

BARK VOLUME TABLES OF CHIR PINE (*PINUS ROXBURGHII*, ROXB)

Raja Walayat Hussain and M. Afzal Cheema*

The bark of a tree is the portion between the inner living phloem and the outer compressed cellular structure which has lost its activity as conductive tissue. The use of tree bark as a mulch has resulted in weed suppression (1). It has been processed into useful garden and farm products (4). It has been accepted as a marketable product in the form of soil amendments and decorative mulches used in landscaping (3). Recent studies conducted in P.F.I. (2) show that chir pine bark can be used as a tanning material. Bark volume estimation will thus help in the development and utilization of this material.

683 chir pine trees constitute the basic data for these tables. Locality wise distribution of the trees with diameter and height range is given below:

Locality	Diameter range (inches)	Height range (feet)	No. of trees
Siran	7—30	31—123	252
Hazara tribal	6—22	38—106	121
Hazara guzaras	4—22	16—104	144
Haripur	10—20	51—95	34
Kahuta	7—20	41—103	83
Murree	12—28	54—130	49
Total:			683

Each tree was divided into 10 feet logs upto 2 in. diameter overbark at thin end of the stem and branches. Diameter overbark was recorded at midpoint of each log. Two bark chips of 4×4 in. each were taken at right angles to each other at midpoint of each log and their thickness was measured. Addition gave double bark thickness. Subtraction of double bark thickness from midpoint diameter overbark gave diameter underbark. Using the midpoint diameter overbark, the diameter underbark and log lengths, cubic feet volumes were computed both overbark and underbark with the help of Huber's formula. Addition of the log volume (overbark and underbark separately) gave over and under bark volumes of each tree. The bark volume of each tree was obtained by subtracting underbark volume from overbark volume. The data were summarised showing bark volume against dbh and height for each tree.

*The authors are Forest Mensuration Officer and Assistant Biometrician at the Pakistan Forest Institute, Peshawar.

The following mathematical models were tried for estimation of height and volume separately for each locality. The data were processed on the IBM 360/44 G Computer, installed in the Computer Centre of Quaid-i-Azam University Islamabad.

Height models:

1. $\log_{10} H = a + b \log D + c (\log D)^2$
2. $D^2/H = a + bD + cD^2$

Volume models

1. $V = a + bD + cD^2$
2. $V = a + bD + cD^2H/100$
3. $V = a + b D^2H/100$ where
 H = Total height in feet
 D = Diameter breast height in inches
 V = Bark volume in cubic feet
 a = Regression constant
 b, c = Regression coefficients.

The data for each locality did not yield accurate estimation with regression analysis as all the diameter classes were not represented adequately. Therefore, the data were pooled and the above models were tried on the pooled data. The resulting equations are given below:

Height equations

1. $\log_{10} H = -0.150334 + 2.810796 \log D - 0.911910 (\log D)^2$
 $r = 0.8838 \quad SE = 10.80$
2. $D^2/H = 0.575774 + 0.056368D + 0.006692 D^2$
 $r = 0.9316$
 $H = D^2 / (0.575774 + 0.056368D + 0.006692 D^2)$
 $SE = 10.89$

Volume equations

1. $V = 5.094992 + 0.716979D + 0.029648 D^2$
 $r = 0.9020 \quad SE = 3.32$
2. $V = -3.435370 + 0.688675 D + 0.029227 \frac{D^2H}{100}$
 $r = 0.9166 \quad SE = 3.07$
3. $V = 11.223805 + 0.048601 \frac{D^2H}{100}$
 $r = 0.9062 \quad SE = 3.25$

Height equation 2 was chosen because it predicted slightly more accurate values than equation 1 for diameters greater than 24 inches. Volume equation 2 was selected because of its higher correlation coefficient (r) and lower standard error of estimate (SE).

The selected equations for height and volume were converted to metric system of measurements and are given below:

$$H = D^2/12.187204 + 0.469733D + 0.021955D^2$$

$$V = 0.097279 + 0.007678D + 0.000421 D^2H/100$$

where

H = Total height in metres

D = Diameter breast height in centimetres

V = Volume in cubic metres

Using the selected volume equation, the bark volume tables were prepared for different diameter classes and height intervals both in British and metric systems of measurements. These are given in Tables 1 and 2. Table 3 gives bark volume against diameter classes.

The original data were categorised in one inch 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.

From the figures it is clear that the regression equations follow the trend of the measured values closely enough. However, height and volume cannot be predicted confidently for diameters greater than 25 inches.

Average of total volume for each dbh class was worked out by grouping the original data into 1 inch dbh classes. The bark percent for each dbh class was found out using the following relation:

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

Table 4 gives bark percent for different dbh classes. With the increase in dbh class the bark percent decreases. It is worth noting from the table that average bark volume of chir pine from 14 inch to 20 inch dbh classes is approximately 25 percent of total volume.

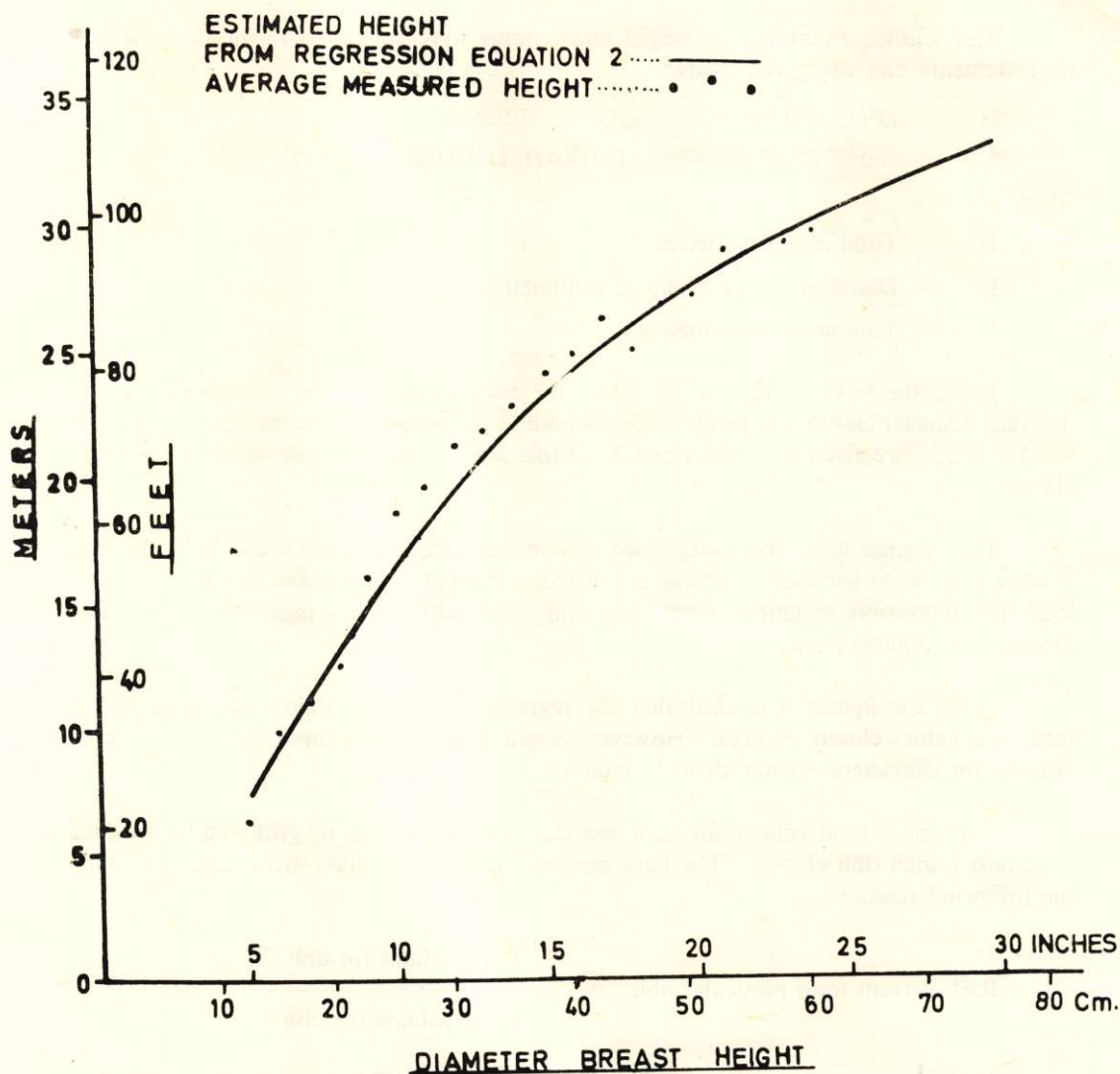


Fig. 1 Comparison of Estimated and Average Measured Heights

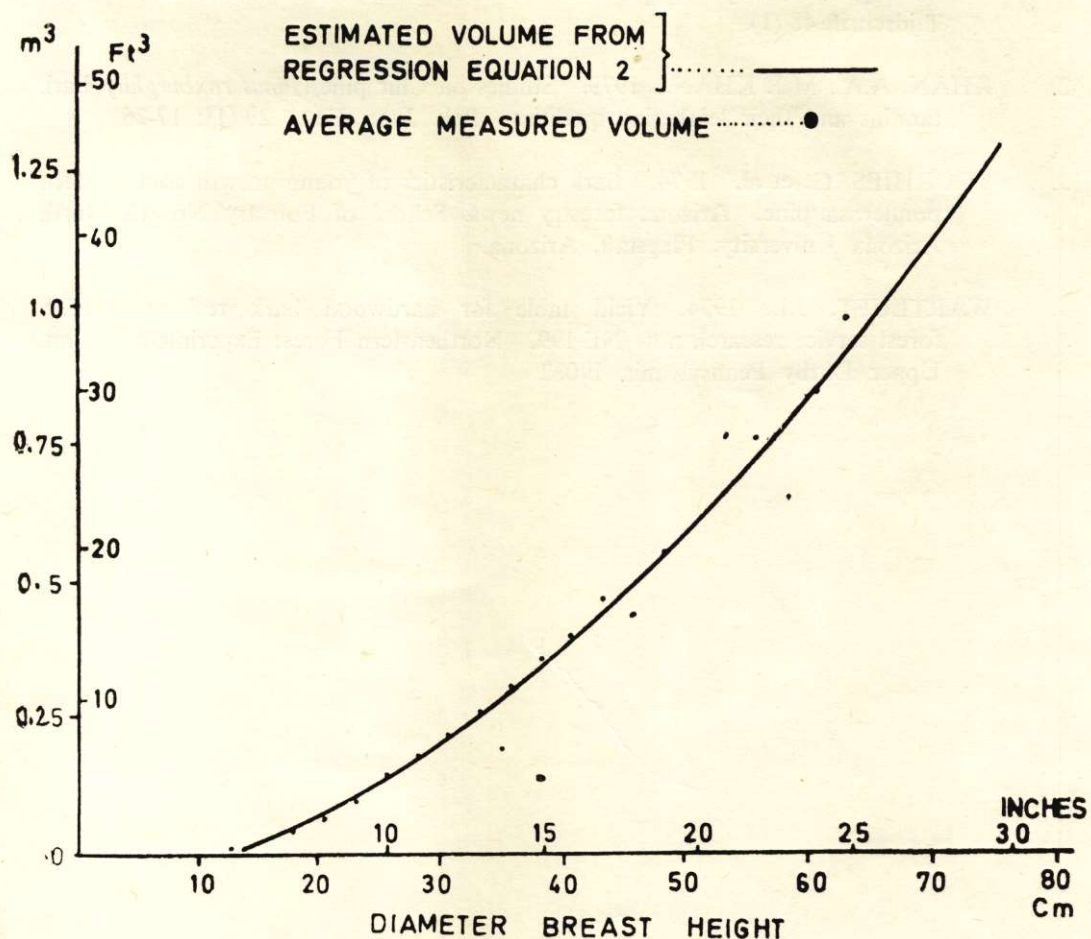


Fig. 2 Comparison of Estimated and Average Measured Volume

References

1. 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).
2. KHAN, A.A., M.J. KHAN. 1979. Studies on Chir pine (*Pinus roxburghii*) bark tannins and their leathering qualities. Pak. Jour. For. 29 (1): 17-26.
3. VOORHIES, G. et al. 1974. Bark characteristics of young growth southwestern ponderosa pine. Arizona forestry news. School of Forestry No. 12, North Arizona University, Flagstaff, Arizona.
4. 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.

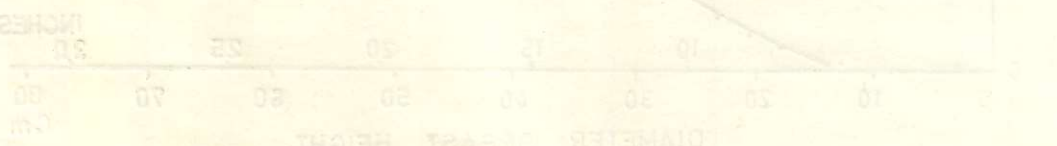


Fig. 2. Comparison of Diameter at Breast Height and Height

TABLE I
Bark volume of chir pine in British units

d.b.h. (inch)	HEIGHT IN FEET																				Volume (cf)								
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110		115	120	125	130	135	140	145	150
5	0.118	0.154	0.191	0.227																									
6	0.855	0.907	0.960	1.01	1.06	1.12																							
7		1.67	1.74	1.81	1.89	1.96	2.03	2.10																					
8			2.54	2.64	2.73	2.82	2.92	3.01	3.10	3.20	3.29																		
9				3.47	3.59	3.71	3.83	3.95	4.06	4.18	4.30	4.42																	
10					4.33	4.47	4.62	4.77	4.91	5.06	5.21	5.35	5.50	5.64	5.79														
11						5.55	5.73	5.91	6.09	6.26	6.44	6.62	6.79	6.97	7.15														
12							6.72	6.73	7.14	7.35	7.56	7.77	7.99	8.20	8.41	8.62	8.83												
13								7.74	7.99	8.23	8.48	8.73	8.97	9.22	9.47	9.72	9.96	10.2	10.5	10.7									
14									9.07	9.36	9.64	9.93	10.2	10.5	10.8	11.1	11.4	11.6	11.9	12.2	12.5								
15										10.2	10.5	10.8	11.2	11.5	11.8	12.2	12.5	12.8	13.1	13.5	13.8	14.1	14.5						
16											11.7	12.1	12.4	12.8	13.2	13.6	13.9	14.3	14.7	15.1	15.4	15.8	16.2	16.6					
17												12.8	13.3	13.8	14.2	14.6	15.0	15.5	15.9	16.3	16.7	17.1	17.6	18.0	18.4				
18													14.6	15.1	15.6	16.1	16.5	17.0	17.5	18.0	18.4	18.9	19.4	19.9	20.3				
19														16.5	17.0	17.6	18.1	18.6	19.1	19.7	20.2	20.7	21.3	21.8	22.3	22.8			
20															17.9	18.5	19.1	19.7	20.3	20.9	21.4	22.0	22.7	23.2	23.8	24.4	25.0		
21																20.0	20.7	21.3	22.0	22.6	23.3	23.9	24.6	25.2	25.8	26.5	27.1	27.8	
22																	22.3	23.0	23.7	24.4	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8
23																		24.0	24.8	25.5	26.3	27.1	27.9	28.6	29.4	30.2	31.0	31.7	32.5
24																			25.7	26.6	27.4	28.2	29.1	29.9	30.8	31.6	32.5	33.3	34.1
25																				27.5	28.4	29.3	30.2	31.1	32.0	33.0	33.9	34.8	35.7
26																					30.3	31.3	32.3	33.2	34.2	35.2	36.2	37.2	38.2
27																						33.3	34.3	35.4	36.5	37.5	38.6	39.7	40.7
28																							36.5	37.6	38.8	39.9	41.1	42.2	43.3
29																								38.6	39.9	41.1	42.3	43.6	44.8
30																									42.2	43.5	44.8	46.2	47.5
31																										44.6	46.0	47.4	48.8
32																											48.5	50.0	51.5
33																												51.1	52.7
34																													55.5
35																													58.3

*d.b.h. — diameter breast height overbark.

TABLE 2
Bank volume table for chir pine in metric units

dbh* cm)		HEIGHT IN 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	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															
12	—	—	—	—	.0003	.0012	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
14	.0139	.0152	.0164	.0176	.0189	.0201	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
16	.0304	.0320	.0337	.0353	.0369	.0385	.0401	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
18	—	.0491	.0512	.0532	.0552	.0573	.0593	.0614	.0634	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
20	—	—	.0689	.0714	.0740	.0765	.0790	.0814	.0841	.0866	.0891	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
22	—	—	—	.0900	.0930	.0961	.0991	.1022	.1053	.1083	.1114	.1144	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
24	—	—	—	.1088	.1125	.1161	.1197	.1234	.1270	.1306	.1343	.1379	.1416	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
26	—	—	—	.1280	.1322	.1365	.1408	.1450	.1493	.1536	.1578	.1621	.1664	.1707	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
28	—	—	—	—	.1524	.1573	.1623	.1672	.1722	.1771	.1821	.1870	.1920	.1969	.2019	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
30	—	—	—	—	—	.1785	.1842	.1899	.1956	.2013	.2069	.2126	.2183	.2240	.2297	.2354	.2410	—	—	—	—	—	—	—	—	—	—	—	—	—	—														
32	—	—	—	—	—	—	.2066	.2131	.2195	.2260	.2325	.2389	.2454	.2519	.2583	.2648	.2713	.2777	.2842	—	—	—	—	—	—	—	—	—	—	—	—														
34	—	—	—	—	—	—	—	.2368	.2441	.2514	.2587	.2660	.2733	.2806	.2879	.2952	.3025	.3098	.3171	.3244	—	—	—	—	—	—	—	—	—	—	—														
36	—	—	—	—	—	—	—	.2610	.2692	.2773	.2855	.2937	.3019	.3101	.3183	.3264	.3346	.3428	.3510	.3592	.3674	—	—	—	—	—	—	—	—	—	—														
38	—	—	—	—	—	—	—	—	.2857	.2948	.3039	.3130	.3221	.3313	.3405	.3495	.3586	.3677	.3769	.3860	.3951	.4042	.4133	—	—	—	—	—	—	—	—														
40	—	—	—	—	—	—	—	—	—	.3210	.3311	.3411	.3513	.3614	.3715	.3816	.3917	.4018	.4119	.4220	.4321	.4422	.4523	.4624	—	—	—	—	—	—	—														
42	—	—	—	—	—	—	—	—	—	—	.3477	.3589	.3700	.3812	.3923	.4034	.4146	.4257	.4369	.4480	.4591	.4703	.4814	.4925	.5037	—	—	—	—	—	—														
44	—	—	—	—	—	—	—	—	—	—	—	.3750	.3873	.3995	.4117	.4239	.4362	.4484	.4606	.4728	.4851	.4973	.5095	.5217	.5340	.5462	—	—	—	—	—														
46	—	—	—	—	—	—	—	—	—	—	—	—	.4163	.4296	.4430	.4563	.4697	.4831	.4964	.5098	.5232	.5365	.5499	.5632	.5766	.5900	—	—	—	—	—														
48	—	—	—	—	—	—	—	—	—	—	—	—	—	.4604	.4750	.4895	.5041	.5186	.5332	.5477	.5623	.5768	.5914	.6059	.6205	.6350	.6496	—	—	—	—														
50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.4919	.5076	.5234	.5392	.5550	.5708	.5866	.6024	.6182	.6339	.6497	.6655	.6813	.6971	—	—	—														
52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.5410	.5581	.5752	.5923	.6093	.6264	.6435	.6606	.6776	.6947	.7118	.7289	.7459	—	—	—														
54	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.5751	.5936	.6120	.6304	.6488	.6672	.6856	.7040	.7225	.7409	.7593	.7777	.7961	.8145	—														
56	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.6099	.6297	.6496	.6694	.6892	.7090	.7288	.7486	.7684	.7882	.8080	.8278	.8476	.8674	.8872													
58	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.6455	.6667	.6879	.7092	.7304	.7517	.7729	.7942	.8154	.8366	.8579	.8791	.9004	.9216	.9429												
60	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.6817	.7044	.7271	.7499	.7726	.7953	.8181	.8408	.8635	.8863	.9090	.9318	.9545	.9772	1.0001											
62	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.7186	.7429	.7672	.7914	.8157	.8400	.8643	.8885	.9128	.9371	.9614	.9856	1.0101	1.0341	1.0581										
64	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.7821	.8080	.8338	.8597	.8856	.9114	.9373	.9632	.9890	1.0151	1.0411	1.0671	1.0931	1.1181										
66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.8496	.8771	.9046	.9321	.9596	.9871	1.0151	1.0421	1.0701	1.0971	1.1251	1.1521	1.1801										
68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.8955	.9247	.9539	.9831	1.0121	1.0421	1.0711	1.1001	1.1291	1.1581	1.1881	1.2171										
70	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.9972	1.0281	1.0591	1.0901	1.1211	1.1521	1.1831	1.2141	1.2451	1.2761	1.3071										
72	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.0451	1.0781	1.1110	1.1431	1.1761	1.2081	1.2411	1.2741	1.3071	1.3391	1.3721									
74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.1281	1.1631	1.1971	1.2321	1.2661	1.3011	1.3371	1.3701	1.4051	1.4391	1.4741								
76	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.1791	1.2161	1.2521	1.2891	1.3251	1.3621	1.3981	1.4351	1.4711	1.5081	1.5441							
78	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.2321	1.2701	1.3081	1.3471	1.3851	1.4241	1.4621	1.5011	1.5391	1.5771	1.6161						
80	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.2851	1.3251	1.3661	1.4061	1.4471	1.4871	1.5271	1.5681	1.6081	1.6491	1.6891					
82	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.3821	1.4241	1.4661	1.5091	1.5511	1.5941	1.6361	1.6791	1.7211	1.7641	1.8061				
84	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.4831	1.5281	1.5731	1.6171	1.6621	1.7061	1.7511	1.7951	1.8401	1.8841				
86	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.5441	1.5911	1.6371	1.6841	1.7311	1.7771	1.8241	1.8711	1.9171	1.9641	2.0111		
88	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.6051	1.6541	1.7031	1.7521	1.8011	1.8501	1.8991	1.9481	1.9971	2.0451	2.0941	
90	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.6681	1.7191	1.7701	1.8211	1.8731	1.9241	1.9751	2.0261	2.0771	2.1281	2.1791

d. b. h. diameter breast height overbark.

* d, b, h, diameter breast height overbark.

TABLE 3

Bark volume of chir pine in British and Metric system of measurements

BRITISH			METRIC		
dbh (inches)	Estimated height (ft)	Volume (ft ³)	dbh (cm)	Estimated height (m)	Volume (m ³)
5.0	24.4	0.186	14.0	8.50	0.017
6.0	31.2	1.02	16.0	10.11	0.036
7.0	37.7	1.93	18.0	11.67	0.057
8.0	44.0	2.90	20.0	13.17	0.078
9.0	49.8	3.94	22.0	14.60	0.101
10.0	55.3	5.07	24.0	15.95	0.126
11.0	60.3	6.27	26.0	17.23	0.151
12.0	65.0	7.56	28.0	18.42	0.178
13.0	69.3	8.94	30.0	19.55	0.207
14.0	73.2	10.4	32.0	20.60	0.237
15.0	76.9	12.0	34.0	21.59	0.269
16.0	80.2	13.6	36.0	22.52	0.302
17.0	83.3	15.3	38.0	23.39	0.337
18.0	86.2	17.1	40.0	24.20	0.373
19.0	88.9	19.0	42.0	24.97	0.411
20.0	91.3	21.0	44.0	25.69	0.450
21.0	93.6	23.1	46.0	26.37	0.491
22.0	95.7	25.3	48.0	27.00	0.533
23.0	97.7	27.5	50.0	27.61	0.577
24.0	99.6	29.9	52.0	28.17	0.623
25.0	101.3	32.3	54.0	28.72	0.670
26.0	103.0	34.8	56.0	29.21	0.718
27.0	104.5	37.4	58.0	29.69	0.769
28.0	105.9	40.1	60.0	30.15	0.820
29.0	107.3	42.9	62.0	30.58	0.874
30.0	108.6	45.8	64.0	30.99	0.928
31.0	109.8	48.8	66.0	31.38	0.985
32.0	110.9	51.8	68.0	31.75	1.043
33.0	112.0	54.9	70.0	32.10	1.102
34.0	113.0	58.2	72.0	32.44	1.163
35.0	114.0	61.5	74.0	32.76	1.226
			76.0	33.06	1.290
			78.0	33.36	1.356
			80.0	33.64	1.423
			82.0	33.90	1.492
			84.0	34.16	1.562
			86.0	34.41	1.634
			88.0	34.64	1.708
			90.0	34.87	1.783

TABLE 4

Bark as a percentage of total stem volume

dbh (inches)	No. of trees	Estimated bark volume (cft)	Average total (o. b) volume (cft)	Bark percentage
6.0	10	1.02	4	25
7.0	14	1.93	6	32
8.0	19	2.90	9	32
9.0	19	3.94	12	33
10.0	29	5.07	16	32
11.0	57	6.27	21	30
12.0	65	7.56	26	29
13.0	73	8.94	32	28
14.0	58	10.4	39	27
15.0	65	12.0	46	26
16.0	51	13.6	54	25
17.0	31	15.3	62	25
18.0	27	17.1	72	24
19.0	30	19.0	82	23
20.0	24	21.0	93	23
21.0	15	23.1	105	22
22.0	16	25.3	118	21
23.0	5	27.5	131	21
24.0	5	29.9	147	20
25.0	5	32.3	166	19