Centre-of-Gravity Positions of the Whole Tree and Stem

Centre of Gravity			Centre of Gravity		
Tree height (m)	Tree (TC) (m)	Stem (SC) (m)	DBH (cm)	Tree (TC) (m)	Stem (SC) (m)
5	1.8	1.6	5	2.5	1.8
10	3.7	3.2	10	3.5	2.7
15	5.6	4.7	15	4.5	3.7
20	7.4	6.3	20	5.4	4.5
25	9.3	7.9	25	6.2	5.2
30	11.1	9.5	30	6.9	5.9
35	13.0	11.0	35	7.5	6.5
40	14.8	12.6	40	8.1	7.0
45	16.7	14.2	45	8.5	7.4
			50	8.9	7.8
			55	9.2	8.0
			60	9.4	8.2
			65	9.5	8.3
			70	9.5	8.3
			75	9.4	8.2

*Based on Table III-1. Heights and centres of gravity measured from butt of tree.

$TC = 1.34 + 0.237\ DBH - 0.00172\ DBH^2$ $SE_E = 0.70$ $r^2 = .91$

$SC = 0.67 + 0.224\ DBH - 0.00164\ DBH^2$ $SE_E = 0.71$ $r^2 = .90$

All coefficients significant at p.01 level (n = 24).

TABLE III-4. Green Weight* of Whole Tree (TW) for Dry-Interior Douglas-Fir

DBH CM	TREE HEIGHT - METRES (weight, kg)							
	10	15	20	25	30	35	40	45
10	255	265	274	284				
15	279	300	322	343	364			
20	312	350	388	426	464			
25	355	414	473	532	592	651		
30	407	492	577	663	748	833	918	
35	468	584	700	816	932	1048	1164	
40	539	691	842	994	1145	1297	1448	
45	620	812	1003	1195	1387	1578	1770	
50	710	940	1183	1420	1656	1893	2130	2366
55	809	1096	1382	1668	1955	2241	2527	2814
60	918	1259	1600	1940	2281	2622	2963	3304
65	1036	1436	1836	2236	2636	3036	3436	3836
70		1628	2092	2556	3020	3483	3947	4411
75		1834	2366	2899	3431	3964	4496	5029
80		2054	2660	3266	3871	4477	5083	5689

*Based on the regression:

$TW = 236.5 + 0.0189\ DBH^2 \cdot TH$ $\quad SE_E = 326.4$ $\quad r^2 = .94$

All coefficients significant at p.01 level (n - 24).

The range of original data is delimited in the table.

TABLE III-5. Green Weight* of Stem (SW) for Dry-Interior Douglas-Fir

	TREE HEIGHT - METRES							
	10	15	20	25	30	35	40	45
DBH CM	(weight, kg)							
10	191	199	207	215				
15	211	229	247	265	283			
20	239	271	303	335	367			
25	275	325	375	425	475	525		
30	319	391	463	535	607	680	752	
35	371	469	567	665	764	862	960	
40	431	559	688	816	944	1072	1200	
45	499	661	824	986	1148	1311	1473	
50	575	776	976	1176	1377	1577	1778	1978
55	659	902	1144	1387	1629	1872	2114	2357
60	752	1040	1329	1617	1906	2194	2483	2771
65	852	1190	1529	1868	2206	2545	2884	3222
70		1353	1746	2138	2531	2924	3316	3709
75		1527	1978	2429	2880	3330	3781	4232
80		1713	2226	2739	3252	3765	4278	4791

*Based on the regression:

$SW = 174.56 + 0.0160\ DBH^2 \cdot TH$ $\quad SE_E = 241.1$ $\quad r^2 = .95$

All coefficients significant at p.01 level (n = 24).

The range of original data is delimited in the table.

TABLE III-6. Green Weight* of Bark (BaW) for Dry-Interior Douglas-Fir

TREE HEIGHT - METRES

DBH CM	10	15	20	25	30	35	40	45
	(weight, kg)							
10	20	21	23	24				
15	24	27	30	34	37			
20	29	35	41	47	53			
25	36	45	54	64	73	83		
30	44	57	71	85	98	112	125	
35	54	72	91	109	127	146	164	
40	65	89	113	137	161	185	209	
45	78	108	139	169	200	230	261	
50	92	130	167	205	243	280	318	355
55	108	153	199	244	290	335	381	426
60	125	179	234	288	342	396	450	504
65	144	208	271	335	398	462	525	589
70		238	312	385	459	533	607	680
75		271	355	440	525	609	694	779
80		306	402	498	595	691	787	884

*Based on the regression:

$BaW = 16.87 + 0.0030\ DBH^2 \cdot TH$ $\quad SE_E = 34.35$ $\quad r^2 = .97$

All coefficients sifnificant at p.01 level (n = 15)

The range of original data is delimited in the table.

TABLE III-7. Green Weight* of Bole (BW) for Dry-Interior Douglas-Fir

	TREE HEIGHT - METRES							
	10	15	20	25	30	35	40	45
DBH CM	(weight, kg)							
10	159	165	171	177				
15	174	188	202	216	230			
20	196	220	245	270	294			
25	223	262	301	339	378	416		
30	257	313	368	424	479	535	590	
35	297	373	449	524	600	675	751	
40	344	442	541	640	738	837	936	
45	396	521	646	771	896	1021	1145	
50	455	609	763	917	1071	1226	1380	1534
55	520	706	893	1079	1266	1452	1639	1825
60	590	812	1034	1256	1478	1700	1923	2145
65	668	928	1189	1449	1710	1970	2231	2491
70		1053	1355	1657	1960	2262	2564	2866
75		1187	1534	1881	2228	2575	2922	3268
80		1330	1725	2120	2515	2909	3304	3699

*Based on the regression:

$BW = 146.41 + 0.0123\ DBH^2 \cdot TH$ $\quad SE_E = 16.47$ $\quad r^2 = .96$

All coefficients sifnificant at p.01 level (n = 15).

The range of original data is delimited in the table.

TABLE III-8. Green Weight* of Branches (BrW) for Dry-Interior Douglas-Fir

	TREE HEIGHT - METRES							
	10	15	20	25	30	35	40	45
DBH CM	(weight, kg)							
10	65	66	68	69				
15	69	72	75	78	82			
20	74	79	85	91	97			
25	80	89	98	107	116	125		
30	88	101	114	127	140	153	166	
35	98	115	133	151	169	186	204	
40	108	132	155	178	201	224	248	
45	121	150	180	209	238	268	297	
50	135	171	207	243	280	316	352	388
55	150	194	238	281	325	369	413	457
60	166	219	271	323	375	428	480	532
65	185	246	307	368	430	491	552	614
70		275	346	417	489	560	631	702
75		307	388	470	552	633	715	797
80		341	433	526	619	712	805	898

*Based on the regression:

$BrW = 61.97 + 0.0029\ DBH^2 \cdot TH$ $\quad SE_E = 110.05$ $\quad r^2 = .76$

All coefficients significant at p.01 level (n = 24)

The range of original data is delimited in the table.

TABLE III-9. Green Weight* and Centre of Gravity** of Merchantable Stem to a 10-cm Top Diameter Inside Bark for Dry-Interior Douglas-Fir

	Dry-Interior Douglas-Fir					TREE HEIGHT - METRES		
DBM-CM	10	15	20	25	30	35	40	45
10	105 2.5	172 3.8	178 5.1	185 6.3				
15	208 3.1	226 4.6	243 6.2	261 7.7	279 9.2			
20	233 3.0	264 4.5	295 6.0	326 7.5	358 9.0			
25	266 3.0	314 4.5	363 6.0	411 7.4	460 8.9	508 10.4		
30	318 3.1	390 4.7	462 6.3	534 7.8	606 9.4	678 11.0	750 12.6	
35	370 3.1	467 4.7	565 6.3	663 7.8	761 9.4	859 11.0	957 12.5	
40	429 3.1	557 4.7	685 6.2	813 7.8	940 9.4	1068 10.9	1196 12.5	
45	497 3.1	658 4.7	820 6.2	982 7.8	1143 9.4	1305 10.9	1467 12.5	
50	572 3.1	772 4.7	971 6.2	1171 7.8	1370 9.4	1570 10.9	1769 12.5	1969 14.0
55	656 3.1	897 4.7	1138 6.2	1380 7.8	1621 9.4	1862 10.9	2103 12.5	2345 14.0
60	747 3.1	1034 4.7	1321 6.2	1608 7.8	1895 9.3	2182 10.9	2469 12.5	2756 14.0
65	847 3.1	1183 4.7	1520 6.2	1857 7.8	2194 9.3	2530 10.9	2867 12.5	3204 14.0
70		1344 4.7	1735 6.2	2125 7.8	2516 9.3	2906 10.9	3297 12.4	3687 14.0
75		1517 4.7	1966 6.2	2414 7.8	2862 9.3	3310 10.9	3758 12.4	4206 14.0
80		1702 4.7	2212 6.2	2722 7.8	3232 9.3	3741 10.9	4251 12.4	4761 14.0

* Upper figure, kg
** Lower figure, m measured from butt.

TABLE III-10. Ratios of Green Weight/Merchantable Wood Volume for Representative Trees for Dry-Interior Douglas-Fir

Tree DBH cm (in.)	30 (12)	60 (24)
Total height m (local curve) (ft)	18 (59)	26 (85)
Wood volume between ground and 10-cm top diameter inside bark* m^3 (ft^3)	0.451 (15.92)	2.354 (83.12)
Green Weight/Merch. Volume Ratios		
Bole (bark-free) kg/m^3 (lb/ft^3)	767 (47.9)	552 (34.5)
percent of stem	80%	78%
Stem (incl. bark) kg/m^3 (lb/ft^3)	963 (60.1)	711 (44.4)
percent of stem	100%	100%
Whole tree (incl. bark and branches) kg/m^3 (lb/ft^3)	1 204 (75.1)	853 (53.2)
percent of stem	125%	120%

*Source: Browne, J.E. 1962. Standard cubic-foot volume tables for commercial tree species of British Columbia. B. C. Forest Service, Victoria.

APPENDIX IV. Green Weight and Centre of Gravity: Wet-Interior Douglas-Fir

TABLE IV-1. Basic Statistics of Wet-Interior Douglas-Fir Sample Trees

Factors	Units	n	Mean	Range	
				Minimum	Maximum
Age	yr	20	140	58	280
Breast height diameter (DBH)	cm	20	39	9	72
Tree height (TH)	m	20	25.5	10.9	39.9
Crown length (CL)	m	20	12.8	3.9	25.3
Crown ratio (CL/TH x 100)	%	20	48	30	66
Weight of tree (TW)	kg	20	1513	29	4923
Weight of stem (SW)	kg	20	1324	24	4223
Weight of bole (BW)	kg	14	1209	19	3681
Weight of bark (BaW)	kg	14	201	4	541
Weight of branches (BrW)	kg	20	188	4	699
Tree centre	m	20	9.5	4.7	14.8
Stem centre	m	20	8.4	3.8	12.9
Tree centre (/TH x 100)	%	20	38	29	43
Stem centre (/TH x 100)	%	20	33	28	36
Crown centre CL x 100)	%	14	39	36	48

TABLE IV-2. Green Weight Distribution Patterns for Dry-Interior Douglas-Fir for Deciles of Tree Heights

Dry-Interior Douglas-Fir

	Decile	Tree Weight %	SD	Stem Weight %	SD	Bole Weight %	SD	Bark Weight %	SD	Branch Weight %	SD
(Butt)	1	17.74	1.26	20.40	2.19	20.49	2.28	19.79	3.13	0.0	0.0
	2	14.23	0.78	16.10	1.20	16.20	1.24	15.58	1.29	1.03	1.84
	3	13.43	0.84	14.72	0.87	14.87	0.96	13.93	1.21	2.69	4.66
	4	12.24	1.17	13.00	0.94	12.98	1.07	13.14	0.84	5.12	6.43
	5	11.27	1.78	11.05	0.95	10.86	1.12	12.17	0.87	9.10	9.23
	6	10.32	1.91	9.05	0.78	8.94	0.81	9.63	0.72	16.48	7.93
	7	8.24	1.58	6.93	1.46	6.94	1.58	6.79	1.35	18.61	6.48
	8	6.82	1.93	5.19	1.60	5.27	1.75	4.89	1.42	21.31	9.19
	9	4.25	1.64	2.71	0.95	2.66	1.00	2.94	0.96	18.66	10.66
(Top)	10	1.47	0.65	0.85	0.50	0.79	0.57	1.15	0.56	7.00	4.24

TABLE IV-3. Average Centre-of-Gravity Positions of the Whole Tree and Stem of Wet-Interior Douglas-Fir Based on Tree Height* and dbh.**

Centre of Gravity			Centre of Gravity		
Tree height (m)	Tree (TC) (m)	Stem (SC) (m)	DBH (cm)	Tree (TC) (m)	Stem (SC) (m)
5	1.9	1.7	5	3.9	3.2
10	3.8	3.3	10	5.0	4.2
15	5.7	5.0	15	6.1	5.1
20	7.7	6.6	20	7.1	6.0
25	9.6	8.4	25	8.0	6.9
30	11.5	10.0	30	8.8	7.7
35	13.4	11.7	35	9.6	8.4
40	15.3	13.4	40	10.3	9.0
45	17.2	15.0	45	11.0	9.6
			50	11.5	10.2
			55	12.0	10.6
			60	12.4	11.0
			65	12.7	11.4
			70	13.0	11.7
			75	13.2	11.9

*Based on Table IV-1. Heights and center of gravity measured from butt of tree.

**$TC = 2.65 + 0.25\ DBH - 0.00145\ DBH^2$ $SE_E = 1.27$ $r^2 = .86$

$SC = 2.08 + 0.22\ DBH - 0.00122\ DBH^2$ $SE_E = 1.02$ $r^2 = .89$

All coefficients significant at p.01 level (n = 20)

TABLE IV-4. Green Weight* of Whole Tree (TW) for Wet-Interior Douglas-Fir

	TREE HEIGHT - METRES										
	10	15	20	25	30	35	40	45	50	55	60
dbh cm	(weight, kg)										
10	158	169	179	190							
15	185	208	232	256	280						
20	222	264	306	348	390	432					
25	269	335	401	467	533	598	664				
30	327	422	517	612	706	801	896	991			
35	395	525	654	783	912	1041	1170	1299			
40	475	643	812	981	1149	1318	1486	1655			
45	564	778	991	1205	1418	1631	1845	2058	2272		
50		928	1191	1455	1718	1982	2245	2509	2772	3036	
55		1094	1413	1732	2050	2369	2688	3007	3326	3645	
60			1655	2035	2414	2794	3173	3553	3932	4311	4691
65			1919	2364	2809	3255	3700	4145	4591	5036	5482
70			2203	2720	3236	3753	4269	4786	5302	5819	6335
75				3102	3695	4288	4881	5474	6067	6660	7252
80				3510	4185	4860	5534	6209	6883	7558	8233

*Based on the regression:

$TW = 137.23 + 0.0211\ DBH^2 \cdot TH$ $\quad SE_E = 35.12$ $\quad r^2 = .94$

All coefficients significant at the p.01 level (n = 20).

The range of original data is delimited in the table.

TABLE IV-5. Green Weight* of Stem (SW) for Wet-Interior Douglas-Fir

DBH CM	TREE HEIGHT - METRES (weight, kg)										
	10	15	20	25	30	35	40	45	50	55	60
10	130	139	148	157							
15	153	174	195	216	236						
20	185	222	260	297	334	371					
25	227	285	343	401	460	518	576				
30	278	362	446	529	613	697	780	864			
35	339	453	566	680	794	908	1022	1136			
40	408	557	706	855	1003	1152	1301	1450	1598		
45	487	676	864	1052	1241	1429	1617	1805	1994	2182	
50		808	1041	1273	1506	1738	1970	2203	2435	2668	
55		955	1236	1517	1798	2080	2361	2642	2923	3205	
60			1450	1784	2119	2454	2789	3123	3458	3793	4127
65			1682	2075	2468	2861	3253	3646	4039	4432	4825
70			1933	2389	2844	3300	3755	4211	4667	5122	5578
75				2726	3249	3772	4295	4818	5341	5864	6387
80				3086	3681	4276	4871	5466	6061	6656	7251

*Based on the regression:

$SW = 110.93 + 0.0186\ DBH^2 \cdot TH$ $\quad SE_E = 29.14$ $\quad r^2 = .95$

All coefficients significant at p.01 level (n = 20)

The range of original data is delimited in the table.

TABLE IV-6. Green Weight* of Bark (BaW) for Wet-Interior Douglas-Fir

TREE HEIGHT - METRES

DBH CM	10	15	20	25	30	35	40	45	50	55	60
	(weight, kg)										
10	37	38	40	41							
15	40	43	46	48	51						
20	44	49	54	59	64	68					
25	50	57	65	72	80	87	95				
30	56	67	78	89	100	110	121	132			
35	64	79	94	108	123	138	152	167			
40	73	92	112	131	150	169	189	208			
45	83	108	132	156	181	205	229	254	278		
50		125	155	185	215	245	275	305	335	365	
55		144	180	216	253	289	325	362	398	434	
60			208	251	294	337	381	424	467	510	554
65			238	288	339	390	441	491	542	593	644
70			270	329	388	447	506	564	623	682	741
75				373	440	508	575	643	710	778	845
80				419	496	573	650	726	803	880	957

*Based on the regression:

$BaW = 34.82 + 0.0024\ DBH^2 \cdot TH$ $\quad SE_E = 56.07$ $\quad r^2 = .90$

All coefficients significant at p.01 level (n = 14)

The range of original data is delimited in the table.

TABLE IV-7. Green Weight* of Bole (BW) for Wet-Interior Douglas-Fir

	TREE HEIGHT - METRES										
	10	15	20	25	30	35	40	45	50	55	60
dbh cm	(weight, kg)										
10	129	137	145	152							
15	149	166	184	202	220						
20	176	208	239	271	303	334					
25	212	261	311	360	409	459	508				
30	255	326	397	469	540	611	682	753			
35	307	403	500	597	694	791	887	984			
40	366	492	619	745	872	998	1124	1251			
45	433	593	753	913	1073	1233	1393	1553	1713		
50		706	903	1101	1298	1496	1693	1891	2089	2286	
55		830	1069	1308	1547	1786	2025	2264	2503	2743	
60			1251	1535	1820	2104	2389	2673	2958	3242	3527
65			1448	1782	2116	2450	2784	3118	3452	3786	4120
70			1662	2049	2436	2824	3211	3598	3985	4372	4760
75				2336	2780	3225	3669	4114	4558	5003	5447
80				2642	3148	3653	4159	4665	5171	5676	6182

*Based on the regression:

$BW = 112.99 + 0.0158\ DBH^2 \cdot TH$ $\quad SE_E = 30.21$ $\quad r^2 = .93$

All coefficients significant at p.01 level (n = 14).

The range of the original data is delimited in the table.

TABLE IV-8. Green Weight* of Branches (BrW) for Wet-Interior Douglas-Fir

TREE HEIGHT - METRES

dbh cm	10	15	20	25	30	35	40	45	50	55	60
	(weight, kg)										
10	29	30	31	33							
15	32	35	37	40	43						
20	36	41	46	51	56	61					
25	42	50	57	65	73	81	88				
30	49	60	71	82	93	105	116	127			
35	57	72	87	102	118	133	148	163			
40	66	86	106	126	146	166	186	205			
45	77	102	127	152	177	203	228	253	278		
50		120	151	182	213	244	275	306	337	368	
55		139	177	214	252	290	327	365	403	440	
60			205	250	295	340	385	429	474	519	564
65			237	289	342	394	447	499	552	604	657
70			270	331	392	453	514	575	636	697	758
75				376	446	516	586	656	726	796	866
80				424	504	584	663	743	822	902	982

*Based on the regression:

$BrW = 26.30 + 0.0025\ DBH^2 \cdot TH$ $\quad SE_E = 76.56$ $\quad r^2 = .84$

All coefficients significant at p.01 level (n = 20).

The range of the original data is delimited in the table.

TABLE IV-9. Green Weight* and Centre-of-Gravity** of Merchantable Stem to a 10-cm Top Diameter Inside Bark for Wet-Interior Douglas-Fir

TREE HEIGHT - METRES

DBH-CM	10	15	20	25	30	35	40	45	50	55	60
10	119 2.9	128 4.4	136 5.9	145 7.4							
15	147 3.1	167 4.7	188 6.3	208 7.9	228 9.4						
20	184 3.3	222 5.0	259 6.6	296 8.3	333 10.0	370 11.6					
25	226 3.3	284 5.0	342 6.6	399 8.3	457 9.9	515 11.6	573 13.2				
30	276 3.3	360 5.0	443 6.6	526 8.3	609 9.9	693 11.6	776 13.2	859 14.9			
35	336 3.3	450 4.9	563 6.6	676 8.2	789 9.9	903 11.5	1016 13.2	1129 14.8			
40	405 3.3	553 4.9	701 6.6	849 8.2	997 9.9	1144 11.5	1292 13.2	1440 14.8			
45	484 3.3	671 4.9	858 6.6	1045 8.2	1232 9.9	1419 11.5	1606 13.2	1793 14.8	1980 16.5		
50		802 4.9	1033 6.6	1264 8.2	1494 9.9	1725 11.5	1956 13.2	2187 14.8	2417 16.4	2648 18.1	
55		947 4.9	1226 6.6	1505 8.2	1784 9.9	2064 11.5	2343 13.1	2622 14.8	2901 16.4	3180 18.1	
60			1438 6.6	1770 8.2	2102 9.9	11.5	2767 13.1	3099 14.8	3431 16.4	3763 18.1	4095 19.7
65			1668 6.6	2058 8.2	2448 9.9	2837 11.5	3227 13.1	3617 14.8	4007 16.4	4396 18.1	4786 19.7
70			1917 6.6	2369 8.2	2821 9.8	3273 11.5	3725 13.1	4176 14.8	4628 16.4	5080 18.1	5532 19.7
75				2703 8.2	3221 9.8	3740 11.5	4259 13.1	4777 14.8	5296 16.4	5815 18.1	6333 19.7
80				3060 8.2	3650 9.8	4240 11.5	4830 13.1	5420 14.8	6010 16.4	6600 18.0	7190 19.7

* Upper figure, kg
** Lower figure, m measured from the butt.

TABLE IV-10. Ratios of Green Weight/Merchantable Wood Volume for Representative Trees for Wet-Interior Douglas-Fir

Tree DBH (cm)		30	60
	(in)	(12)	(24)
Total height	(m)	23	34
	(ft)	(74)	(112)
Wood volume between ground and 10-cm top diameter inside bark*	(m^3)	0.582	3.204
	(ft^3)	(20.55)	(113.14)
Green weight/Merch. volume ratios:			
Bole (bark-free)	kg/m^3	756	639
	(lb/ft^3)	(47.1)	(39.9)
	percent of stem	89%	86%
Stem (incl. bark)	kg/m^3	852	745
	(lb/ft^3)	(53.2)	(46.5)
	percent of stem	100%	100%
Whole tree (incl. bark and branches)	kg/m^3	986	848
	(lb/ft^3)	(61.5)	(52.9)
	percent of stem	116%	114%

*Source: Browne, J.E. 1962. Standard cubic foot volume tables for commercial tree species of British Columbia. B. C. Forest Service, Victoria.

APPENDIX V. Green Weight and Centre of Gravity Interior Western Hemlock

TABLE V-1. Basic Statistics of Westerm Hemlock Sample Trees

Factor	Units	n	Mean	Mini-mum	Maxi-mum
Age	yr	15	207	78	310
Breast height diameter (DBH)	cm	15	45	7	79
Tree height (TH)	m	15	27.7	5.3	41.4
Crown length (CL)	m	15	15.6	4.7	25.9
Crown ratio (CL/TH x 100)	%	15	60	36	88
Weight of tree (TW)	kg	15	2 427	16	6 580
Weight of stem (SW)	kg	15	2 156	11	6 080
Weight of bole (BW)	kg	7	2 014	106	4 830
Weight of bark (BaW)	kg	7	343	23	672
Weight of branches (BrW)	kg	15	270	5	589
Tree centre (TC)	m	15	10.3	1.7	14.3
Stem centre (SC)	m	15	9.2	1.5	12.8
Tree centre (/TH x 100)	%	15	36	30	46
Stem centre (/TH x 100)	%	15	32	25	40
Crown centre (CC/CL x 100)	%	7	37	33	41

TABLE V-2. Green Weight Distribution Patterns for Western Hemlock for Deciles of Tree Heights

	Decile	Tree Weight %	S.D.	Stem Weight %	S.D.	Bole Weight %	S.D.	Bark Weight %	S.D.	Branch Weight %	S.D.
(butt)	1	17.89	1.87	20.67	1.98	20.13	2.31	24.09	5.71	0.0	0.0
	2	13.67	0.79	15.80	0.76	16.09	0.88	14.33	1.41	0.0	0.0
	3	12.09	0.34	13.97	0.31	14.33	0.52	12.03	1.44	0.0	0.0
	4	11.14	0.83	12.63	0.55	12.95	0.63	10.89	1.22	1.74	3.14
	5	10.76	1.41	11.28	0.95	11.55	1.15	9.77	1.21	7.16	7.27
	6	10.03	1.25	9.28	0.51	9.32	0.68	8.98	1.48	15.22	9.71
	7	9.07	0.96	7.40	0.71	7.25	0.79	8.12	1.81	20.72	8.44
	8	7.49	1.43	5.17	0.76	4.92	0.71	6.42	1.22	22.05	5.33
	9	5.40	2.27	2.75	0.71	2.51	0.80	3.98	0.74	21.76	11.17
(top)	10	2.45	1.11	1.03	0.52	0.95	0.54	1.41	0.60	11.35	6.29

TABLE V-3. Centre-of-Gravity Positions of the Whole Tree and Stem of Western Hemlock Based on Tree Height* and dbh **

Centre of Gravity			Centre of Gravity		
Tree height (m)	Tree (TC) (m)	Stem (SC) (m)	DBH (cm)	Tree (TC) (m)	Stem (SC) (m)
5	1.8	1.6	5	0.8	---
10	3.7	3.3	10	1.7	1.3
15	5.5	4.3	15	3.5	3.0
20	7.3	6.5	20	5.2	4.5
25	9.2	8.2	25	6.7	5.9
30	11.0	9.8	30	8.0	7.2
35	12.9	11.4	35	9.2	8.3
40	14.7	13.0	40	10.3	9.3
45	16.5	14.7	45	11.3	10.2
			50	12.1	11.0
			55	12.7	11.6
			60	13.2	12.1
			65	13.6	12.5
			70	13.8	12.7
			75	13.9	12.8

*Based on Table V-1. Heights and centers of gravity measured from butt of tree.

**$TC = -2.41 + 0.438\ DBH - 0.00289\ DBH^2$ $SE_E = 1.01$ $r^2 = .95$

$SC = -2.41 + 0.398\ DBH - 0.00260\ DBH^2$ $SE_E = 0.93$ $r^2 = .95$

All coefficients significant at p.01 level (n = 15).

TABLE V-4. Green Weight* of Whole Tree (TW) for Western Hemlock

DBH CM	TREE HEIGHT - METRES (weight, kg)										
	10	15	20	25	30	35	40	45	50	55	60
10	159	172	186	199							
15	192	223	253	283	314						
20	240	294	347	401	455						
25	300	385	469	553	638	722					
30	374	496	617	739	860	982	1103				
35	462	628	793	958	1124	1289	1454	1620			
40	563	779	995	1211	1427	1643	1859	2075			
45		951	1225	1498	1771	2045	2318	2591	2865		
50		1144	1481	1819	2156	2493	2831	3168	3506		
55		1356	1765	2173	2581	2989	3398	3806	4214		
60			2075	2561	3047	3533	4019	4504	4990	5476	
65			2412	2983	3553	4123	4693	5264	5834	6404	
70				3438	4100	4761	5422	6084	6745	7406	8068
75				3928	4687	5446	6205	6964	7723	8483	9242
80				4450	5314	6178	7042	7906	8769	9633	10497

*Based on the regression.

$TW = 131.54 + 0.0270\ DBH^2 \cdot TH$ $\quad SE_E = 27.49$ $\quad r^2 = .98$

All coefficients significant at the p.01 level (n = 15)

The range of the original data is delimited in the table.

TABLE V-5. Green Weight* of Stem (SW) for Western Hemlock

DBH CM	TREE HEIGHT - METRES (weight, kg)										
	10	15	20	25	30	35	40	45	50	55	60
10	82	95	107	119							
15	113	141	169	196	224						
20	156	206	255	304	354						
25	212	289	366	443	520	597					
30	280	391	502	613	724	835	946				
35	360	511	662	813	965	1116	1267	1418			
40	452	650	847	1045	1242	1440	1637	1834			
45		807	1057	1307	1557	1807	2057	2307	2556		
50		983	1292	1600	1909	2217	2526	2834	3143		
55		1177	1551	1924	2297	2671	3044	3417	3790		
60			1834	2279	2723	3167	3611	4056	4500	4944	
65			2143	2664	3186	3707	4228	4750	5271	5793	
70				3081	3686	4290	4895	5499	6104	6709	7313
75				3528	4222	4916	5611	6305	6999	7693	8387
80				4006	4796	5586	6376	7165	7955	8745	9535

*Based on the regression:

$SW = 57.53 + 0.0247\ DBH^2 \cdot TH$ $\quad SE_E = 24.12$ $\quad r^2 = .98$

All coefficients significant at p.01 level (n = 15)

The range of the original data is delimited in the table.

TABLE V-6. Green Weight* of Bark (BaW) for Western Hemlock

TREE HEIGHT - METRES

DBH CM	10	15	20	25	30	35	40	45	50	55	60
	(weight, kg)										
10	89	90	91	93							
15	92	95	98	101	104						
20	97	102	108	113	119						
25	103	112	120	129	138	146					
30	111	123	135	148	160	173	185				
35	120	136	153	170	187	204	221	238			
40	130	152	174	196	218	240	262	284			
45		170	197	225	253	281	309	337	365		
50		189	224	258	292	327	361	396	430		
55		211	252	294	336	377	419	461	502		
60			284	334	383	433	482	532	582	631	
65			319	377	435	493	551	609	668	726	
70				423	491	558	626	693	760	828	895
75				473	551	628	705	783	860	938	1015
80				526	615	703	791	879	967	1055	1143

*Based on the regression:

$BaW = 85.88 + 0.0028\ DBH^2 \cdot TH$ $\quad SE_E = 80.18$ $\quad r^2 = .90$

All coefficients significant at p.01 level (n = 7).

The range of the original data is delimited in the table.

TABLE V-7. Green Weight* of Bole (BW) for Western Hemlock

	TREE HEIGHT - METRES										
	10	15	20	25	30	35	40	45	50	55	60
DBH CM	(weight, kg)										
10	129	139	149	159							
15	154	177	200	223	246						
20	190	231	271	312	353						
25	236	299	363	427	491	554					
30	292	384	475	567	659	751	842				
35	358	483	608	733	858	982	1107	1232			
40	435	598	761	924	1087	1250	1413	1576			
45		728	934	1140	1347	1553	1760	1966	2172		
50		873	1128	1382	1637	1892	2147	2402	2657		
55		1033	1342	1650	1958	2267	2575	2883	3192		
60			1576	1943	2310	2677	3044	3411	3778	4145	
65			1831	2262	2692	3123	3554	3984	4415	4846	
70				2606	3105	3605	4104	4603	5103	5602	6102
75				2975	3549	4122	4695	5269	5842	6415	6989
80				3370	4022	4675	5327	5980	6632	7284	7937

*Based on the regression:

$BW = 108.36 + 0.0204\ DBH^2 \cdot TH$ $\quad SE_E = 10.49$ $\quad r^2 = .99$

All coefficients significant at p.01 level (n = 7)

The range of the original data is delimited in the table.

TABLE V-8. Green Weight* of Branches (BrW) for Western Hemlock

DBH CM	TREE HEIGHT - METRES (weight, kg)										
	10	15	20	25	30	35	40	45	50	55	60
10	76	77	79	80							
15	79	82	84	87	90						
20	83	88	93	97	102						
25	88	96	103	110	117	125					
30	95	105	116	126	136	147	157				
35	102	117	131	145	159	173	187	202			
40	111	130	148	167	185	204	222	241			
45		144	168	191	215	238	261	285	308		
50		161	190	219	248	276	305	334	363		
55		179	214	249	284	319	354	389	424		
60			241	282	324	365	407	449	490	532	
65			269	318	367	416	465	514	563	612	
70				357	414	471	527	584	641	697	754
75				399	464	529	595	660	725	790	855
80				444	518	592	666	740	814	888	962

*Based on the regression:

$BrW = 74.01 + 0.0023\ DBH^2 \cdot TH$ $\quad SE_E = 100.98$ $\quad r^2 = .77$

All coefficients significant at p.01 level (n = 15)

The range of original data is delimited in the table.

TABLE V-9. Green Weight* and Centre-of-Gravity** of Merchantable Stem to a 10-cm Top Diameter Inside Bark for Western Hemlock

dbh-cm	TREE HEIGHT - METRES										
	10	15	20	25	30	35	40	45	50	55	60
10	77 2.9	88 4.4	100 5.9	111 7.3							
15	110 3.1	137 4.7	164 6.2	191 7.8	218 9.3						
20	156 3.2	205 4.9	254 6.5	304 8.1	353 9.7						
25	211 3.2	288 4.9	365 6.5	442 8.1	519 9.7	596 11.3					
30	278 3.2	389 4.8	500 6.5	610 8.1	721 9.7	832 11.3	942 12.9				
35	358 3.2	506 4.8	659 6.5	810 8.1	960 9.7	1111 11.3	1261 12.9	1412 14.5			
40	450 3.2	646 4.8	843 6.4	1039 8.1	1236 9.7	1432 11.3	1629 12.9	1825 14.5			
45		803 4.8	1051 6.4	1300 8.1	1548 9.7	1797 11.3	2046 12.9	2294 14.5	2543 16.1		
50		977 4.8	1284 6.4	1591 8.0	1898 9.7	2205 11.3	2511 12,9	2818 14.5	3125 16.1		
55		1170 4.8	1541 6.4	1912 8.0	2284 9.7	2655 11.3	3026 12.9	3397 14.5	3768 16.1		
60			1823 6.4	2265 8.0	2706 9.6	3148 11.3	3590 12.9	4031 14.5	4473 16.1	4914 17.7	
65			2129 6.4	2648 8.0	3166 9.6	3684 11.3	4202 12,9	4720 14.5	5238 16.1	5756 17.7	
70				3061 8.0	3662 9.6	4263 11.2	4863 12.9	5464 14.5	6065 16.1	6666 17.7	7267 19.3
75				3505 8.0	4195 9.6	4884 11.2	5574 12.9	6263 14.5	6953 16.1	7643 17.7	8332 19.3
80				3979 8.0	4764 9.6	5549 11.2	6333 12.8	7118 14.5	7902 16.1	8687 17.7	9471 19.3

*Upper figure, kg
** Lower figure, m measured from the butt.

TABLE V-10. Ratios of Green Weight/Merchantable Wood Volume for Representative Trees for Interior Western Hemlock

Tree dbh (cm)	30	60
(in)	(12)	(24)
Total height (m)	21	36
(ft)	(70)	(117)
Wood volume between ground and 10-cm diameter inside bark* (m^3)	0.621	4.130
(ft^3)	(21.92)	(145.83)
Green weight/merch. Volume Ratios		
Bole (bark-free) kg/m^3	795	666
(lb/ft^3)	(49.6)	(41.6)
percent of stem	94%	85%
Stem (incl. bark) kg/m^3	845	788
(lb/ft^3)	(52.7)	(49.2)
percent of stem	100%	100%
Whole tree (incl. bark and branches) kg/m^3	1034	879
(lb/ft^3)	(64.5)	(54.8)
percent of stem	122%	112%

*Source: Browne, J.E. 1962. Standard cubic foot volume tables for commercial tree species of British Columbia. B. C. Forest Service, Victoria.