

BARK VOLUME TABLES OF KAIL (*PINUS WALLICHIANA*, A.B. JACKSON)

by

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The bark of a tree is the portion between the inner living phloem and outer compressed cellular structure which has lost its activity as conductive tissue. Use of tree bark for different purposes has been enumerated by Hussain and Cheema(1).

274 trees were used in this study. Locality-wise distribution of the trees with diameter and height range is given below:

Locality	Diameter range inches (cms)	Height range feet (metres)	Number of trees
Murree	5—26 (13—66)	36—108 (11.0—32.2)	87
Galies	4—23 (10—58)	22—110 (6.7—33.5)	62
Swat	5—18 (13—46)	48—92 (14.6—28.0)	30
Indus Kohistan	5—31 (13—79)	25—132 (7.6—40.3)	95
Total:			274

Bark volume of individual trees was calculated on the lines described by Hussain and Cheema(1) for chir pine. The mathematical models used for estimation of height and volume were the same as for chir pine.

The regression equations derived from the models for pooled data are given below alongwith correlation coefficient (r) and standard error of estimate (SE).

Height equations:

1. $\text{Log}_{10}H = 0.625781 + 1.568279 \text{ Log}_{10}D - 0.409909 (\text{Log}_{10}D)^2$
 $r = 0.8866, \quad \text{SE} = 9.86$
2. $D^2/H = 0.008965 + 0.119802 D + 0.004684 D^2$
 $r = 0.9725, \quad S = 9.92$

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Volume equations

1. $V = 0.460282 - 0.013719D + 0.028049 D^2$
 $r = 0.9287, \quad SE = 2.10$
2. $V = -1.738800 + 0.300632 D + 0.016288 \frac{D^2 H}{100}$
 $r = 0.9301, \quad SE = 2.08$
3. $V = 5.198977 + 0.023689 \frac{D^2 H}{100}$
 $r = 0.9240, \quad SE = 2.17$

Height equation 2 was selected being more accurate in estimates. Similarly volume equation 2 was selected for estimation of volume as it yielded better estimates.

The selected equations were converted to metric system of measurements and are given below:—

$$H = D^2 / (0.189759 + 0.998350 D + 0.015367 D^2)$$

$$V = -0.049237 + 0.003352 D + 0.000235 \frac{D^2 H}{100}$$

Where

H = Total height in metres

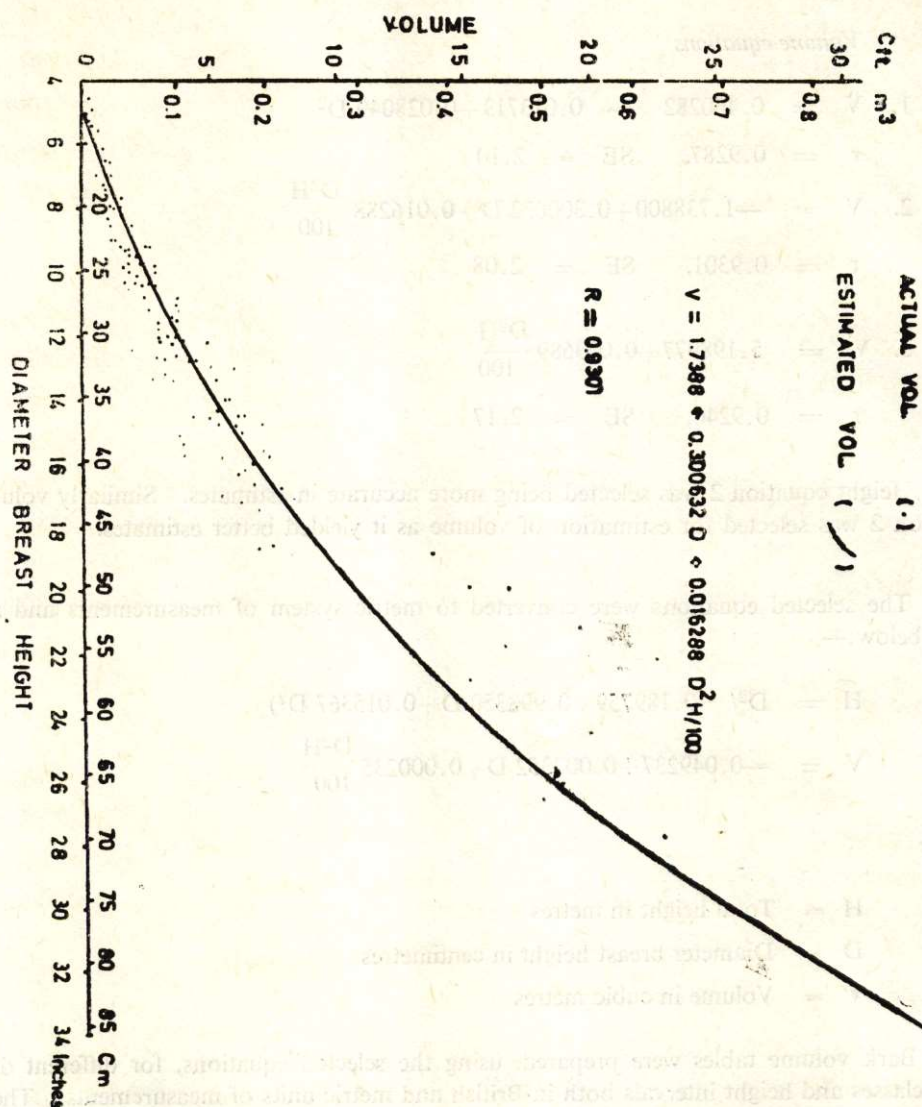
D = Diameter breast height in centimetres

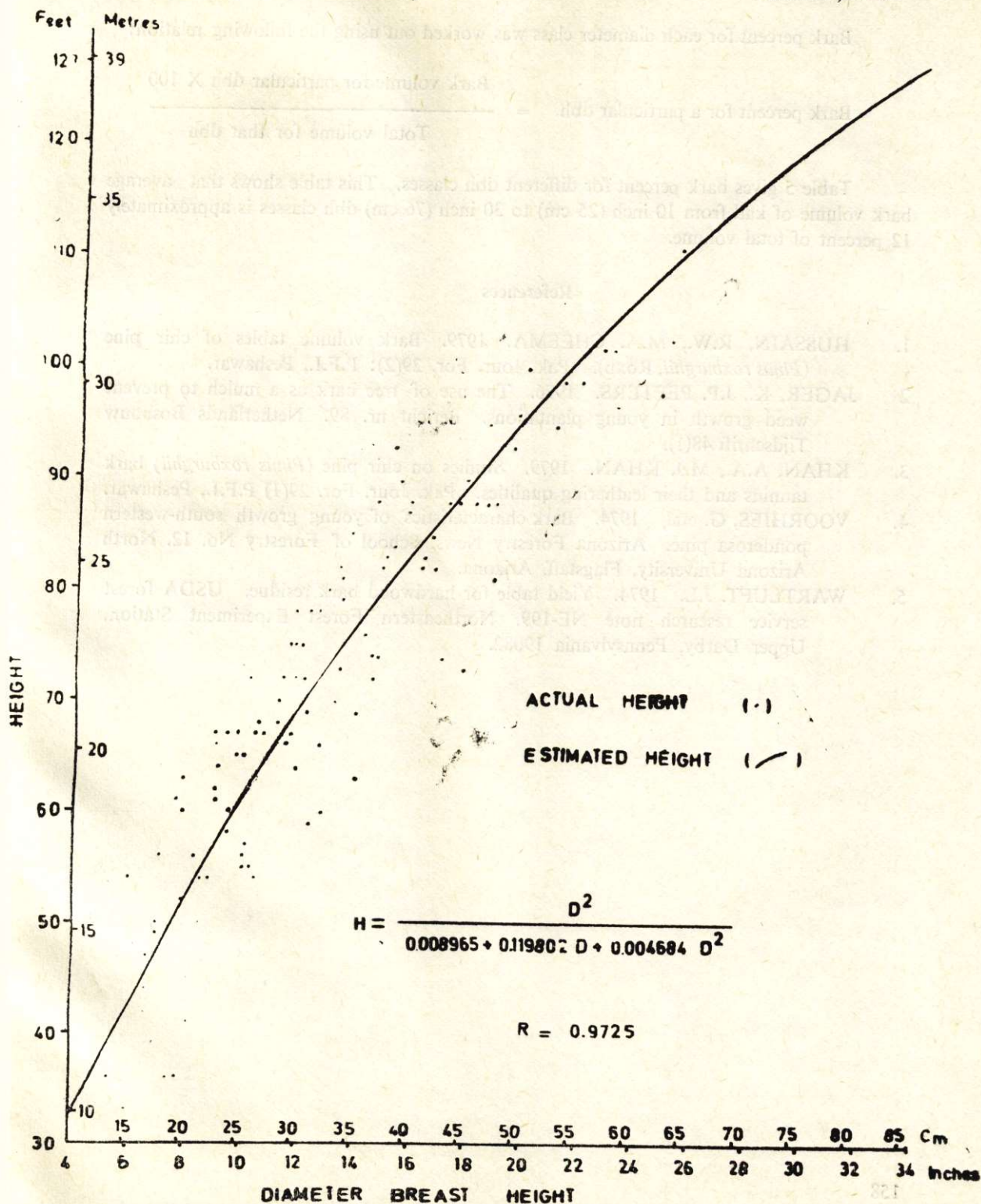
V = Volume in cubic metres

Bark volume tables were prepared, using the selected equations, for different diameter classes and height intervals both in British and metric units of measurements. These are given in Table 1 and 2. Bark volumes for different diameter classes appear in Table 3 and 4 in British and metric system of measurements respectively.

The original data were categorised in one inch (2.5 cm) diameter classes and average bark volume and height for each class was calculated. The bark volume and height estimated from the regression equations were then compared with the average measured values as shown in Figures 1 and 2.

The figures show that regression equations are close enough to the measured values. However prediction beyond 30 inch (76 cm) diameter class is not reliable enough using regression equations.





Bark percent for each diameter class was worked out using the following relation:

$$\text{Bark percent for a particular dbh} = \frac{\text{Bark volume for particular dbh} \times 100}{\text{Total volume for that dbh}}$$

Table 5 gives bark percent for different dbh classes. This table shows that average bark volume of kail from 10 inch (25 cm) to 30 inch (76 cm) dbh classes is approximately 12 percent of total volume.

References

1. HUSSAIN, R.W., M.A. CHEEMA. 1979. Bark volume tables of chir pine (*Pinus roxburghii*, Roxb). Pak. Jour. For. 29(2): P.F.I., Peshawar.
2. JAGER, K., J.P. PEETERS. 1976. The use of tree bark as a mulch to prevent weed growth in young plantations. Bericht nr. 89. Netherlands Bosbouw Tijdschrift 48(1).
3. KHAN, A.A., M.J. KHAN. 1979. Studies on chir pine (*Pinus roxburghii*) bark tannins and their leathering qualities. Pak. Jour. For. 29(1) P.F.I., Peshawar.
4. VOORHIES, G. et al, 1974. Bark characteristics of young growth south-western ponderosa pine. Arizona Forestry News. School of Forestry No. 12. North Arizona University, Flagstaff, Arizona.
5. WARTLUFT, J.L. 1974. Yield table for hardwood bark residue. USDA forest service research note NE-199. Northeastern Forest Experiment Station, Upper Darby, Pennsylvania 19082.

Table 1
Bark volume of Kail (*Pinus wallichiana*) in British units.

dbh* (inch)	Height (feet)															
	15	20	25	30	35	40	45	50	55	60	65	70	75	80		
6	0.153	0.182	0.212	0.241	0.270	0.300										
7	0.525		0.565	0.605	0.645	0.685	0.725	0.765								
8			0.927	0.979	1.03	1.08	1.14	1.19	1.24	1.29	1.34					
9				1.36	1.43	1.49	1.56	1.63	1.69	1.76	1.82	1.89				
10				1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.33	2.41	2.49	2.57		
11						2.36	2.46	2.55	2.65	2.75	2.85	2.95	3.05	3.14		
12							2.92	3.04	3.16	3.28	3.39	3.51	3.63	3.75		
13							3.41	3.55	3.68	3.82	3.96	4.10	4.23	4.37		
14								4.07	4.23	4.39	4.55	4.70	4.86	5.02		
15								4.61	4.79	4.97	5.15	5.34	5.52	5.70		
16									5.36	5.57	5.78	5.99	6.20	6.41		
17									5.96	6.20	6.43	6.67	6.90	7.14		
18										6.84	7.10	7.37	7.63	7.89		
19											7.80	8.09	8.38	8.68		
20											8.51	8.83	9.16	9.49		
21												9.60	9.96	10.3		
22													10.8	11.2		
23													11.6	12.1		
24													12.5	13.0		
25													13.4	13.9		
26														14.9		

*diameter breast height over bark

Table 1 (Continued)

Bark volume of Kail (*Pinus wallichiana*) in British units.

dbh* (inch)	Height (feet)													
	85	90	95	100	105	110	115	120	125	130	135	140	145	150
	Volume (cubic feet)													
11	3.24													
12	3.86	3.98	4.10											
13	4.51	4.65	4.78	4.92	5.06									
14	5.18	5.34	5.50	5.66	5.82	5.98								
15	5.89	6.07	6.25	6.44	6.62	6.80	6.99							
16	6.62	6.82	7.03	7.24	7.45	7.66	7.87	8.07						
17	7.37	7.61	7.84	8.08	8.31	8.55	8.79	9.02						
18	8.16	8.42	8.69	8.95	9.21	9.48	9.74	10.0						
19	8.97	9.27	9.56	9.85	10.1	10.4	10.7	11.0	11.3					
20	9.81	10.1	10.5	10.8	11.1	11.4	11.8	12.1	12.4					
21	10.7	11.0	11.4	11.8	12.1	12.5	12.8	13.2	13.6	13.9				
22	11.6	12.0	12.4	12.8	13.2	13.5	13.9	14.3	14.7	15.1	15.5			
23	12.5	12.9	13.4	13.8	14.2	14.7	15.1	15.5	15.9	16.4	16.8			
24	13.5	13.9	14.4	14.9	15.3	15.8	16.3	16.7	17.2	17.7	18.1			
25	14.4	14.4	15.4	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5			
26	15.4	16.0	16.5	17.1	17.6	18.2	18.7	19.3	19.8	20.4	20.9			
27	16.5	17.1	17.7	18.3	18.8	19.4	20.0	20.6	21.2	21.8	22.4			
28		18.2	18.9	19.5	20.1	20.7	21.4	22.0	22.6	23.3	23.9	24.6		
29		19.3	20.0	20.7	21.4	22.0	22.7	23.4	24.1	24.8	25.5	26.2		
30			21.2	21.9	22.7	23.4	24.1	24.9	25.6	26.3	27.1	27.8		
31			22.5	23.2	24.0	24.8	25.6	26.4	27.1	27.9	28.7	29.5		
32				24.6	25.4	26.2	27.1	27.9	28.8	29.6	30.4	31.2	32.1	
33				25.9	26.8	27.7	28.6	29.5	30.4	31.2	32.2	33.0	33.9	
34					28.3	29.2	30.1	31.1	32.0	33.0	33.9	34.8	35.8	36.7
35					29.7	30.7	31.7	32.7	33.7	34.7	35.7	36.7	37.7	38.7
36					31.2	32.2	33.4	34.4	35.5	36.5	37.6	38.6	39.7	40.7
37					32.8	33.9	35.0	36.1	37.3	38.4	39.5	40.6	41.7	42.8
38					34.4	35.6	36.7	37.9	39.1	40.3	41.4	42.6	43.8	45.0
39					36.0	37.2	38.5	39.7	41.0	42.2	43.4	44.7	45.9	47.1
40					37.7	39.0	40.3	41.6	42.9	44.2	45.5	46.8	48.1	49.4

*diameter breast height over bark

Table 2

Bark volume of Kail (*Pinus walliciana*) in Metric units

dbh* (cm)	Height (metres)														
	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5
	Volume (cubic metres)														
14	—	—	0.001	0.002	0.002	0.003									
16	0.007	0.008	0.009	0.010	0.011	0.012	0.012								
18	0.014	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.024						
20	0.022	0.023	0.025	0.026	0.028	0.029	0.030	0.032	0.033	0.035	0.036				
22	0.030	0.031	0.033	0.035	0.036	0.038	0.040	0.042	0.043	0.045	0.047	0.048			
24				0.043	0.045	0.047	0.049	0.051	0.053	0.056	0.058	0.060	0.062		
26				0.052	0.055	0.057	0.059	0.062	0.064	0.066	0.069	0.071	0.074	0.076	
28					0.064	0.067	0.069	0.072	0.075	0.078	0.080	0.083	0.086	0.089	0.092
30						0.077	0.080	0.083	0.086	0.089	0.093	0.096	0.099	0.102	0.105
32							0.090	0.094	0.098	0.101	0.105	0.108	0.112	0.116	0.119
34								0.105	0.109	0.114	0.118	0.122	0.126	0.130	0.134
36								0.117	0.122	0.126	0.131	0.135	0.140	0.144	0.149
38								0.129	0.134	0.139	0.144	0.149	0.154	0.159	0.165
40									0.147	0.152	0.158	0.164	0.169	0.175	0.181
42									0.160	0.166	0.172	0.179	0.185	0.191	0.197
44									0.173	0.180	0.187	0.194	0.201	0.207	0.214
46										0.194	0.202	0.209	0.217	0.224	0.232
48											0.217	0.225	0.233	0.242	0.250
50											0.233	0.242	0.250	0.259	0.268
52												0.258	0.268	0.277	0.287
54													0.276	0.286	0.296
56													0.293	0.304	0.315
58													0.311	0.323	0.335
60													0.329	0.342	0.355
62													0.348	0.362	0.375
64														0.382	0.396
66															0.418
68															0.456

*diameter breast height over bark

Table 2 (Continued)

Bark volume of Kail (<i>Pinus wallichiana</i>) in Metric units														
dbh* (cm)	Height (metres)													
	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	43.5	45.0	46.5
Volume (cubic metres)														
30	0.108	0.112												
32	0.123	0.127	0.130	0.134										
34	0.138	0.142	0.146	0.150	0.154									
36	0.154	0.158	0.163	0.167	0.172	0.176								
38	0.170	0.175	0.180	0.185	0.190	0.195	0.200							
40	0.186	0.192	0.198	0.203	0.209	0.214	0.220	0.226						
42	0.203	0.210	0.216	0.222	0.228	0.234	0.241	0.247						
44	0.221	0.228	0.235	0.241	0.248	0.255	0.262	0.289						
46	0.239	0.247	0.254	0.261	0.269	0.276	0.284	0.291						
48	0.258	0.266	0.274	0.282	0.290	0.298	0.306	0.315	0.323					
50	0.277	0.286	0.295	0.303	0.312	0.321	0.330	0.339	0.347					
52	0.297	0.306	0.316	0.325	0.335	0.344	0.354	0.363	0.373					
54	0.317	0.327	0.337	0.348	0.358	0.368	0.378	0.389	0.399	0.409				
56	0.337	0.348	0.359	0.370	0.382	0.392	0.404	0.415	0.426	0.437	0.448			
58	0.359	0.370	0.382	0.394	0.406	0.418	0.430	0.442	0.453	0.465	0.477			
60	0.380	0.393	0.406	0.418	0.431	0.444	0.456	0.469	0.482	0.494	0.507			
62	0.402	0.416	0.429	0.443	0.457	0.470	0.483	0.497	0.510	0.524	0.538			
64	0.425	0.439	0.454	0.468	0.483	0.497	0.512	0.526	0.540	0.555	0.569			
66	0.448	0.464	0.479	0.494	0.510	0.525	0.540	0.556	0.571	0.586	0.602			

*diameter breast height over bark

Table 2 (Continued)

dbh* (cm)	Height (metres)													
	27.0	28.5	30.0	31.5	33.0	34.5	36.0	37.5	39.0	40.5	42.0	43.5	45.0	46.5
68	0.472	0.488	0.505	0.521	0.537	0.553	0.570	0.586	0.602	0.619	0.635			
70	0.496	0.513	0.531	0.548	0.565	0.583	0.600	0.617	0.634	0.652	0.669			
72	0.521	0.539	0.557	0.576	0.594	0.612	0.631	0.649	0.667	0.685	0.704			
74		0.565	0.585	0.604	0.623	0.643	0.662	0.681	0.701	0.720	0.739	0.758		
76		0.592	0.613	0.633	0.653	0.674	0.694	0.714	0.735	0.755	0.775	0.796		
78		0.620	0.641	0.662	0.684	0.705	0.727	0.748	0.770	0.791	0.813	0.834		
80		0.647	0.670	0.693	0.715	0.738	0.760	0.783	0.805	0.828	0.850	0.873		
82			0.699	0.723	0.747	0.771	0.794	0.818	0.842	0.865	0.889	0.913	0.937	
84				0.754	0.779	0.804	0.829	0.854	0.879	0.904	0.929	0.953	0.978	
86				0.786	0.812	0.838	0.865	0.891	0.917	0.943	0.969	0.995	1.021	1.047
88				0.819	0.846	0.873	0.901	0.928	0.955	0.983	1.010	1.037	1.064	1.092
90				0.852	0.880	0.909	0.938	0.966	0.995	1.023	1.052	1.080	1.109	1.137
92				0.886	0.915	0.945	0.975	1.005	1.035	1.065	1.094	1.124	1.154	1.184
94				0.920	0.951	0.982	1.013	1.044	1.075	1.107	1.138	1.169	1.200	1.231
96				0.955	0.987	1.020	1.052	1.085	1.117	1.149	1.182	1.214	1.247	1.279
98				0.990	1.024	1.058	1.092	1.125	1.159	1.193	1.227	1.261	1.295	1.329
100				1.026	1.061	1.097	1.132	1.167	1.202	1.238	1.273	1.308	1.343	1.379

*diameter breast height over bark

Table 3

Bark volume of Kail (Pinus wallichiana) in British units

dbh (inch)	Estimated height (feet)	Volume (cft)
6.0	40.2	0.301
7.0	45.5	0.729
8.0	50.5	1.19
9.0	55.2	1.70
10.0	59.7	2.24
11.0	63.9	2.83
12.0	67.9	3.46
13.0	71.7	4.14
14.0	75.3	4.87
15.0	78.7	5.65
16.0	81.9	6.49
17.0	85.0	7.37
18.0	88.0	8.32
19.0	90.8	9.31
20.0	93.5	10.4
21.0	96.1	11.5
22.0	98.1	12.6
23.0	100.9	13.9
24.0	103.2	15.2
25.0	105.4	16.5
26.0	107.5	17.9
27.0	109.5	19.4
28.0	111.4	20.9
29.4	113.3	22.5
30.0	115.1	24.2
31.0	116.8	25.9
32.0	118.5	27.6
33.0	120.2	29.5
34.0	121.7	31.4
35.0	123.2	33.4
35.0	124.7	35.4
37.0	126.1	37.5
38.0	127.5	39.7
39.0	128.9	41.9
40.0	130.3	44.2

Derived from:

$$H = \frac{D^2}{0.008965 + 0.119802 D + 0.004684 D^2}$$

$$V = 1.738800 - 0.300632 D + 0.016288 \frac{D^2 H}{100}$$

Multiple correlation coefficient for height equation = 0.9725

Standard error in original units for height = 9.92 feet

Multiple correlation coefficient for volume equation = 0.9301

Standard error in original units for volume = 2.08 cft.

Table 4

Bark volume of Kail (Pinus wallichiana) in Metric units.

dbh (cm)	Estimated height (metres)	Volume (Cubic metres)
12.0	10.01	0.001
12.0	10.01	0.001
14.0	11.41	0.003
16.0	12.74	0.012
18.0	14.00	0.022
20.0	15.21	0.032
22.0	16.36	0.043
24.0	17.45	0.055
26.0	18.50	0.067
28.0	19.51	0.081
30.0	20.47	0.095
32.0	21.39	0.109
34.0	22.27	0.125
36.0	23.12	0.142
38.0	23.94	0.159
40.0	24.73	0.178
42.0	25.48	0.197
44.0	26.21	0.217
46.0	26.91	0.239
48.0	27.59	0.261
50.0	28.24	0.284
52.0	28.87	0.309
54.0	29.48	0.334
56.0	30.07	0.360
58.0	30.64	0.387
60.0	31.19	0.416
62.0	31.73	0.445
64.0	32.25	0.476
66.0	32.75	0.507
68.0	33.23	0.540
70.0	33.71	0.574
72.0	34.17	0.608
74.0	34.61	0.644
76.0	35.04	0.681
78.0	35.46	0.719
80.0	35.87	0.758
82.0	36.27	0.799
84.0	36.66	0.840
86.0	37.04	0.883
88.0	37.40	0.926
90.0	37.76	0.971
92.0	38.11	1.02
94.0	38.45	1.07
96.0	38.79	1.11
98.0	39.11	1.16
100.0	39.42	1.21

Derived from:

$$H = \frac{D^2}{0.189759 + 0.998350 D + 0.015367 D^2}$$

$$V = 0.049237 + 0.003352D + 0.000235 \frac{D^2 H}{100}$$

Table 5

Kail bark as percentage of stem volume

dbh (inch)	No. of trees	Actual total volume (cft)	Estimated Bark volume (cft)	Bark (%)
6	11	4.40	0.301	7
7	17	6.42	0.729	11
8	23	8.63	1.19	14
9	24	12.65	1.70	13
10	25	16.22	2.24	14
11	14	22.73	2.83	12
12	21	26.57	3.46	13
13	24	31.36	4.14	13
14	12	38.03	4.87	13
15	16	45.10	5.65	13
16	11	53.43	6.49	12
17	10	57.54	7.37	13
18	8	57.33	8.32	15
19	5	82.18	9.31	11
20	8	89.70	10.4	12
21	6	113.68	11.5	10
22	4	116.90	12.6	11
23	6	118.81	13.9	12
24	5	131.22	15.2	12
25	3	149.13	16.5	11
26	4	163.41	17.9	11
27	1	160.04	19.4	12
28	1	247.02	20.9	8
29	2	207.63	22.5	11
30	1	195.49	24.2	12
31	1	215.93	25.9	12
34	1	353.08	31.4	9