LOCAL VOLUME TABLES OF CONIFEROUS SPECIES FOR GILGIT BALTISTAN, PAKISTAN

By

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Definitions

1.	*Standard timber*	Logs with a minimum mean diameter of 8 inches over bark at the thin end.
2.	*Standard small wood*	Anything less than 8 inches mean diameter over bark down to a minimum mean diameter of 2 inches over bark at the thin end.
3.	*Standard timber volume*	The total volume of standard timber, calculated by full basal area and excluding bark.
4.	*Standard small wood volume*	The total volume of standard small wood, calculated by full basal area and including bark.
5.	*Standard total volume*	The total of standard timber volume and standard small wood volume.

Introduction

The use of volume tables to the management of coniferous forests of North West Pakistan dates back to 1920's when Kulu averages worked out by Sir Gerald Trevor were applied in almost all working plans of these forests. Later on, Standard and Local Volume Tables were prepared for coniferous forests of different areas of Pakistan. However, no volume table was prepared for the natural forests of Gilgit Baltistan. Volume Tables prepared for other areas were applied for estimation of growing stock in the forests of Gilgit-Baltistan.

Gilgit-Baltistan is situated in the extreme north of Pakistan, bordering China and Afghanistan in the north (35˚-37') and India in the east (72˚-75'), covering an area of 72,496 square kilometers. The whole area falls within the high mountain ranges of Karakorum, Himalayas, Hindukush and Pamir with most of the area situated above 4,500 meters above sea level.

Gilgit Baltistan hosts valuable forest ecosystems. The total forest area of Gilgit Baltistan is 337,491 ha. Major forest tree species of GB include *Cedrus deodara* (Deodar), *Pinus wallichiana* (Kail), *Abies pindrow* (Fir), *Picea smithiana* (Spruce), *Pinus gerardiana* (Chilghoza) and *Quercus ilex* (Oak). Accurate estimates of growing stock in the forests are not possible without local volume tables of the tree species.

The volume tables are prepared using different allomteric equations based on regression models. These tables give over bark and under bark estimates of small wood, timber and total volume of given tree species both in metric as well as British units. As the forests of Gilgit Baltistan are under tremendous pressure due to increasing demand for timber and fuelwood, the use of current volume tables to forest working plans will help in minimizing the over-exploitation of the forests.

DATA COLLECTION

Selection of Sample Trees

Basic data for preparation of the current volume tables was collected during a study primarily designed for development of 'Local Biomass and Carbon Tables for Major Tree Species of Gilgit-Bbaltistan' during April-September, 2015. As the biomass study involved destructive sampling and felling of sample trees, the sample size was kept low. However, additional trees were measured for preparation of dia-height functions and volume estimation by taking data from standing sample trees by climbing them. Where the trees could not be climbed,

the measurements were taken with Spiegel Relaskop. The locations of the sample plots are shown in Figure 1. In total 199 trees were measured for volume estimation out of which 95 were felled for measurement whereas 105 trees were measured in standing position. DBH of the sample trees ranged from 8 cm to 123 cm whereas height ranged from 4.5-45 m. Sample trees were arranged in diameter classes of 5 cm from 6 to 125 cm. For determination of height functions, additional trees were measured to cover any variation in height due to site quality, slope and aspect. The location of sample trees is shown in Figure 1. For each species, 2-3 sample trees per DBH class were randomly selected and measured. Efforts were made to select trees of normal form and shape to closely represent the forest stands of the area. Trees with broken top, forked stem, excessive or less branching or any other abnormality were avoided. The detail of sample trees measured for development of dia-height regression models and volume estimation are given in table 1 and table 2 respectively.

Table 1. Detail of sample trees used in the preparation of dia-height functions

Species	**Range of dbh (cm)**	**Range of heights (m)**	**Number of sample trees**
Cedrus deodara	8-152	4.5-44	59
Pinus wallichiana	8-110	5-45	32
Pinus gerardiana	8-65	4.5-19.8	35
Abies pindrow	6.5-118	4.5-36	144
Picea smithiana	9-161	5-40.5	59
Total			328

Table 2. Detail of sample trees used in the preparation of volume tables

Species	Range of dbh (cm)	Range of heights (m)	Number of sample trees (felled)	Number of sample trees (standing)	Total Number of sample trees
Cedrus deodara	8-123	4.5-42	32	20	52
Pinus wallichiana	8-110	5-45	25	16	41
Pinus gerardiana	8-65	4.5-19.8	-	35	35
Abies pindrow	6.5-100	4.5-27.5	22	15	37
Picea smithiana	9-118	5-38	16	18	34
Total			95	104	199

A Deodar Tree felled for volume estimation in Chilas

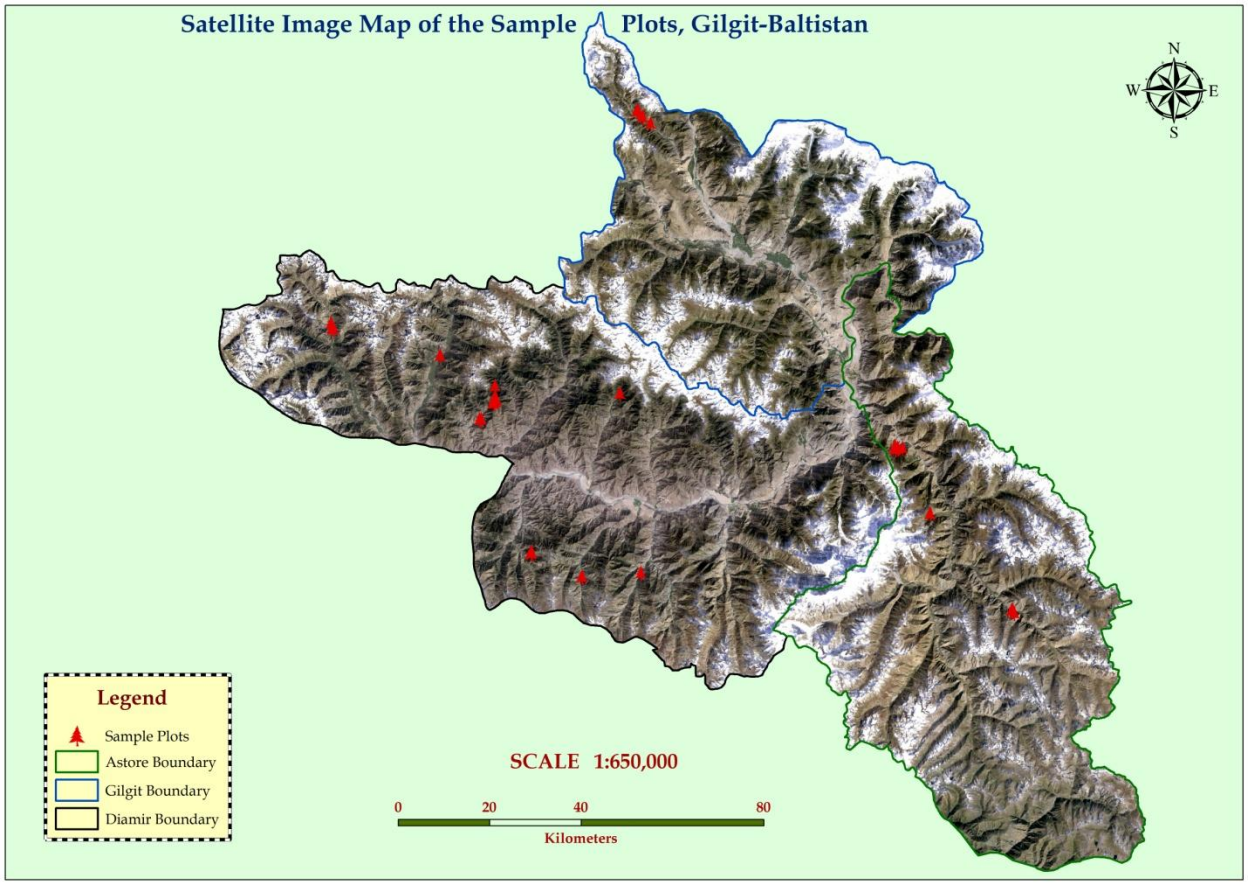

Figure 1: Location of Sample Trees

A view of dense coniferous forest in Gilgit-Baltistan

Methods and Procedure of Measurement

Diameter at Breast Height (DBH) and total height of the sample tree were measured before felling. Point of DBH was marked on stem at 1.37 m (4.5 feet) aboveground on uphill side and DBH was measured with dia tape upto one decimal in centimeter. Total height of the standing tree from ground to tip of the leading shoot was measured in meters upto two decimals with clinometer or relaskop. The sample trees were felled with the help of a chain saw as close to the ground as possible in a pre-decided direction to minimize damage to other trees. After felling the total height was re-measured with a measuring tape and recorded on the proforma (Annex-I). Bole heights upto 20 cm diameter and 5 cm diameter were measured for determining timber height and small wood height respectively. Besides, stand type, stand density, altitude, aspect and coordinates were also recorded with the help of a GPS.

After felling, the branches were removed from the stem. Trees were measured over-bark by dividing the stem and branches into 2 m logs with end log of variable length. The over bark mid diameter of the log and its length were measured for determining volume of logs using Huber's formula. Big branches upto 20 cm diameter at thin end were included in timber measurement whereas small branches upto 5 cm diameter at thin end were included in small wood. Volume upto 5 cm overbark diameter at the thin end of the stem including branches was taken as total volume of the tree, whereas volume upto 20 cm diameter over bark at the thin end of the stem including branches was taken as timber volume of the tree. The volume from 20 cm down to 5 cm over bark of the stem and branches was accounted as volume of small wood of the tree. Total volume of a tree was determined by adding volumes of all logs upto 5 cm at the thin end.

Measurement of logs for volume estimation

Measurement of bole in the field

Method adopted for volume estimation of standing sample trees

Some of the sample trees were measured in standing position. For this purpose the services of skilled climbers were hired. However, where climbing was not possible upper stem diameters were measured with Spiegel Relaskop. This was done after ascertaining that there is no significant difference between actual diameter measurement and Relaskop measurement. The DBH and total height of the sample trees were measured as per procedure described under the previous section.

The tree bole was marked at every 2 m above DBH and the mid diameter of the bole sections were measured using diameter tape. The volume of each section was determined through Huber's formula and summed up for the bole. Similarly length and mid diameter of all the branches were measured for calculating their volume. The volume of the branches was added with that of the bole to get total volume of the tree in cubic meter.

Measurement of standing sample tree

Model Fitting

The method employed for development of the current volume tables consists of two stages. In the first stage an analytical relationship was developed between DBH and height and in the second stage allometric equations were developed for estimation of timber and total volume using various regression models. The following regression models were used for estimating height, timber volume and total volume for each species.

i. Models for Height Estimation

$H= a+bD$

$H= a+bD+cD^2$

$H= a+bln(D)$

ii. Models for Timber Volume (O.B) Estimation

$TM= a+bD+cD^2$

$TM= a+b(D^2H)+c(D^2H)^2$

$TM=aD^b$

$TM= a(D^2H)^b$

iii. Models for Total Volume (O.B) Estimation

$TV = a+bD+cD^2$

$TV = a+b(D^2H)+c(D^2H)^2$

$TV = aD^b$

$TV = a(D^2H)^b$

Where

D = Diameter over bark at Breast Height in cm

H = Total height of tree in m

TM =Timber Volume in m^3

TV =Total Volume in m^3

ln = Natural Logarithm

a = regression constant

b, c = regression coefficients

The above models were used separately for each species. All the data analysis was performed in MS Excel and SPSS 16.

Models evaluation and selection

All the above mentioned models were tested for all species and the model which showed best performance on the following criteria was finally selected.

i) Minimum sum of square of the residual error
ii) Minimum standard error of the estimate
iii) Maximum value of R^2

The equations alongwith indices of best fit for the selected models are given in the Table No.3. The graphical representations of the selected models are shown in figures 2-20.

Table 3. Regression Models alongwith indices of best fit

Species	Estimate	Regression Model	Allometric equation	N	SEE (%)	SS of Residuals	R^2
Cedrus deodara (Deodar)	Height	H=a+lnD	H=15.355ln(D) - 34.394	59	5.52	1733.47	0.743
	Timber Volume	TV=a+b(D^2H)+c(D^2H)^2	TV=4E-12(D^2H)^2 + 2E-05(D^2H) + 0.0478	49	16.31	22.19	0.984
	Total Volume	V= a(D^2H)^b	TV = 4E-05(D^2H)$^{0.9733}$	52	16.37	16.14	0.989
Pinus wallichiana (Kail)	Height	H=a+blnD	H=14.456ln(D) - 28.244	32	7.37	835.84	0.807
	Timber Volume	TV=a+b(D^2H)+c(D^2H)^2	TV=-5E-12(D^2H)^2 + 3E-05(D^2H) - 0.0489	35	13.98	18.02	0.980
	Total Volume	V= a(D^2H)^b	V=5E-05(D^2H)$^{0.9614}$	41	14.97	23.56	0.993
Pinus gerardiana (Chilghoza)	Height	H=a+bD+cD^2	H=-0.0004D^2 + 0.2491D + 2.3583	35	7.32	211.99	0.689
	Timber Volume	TV=a+bD+cD^2	TV=8E-11(D^2H)^2 + 1E-05(D^2H) + 0.0572	27	19.91	0.558	0.956
	Total Volume	V=a+bD+cD^2	V=8E-11(D^2H)^2 + 2E-05(D^2H) + 0.0427	35	20.90	0.417	0.962
Abies pindrow (Fir)	Height	H=a+blnD	H= 9.7271ln(D) - 11.394	144	3.47	2951.89	0.694
	Timber Volume	TV= a(D^2H)^b	TV=7E-06(D^2H)$^{1.1029}$	31	13.98	5.562	0.961
	Total Volume	V= a(D^2H)^b	V=5E-05(D^2H)$^{0.9508}$	37	15.29	6.688	0.991
Picea smithiana (Spruce)	Height	H=a+blnD	H=11.658ln(D) - 20.392	59	4.29	799.50	0.790
	Timber Volume	TV=a+bD+cD^2	TV=-7E-12(D^2H)^2 + 3E-05(D^2H) - 0.1623	32	21.51	36.08	0.995
	Total Volume	V=a+bD+cD^2	V=-6E-12(D^2H)^2 + 3E-05(D^2H) - 0.0022	34	21.11	2.537	0.996

Volume Tables

Volume Tables were prepared on the basis of selected regression models both in metric as well as British units. The Volume Tables given from table 1 to 5 were prepared by 2 cm diameter class interval in metric units and the tables from 6 to 10 were prepared by 1 inch diameter class intervals in British units. Diameter classes show mid values for the range of diameters. For example 50 cm DBH class include trees with DBH 49.1 to 51.0 cm in metric units. On the other hand, 20 DBH class includes trees ranging from 19.6 to 20.5 inches in British units. These tables provide under bark estimates of timber and total volume. The small wood volume estimates can be obtained by subtracting timber from the total volume of the tree. In order to obtain over bark estimates, multiply the volume table figures by factors given at the end of each table.

TABLE-1

Local Volume Table (UB) of *Cedrus deodara* (Deodar) in Metric Units

DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3	DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3
12	5.00	-	0.024	82	33.27	4.722	6.440
14	6.13	-	0.040	84	33.64	5.021	6.823
16	8.18	-	0.068	86	34.00	5.330	7.217
18	9.99	-	0.104	88	34.36	5.652	7.624
20	11.61	0.063	0.148	90	34.70	5.985	8.043
22	13.07	0.076	0.200	92	35.04	6.331	8.474
24	14.41	0.214	0.261	94	35.37	6.689	8.917
26	15.63	0.260	0.330	96	35.69	7.059	9.373
28	16.77	0.311	0.408	98	36.01	7.443	9.841
30	17.83	0.370	0.496	100	36.32	7.839	10.321
32	18.82	0.435	0.592	102	36.62	8.249	10.814
34	19.75	0.507	0.699	104	36.92	8.672	11.320
36	20.63	0.585	0.815	106	37.21	9.110	11.838
38	21.46	0.671	0.941	108	37.50	9.561	12.369
40	22.25	0.765	1.076	110	37.78	10.027	12.912
42	23.00	0.866	1.222	112	38.06	10.508	13.469
44	23.71	0.974	1.379	114	38.33	11.003	14.038
46	24.39	1.091	1.545	116	38.60	11.514	14.619
48	25.05	1.215	1.723	118	38.86	12.041	15.214
50	25.68	1.348	1.911	120	39.12	12.583	15.822
52	26.28	1.489	2.109	122	39.37	13.142	16.442
54	26.86	1.639	2.319	124	39.62	13.717	17.076
56	27.42	1.797	2.539	126	39.87	14.309	17.722
58	27.95	1.964	2.771	128	40.11	14.918	18.382
60	28.47	2.140	3.013	130	40.35	15.545	19.055
62	28.98	2.325	3.267	132	40.58	16.190	19.740
64	29.47	2.520	3.532	134	40.81	16.852	20.439
66	29.94	2.724	3.809	136	41.04	17.534	21.151
68	30.40	2.938	4.097	138	41.26	18.235	21.877
70	30.84	3.162	4.396	140	41.48	18.954	22.615
72	31.27	3.395	4.708	142	41.70	19.694	23.367
74	31.69	3.640	5.031	144	41.92	20.454	24.133
76	32.10	3.894	5.365	146	42.13	21.234	24.911
78	32.50	4.159	5.712	148	42.34	22.035	25.703
80	32.89	4.435	6.070	150	42.54	22.858	26.509

Derived from the equations:

Volume (UB) = $4E\text{-}05(D^2H)^{0.9733}$

Timber Volume (UB) = $4E\text{-}12(D^2H)^2 + 2E\text{-}05(D^2H) + 0.0478$

Height= $15.355\ln(D) - 34.394$

Where D is DBH in cm, H is tree height in m, Ln is the natural log

To obtain over bark estimates multiply values in the table by 1.18

TABLE-2

Local Volume Table (UB) of *Pinus wallichiana* (Kail/Blue Pine) in Metric Units

DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3	DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3
12	7.68	-	0.042	82	35.46	6.820	7.392
14	9.91	-	0.072	84	35.81	7.212	7.816
16	11.84	-	0.111	86	36.15	7.614	8.252
18	13.54	-	0.159	88	36.48	8.027	8.701
20	15.06	0.132	0.215	90	36.81	8.450	9.163
22	16.44	0.189	0.281	92	37.12	8.884	9.638
24	17.70	0.256	0.357	94	37.43	9.327	10.126
26	18.86	0.333	0.442	96	37.74	9.780	10.627
28	19.93	0.419	0.538	98	38.04	10.243	11.140
30	20.92	0.514	0.644	100	38.33	10.715	11.667
32	21.86	0.620	0.760	102	38.61	11.196	12.207
34	22.73	0.736	0.887	104	38.90	11.687	12.760
36	23.56	0.862	1.025	106	39.17	12.186	13.326
38	24.34	0.999	1.173	108	39.44	12.694	13.905
40	25.08	1.147	1.333	110	39.71	13.210	14.498
42	25.79	1.305	1.503	112	39.97	13.735	15.104
44	26.46	1.475	1.685	114	40.22	14.267	15.723
46	27.10	1.655	1.879	116	40.47	14.807	16.355
48	27.72	1.847	2.083	118	40.72	15.354	17.001
50	28.31	2.049	2.299	120	40.96	15.908	17.660
52	28.88	2.263	2.527	122	41.20	16.469	18.332
54	29.42	2.488	2.767	124	41.44	17.036	19.018
56	29.95	2.724	3.018	126	41.67	17.609	19.718
58	30.45	2.972	3.281	128	41.90	18.188	20.431
60	30.94	3.231	3.557	130	42.12	18.773	21.157
62	31.42	3.501	3.844	132	42.34	19.363	21.897
64	31.88	3.783	4.143	134	42.56	19.957	22.651
66	32.32	4.076	4.455	136	42.77	20.556	23.418
68	32.75	4.380	4.778	138	42.98	21.158	24.199
70	33.17	4.695	5.114	140	43.19	21.765	24.993
72	33.58	5.022	5.463	142	43.40	22.374	25.802
74	33.98	5.360	5.824	144	43.60	22.987	26.624
76	34.36	5.708	6.197	146	43.80	23.601	27.459
78	34.74	6.068	6.583	148	44.00	24.218	28.309
80	35.10	6.438	6.981	150	44.19	24.836	29.172

Derived from the equations:

Total Volume (UB) = $5E\text{-}05(D^2H)^{0.9614}$

Timber Volume (UB) = $-5E\text{-}12(D^2H)^2 + 3E\text{-}05(D^2H) - 0.0489$

Height= $14.456\ln(D) - 28.244$

Where D is DBH in cm, H is tree height in m,

To obtain over bark estimates multiply values in the table by 1.14

TABLE-3

Local Volume Table (UB) of *Pinus gerardiana* (Chilghoza Pine) in Metric Units

DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3	DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3
12	5.29	-	0.058	58	15.46	0.794	1.299
14	5.77	-	0.065	60	15.86	0.889	1.446
16	6.24	-	0.075	62	16.26	0.995	1.606
18	6.71	-	0.087	64	16.66	1.112	1.780
20	7.18	0.087	0.101	66	17.06	1.242	1.970
22	7.64	0.095	0.118	68	17.45	1.385	2.177
24	8.11	0.106	0.138	70	17.84	1.542	2.402
26	8.56	0.118	0.161	72	18.22	1.715	2.645
28	9.02	0.132	0.188	74	18.60	1.906	2.910
30	9.47	0.148	0.219	76	18.98	2.115	3.197
32	9.92	0.167	0.254	78	19.35	2.344	3.507
34	10.37	0.189	0.294	80	19.73	2.595	3.843
36	10.81	0.213	0.339	82	20.09	2.869	4.206
38	11.25	0.241	0.389	84	20.46	3.168	4.597
40	11.68	0.272	0.444	86	20.82	3.495	5.020
42	12.11	0.307	0.507	88	21.18	3.850	5.476
44	12.54	0.347	0.576	90	21.54	4.236	5.966
46	12.97	0.392	0.652	92	21.89	4.656	6.494
48	13.39	0.442	0.736	94	22.24	5.111	7.062
50	13.81	0.498	0.829	96	22.59	5.605	7.672
52	14.23	0.560	0.931	98	22.93	6.138	8.326
54	14.64	0.630	1.043	100	23.27	6.715	9.028
56	15.05	0.708	1.165	-	-	-	-

Derived from the equations:

Total Volume (UB) = $8E\text{-}11(D^2H)^2 + 2E\text{-}05(D^2H) + 0.0427$

Timber Volume (UB) = $8E\text{-}11(D^2H)^2 + 1E\text{-}05(D^2H) + 0.0572$

Height= $-0.0004D^2 + 0.2491D + 2.3583$

Where D is DBH in cm, H is tree height in m,

To obtain over bark estimates multiply values in the table by 1.12

TABLE-4

Local Volume Table (UB) of *Abies pindrow* (Fir) in Metric Units

DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3	DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3
12	12.78		0.064	58	28.10	2.151	2.690
14	14.28		0.095	60	28.43	2.348	2.901
16	15.58		0.133	62	28.75	2.556	3.121
18	16.72		0.177	64	29.06	2.774	3.349
20	17.75	0.124	0.229	66	29.36	3.002	3.585
22	18.67	0.162	0.289	68	29.65	3.241	3.831
24	19.52	0.206	0.355	70	29.93	3.492	4.084
26	20.30	0.256	0.429	72	30.21	3.753	4.347
28	21.02	0.313	0.511	74	30.47	4.026	4.617
30	21.69	0.378	0.600	76	30.73	4.310	4.897
32	22.32	0.449	0.697	78	30.98	4.605	5.185
34	22.91	0.529	0.802	80	31.23	4.913	5.482
36	23.46	0.616	0.915	82	31.47	5.232	5.787
38	23.99	0.711	1.036	84	31.70	5.562	6.102
40	24.49	0.814	1.164	86	31.93	5.905	6.425
42	24.96	0.926	1.301	88	32.16	6.261	6.757
44	25.42	1.047	1.446	90	32.38	6.628	7.097
46	25.85	1.176	1.599	92	32.59	7.008	7.446
48	26.26	1.315	1.760	94	32.80	7.401	7.805
50	26.66	1.463	1.929	96	33.00	7.806	8.172
52	27.04	1.620	2.107	98	33.20	8.224	8.547
54	27.41	1.787	2.293	100	33.40	8.655	8.932
56	27.76	1.964	2.487				

Derived from the equations:

Total Volume (UB) = $5E\text{-}05(D^2H)^{0.9508}$

Timber Volume (UB) = $7E\text{-}06(D^2H)^{1.1029}$

Height= $9.7271\ln(D) - 11.394$

Where D is DBH in cm, H is tree height in m

To obtain over bark estimates multiply values in the table by 1.22

TABLE-5

Local Volume Table (UB) of *Picea smithiana* (Spruce) in Metric Units

DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3	DBH_cm	Height_m	Timber Volume_m3	Total Volume_m3
12	8.58	-	0.035	82	30.98	5.784	5.987
14	10.37	-	0.059	84	31.26	6.115	6.323
16	11.93	-	0.089	86	31.54	6.454	6.669
18	13.30	-	0.127	88	31.80	6.802	7.023
20	14.53	-	0.172	90	32.07	7.158	7.385
22	15.64	0.064	0.225	92	32.32	7.521	7.756
24	16.66	0.125	0.285	94	32.57	7.892	8.135
26	17.59	0.193	0.354	96	32.82	8.271	8.523
28	18.45	0.270	0.431	98	33.06	8.657	8.918
30	19.26	0.356	0.516	100	33.30	9.050	9.321
32	20.01	0.450	0.610	102	33.53	9.450	9.732
34	20.72	0.552	0.713	104	33.75	9.857	10.150
36	21.38	0.664	0.825	106	33.97	10.270	10.576
38	22.01	0.784	0.945	108	34.19	10.689	11.008
40	22.61	0.914	1.075	110	34.41	11.114	11.447
42	23.18	1.053	1.215	112	34.62	11.545	11.893
44	23.72	1.201	1.363	114	34.82	11.981	12.346
46	24.24	1.358	1.521	116	35.03	12.422	12.804
48	24.74	1.525	1.688	118	35.22	12.868	13.268
50	25.21	1.701	1.865	120	35.42	13.318	13.739
52	25.67	1.886	2.051	122	35.61	13.773	14.214
54	26.11	2.081	2.247	124	35.80	14.231	14.695
56	26.54	2.286	2.453	126	35.99	14.693	15.180
58	26.94	2.499	2.668	128	36.17	15.159	15.670
60	27.34	2.723	2.892	130	36.35	15.627	16.164
62	27.72	2.955	3.127	132	36.53	16.097	16.663
64	28.09	3.197	3.370	134	36.71	16.570	17.165
66	28.45	3.448	3.624	136	36.88	17.044	17.670
68	28.80	3.709	3.886	138	37.05	17.520	18.178
70	29.14	3.978	4.159	140	37.22	17.997	18.689
72	29.47	4.257	4.440	142	37.38	18.474	19.202
74	29.78	4.545	4.731	144	37.55	18.951	19.718
76	30.10	4.841	5.031	146	37.71	19.428	20.234
78	30.40	5.147	5.341	148	37.87	19.904	20.752
80	30.69	5.461	5.659	150	38.02	20.379	21.271

Derived from the equations:

Total Volume (UB) = $-6E-12(D^2H)^2 + 3E-05(D^2H) - 0.0022$

Timber Volume (UB) = $-7E-12(D^2H)^2 + 3E-05(D^2H) - 0.1623$

Height= $11.658\ln(D) - 20.392$

Where D is DBH in cm, H is tree height in m

To obtain over bark estimates multiply values in the table by 1.15

TABLE-6

Local Volume Table (UB) of *Pinus gerardiana* (Chilghoza Pine) in British Units

DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume (UB)_cft	DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume (UB)_cft
6	20		2.5	24	53	33.6	54.4
7	22		3.0	25	55	38.8	62.2
8	24		3.7	26	57	44.7	70.8
9	26	3.5	4.5	27	58	51.4	80.4
10	28	4.0	5.4	28	60	58.9	91.1
11	30	4.7	6.6	29	62	67.5	103.0
12	32	5.4	8.1	30	63	77.1	116.2
13	33	6.3	9.7	31	65	88.0	130.8
14	35	7.4	11.7	32	67	100.2	147.0
15	37	8.6	13.9	33	68	113.8	164.9
16	39	10.1	16.5	34	70	129.1	184.6
17	41	11.8	19.4	35	71	146.1	206.3
18	43	13.7	22.8	36	73	165.1	230.2
19	44	16.0	26.6	37	74	186.2	256.4
20	46	18.6	31.0	38	76	209.5	285.2
21	48	21.7	35.9	39	77	235.4	316.7
22	50	25.1	41.4	40	79	264.0	351.2
23	52	29.1	47.5				

To obtain over bark estimates multiply values in the table by 1.12

TABLE-7

Local Volume Table (UB) of *Pinus wallichiana* (Kail/Blue Pine) in British Units

DBH_inch	Height_ft	Timber Volume_cft	Total Volume_cft	DBH_inch	Height_ft	Timber Volume_cft	Total Volume_cft
6	36	-	3.3	34	120	273.9	296.9
7	43	-	5.4	35	121	292.8	317.4
8	50	-	7.9	36	123	312.2	338.7
9	56	7.6	11.0	37	124	332.2	360.7
10	61	10.9	14.7	38	125	352.8	383.5
11	65	14.7	18.9	39	127	373.9	407.0
12	70	19.1	23.7	40	128	395.6	431.3
13	73	24.0	29.2	41	129	417.8	456.3
14	77	29.6	35.2	42	130	440.5	482.1
15	80	35.7	41.9	43	131	463.7	508.7
16	83	42.5	49.2	44	132	487.3	536.0
17	86	49.9	57.1	45	133	511.4	564.1
18	89	57.9	65.7	46	134	535.9	592.9
19	92	66.5	75.0	47	136	560.9	622.6
20	94	75.8	84.9	48	137	586.2	653.0
21	97	85.8	95.5	49	138	611.9	684.1
22	99	96.4	106.8	50	139	637.9	716.1
23	101	107.6	118.7	51	139	664.3	748.8
24	103	119.5	131.4	52	140	690.9	782.3
25	105	132.1	144.7	53	141	717.9	816.6
26	107	145.3	158.8	54	142	745.0	851.7
27	109	159.2	173.5	55	143	772.4	887.6
28	110	173.7	189.0	56	144	799.9	924.3
29	112	188.8	205.1	57	145	827.6	961.7
30	114	204.6	222.0	58	146	855.4	1000.0
31	115	221.0	239.7	59	147	883.3	1039.0
32	117	238.0	258.0	60	147	911.3	1078.9
33	118	255.7	277.1				

To obtain over bark estimates multiply values in the table by 1.14

TABLE-8

Local Volume Table (UB) of *Abies pindrow* (Fir) in British Units

DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume(UB)_cft	DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume(UB)_cft
6	50	-	4.1	24	94	86.4	106.1
7	54	-	6.1	25	95	96.0	116.2
8	59	4.6	8.4	26	96	106.2	126.8
9	62	6.3	11.2	27	98	117.0	137.8
10	66	8.5	14.3	28	99	128.4	149.4
11	69	11.0	18.0	29	100	140.5	161.4
12	72	13.9	22.0	30	101	153.2	173.9
13	74	17.3	26.5	31	102	166.6	187.0
14	77	21.0	31.4	32	103	180.6	200.5
15	79	25.3	36.8	33	104	195.4	214.5
16	81	30.0	42.6	34	105	210.8	229.0
17	83	35.2	48.9	35	106	226.9	244.0
18	85	40.9	55.7	36	107	243.7	259.5
19	86	47.1	62.9	37	108	261.2	275.5
20	88	53.8	70.6	38	108	279.5	292.0
21	90	61.1	78.8	39	109	298.4	309.0
22	91	69.0	87.4	40	110	318.1	326.5
23	92	77.4	96.5				

To obtain over bark estimates multiply values in the table by 1.22

TABLE-9

Local Volume Table (UB) of *Cedrus deodara* (Deodar) in British Units

DBH_inch	Height_ft	Timber Volume_cft	Total Volume_cft	DBH_inch	Height_ft	Timber Volume_cft	Total Volume_cft
5	15	-	0.9	33	110	176.3	239.7
6	24	-	2.0	34	112	190.3	257.4
7	32	-	3.5	35	113	204.8	275.8
8	39	-	5.5	36	115	220.1	294.9
9	45	6.7	8.0	37	116	236.1	314.7
10	50	8.7	10.9	38	117	252.8	335.3
11	55	10.9	14.3	39	119	270.2	356.5
12	59	13.6	18.3	40	120	288.4	378.4
13	63	16.6	22.8	41	121	307.3	401.0
14	67	20.0	27.8	42	122	327.1	424.4
15	71	23.9	33.4	43	124	347.6	448.5
16	74	28.1	39.6	44	125	369.0	473.3
17	77	32.8	46.4	45	126	391.3	498.8
18	80	37.9	53.7	46	127	414.4	525.1
19	82	43.5	61.7	47	128	438.4	552.0
20	85	49.6	70.2	48	129	463.3	579.8
21	87	56.1	79.4	49	130	489.2	608.2
22	90	63.1	89.2	50	131	516.0	637.5
23	92	70.6	99.6	51	132	543.8	667.4
24	94	78.7	110.7	52	133	572.7	698.1
25	96	87.2	122.4	53	134	602.5	729.6
26	98	96.3	134.7	54	135	633.5	761.8
27	100	106.0	147.7	55	136	665.5	794.7
28	102	116.2	161.4	56	137	698.7	828.4
29	104	127.0	175.7	57	138	733.0	862.9
30	105	138.4	190.7	58	139	768.5	898.2
31	107	150.4	206.3	59	140	805.2	934.2
32	109	163.1	222.7	60	140	843.1	970.9

To obtain over bark estimates multiply values in the table by 1.18

TABLE-10

Local Volume Table (UB) of *Picea smithiana* (Spruce) in British Units

DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume(UB)_cft	DBH_inch	Height_ft	Timber Volume(UB)_cft	Total Volume(UB)_cft
6	37		2.7	34	104	230.1	237.7
7	43		4.3	35	105	245.8	253.7
8	48		6.4	36	106	262.0	270.2
9	53	3.2	8.8	37	107	278.6	287.2
10	57	6.1	11.7	38	108	295.6	304.6
11	60	9.5	15.1	39	109	313.0	322.4
12	64	13.3	19.0	40	110	330.9	340.7
13	67	17.7	23.4	41	111	349.1	359.5
14	70	22.5	28.2	42	112	367.7	378.6
15	72	27.9	33.6	43	113	386.6	398.2
16	75	33.8	39.5	44	113	405.8	418.1
17	77	40.2	45.9	45	114	425.4	438.4
18	79	47.2	52.9	46	115	445.3	459.0
19	81	54.6	60.4	47	116	465.4	480.0
20	83	62.6	68.5	48	117	485.7	501.3
21	85	71.2	77.0	49	118	506.3	522.8
22	87	80.3	86.2	50	118	527.1	544.7
23	89	89.9	95.8	51	119	548.0	566.8
24	90	100.0	106.1	52	120	569.1	589.1
25	92	110.7	116.8	53	121	590.3	611.7
26	93	121.9	128.1	54	121	611.6	634.4
27	95	133.7	140.0	55	122	633.0	657.3
28	96	146.0	152.4	56	123	654.4	680.3
29	98	158.7	165.3	57	123	675.8	703.4
30	99	172.0	178.8	58	124	697.2	726.6
31	100	185.8	192.7	59	125	718.5	749.9
32	101	200.1	207.2	60	125	739.7	773.2
33	102	214.9	222.2				

To obtain over bark estimates multiply values in the table by 1.15

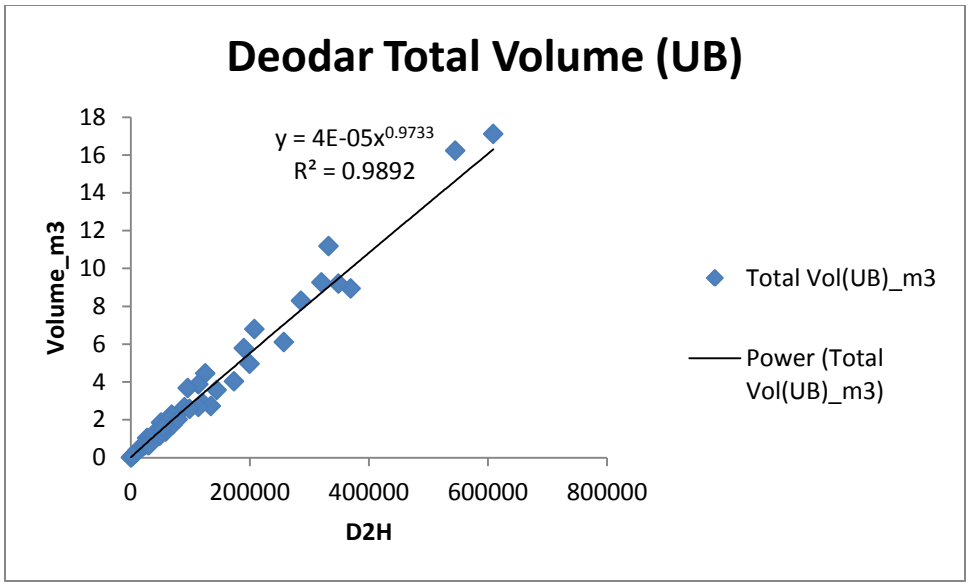

Figure 2. Deodar Total Volume Model

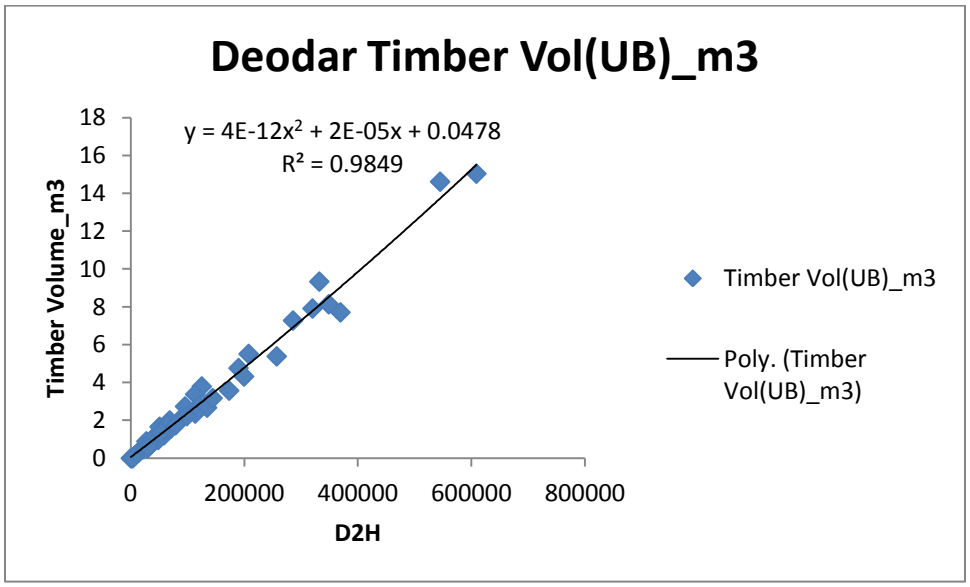

Figure 3. Deodar Timber Volume Model

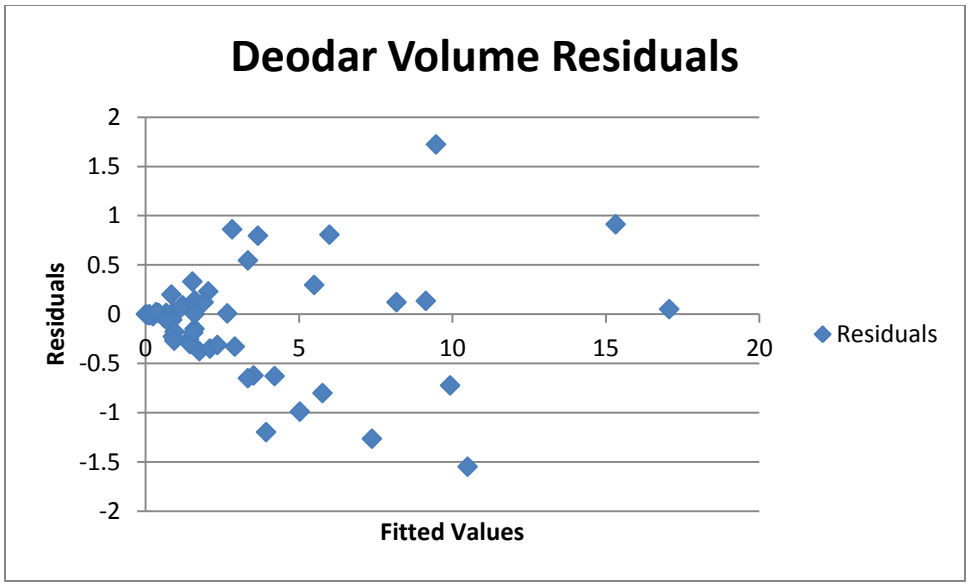

Figure 4. Residual Scatter Plot of Deodar Volume

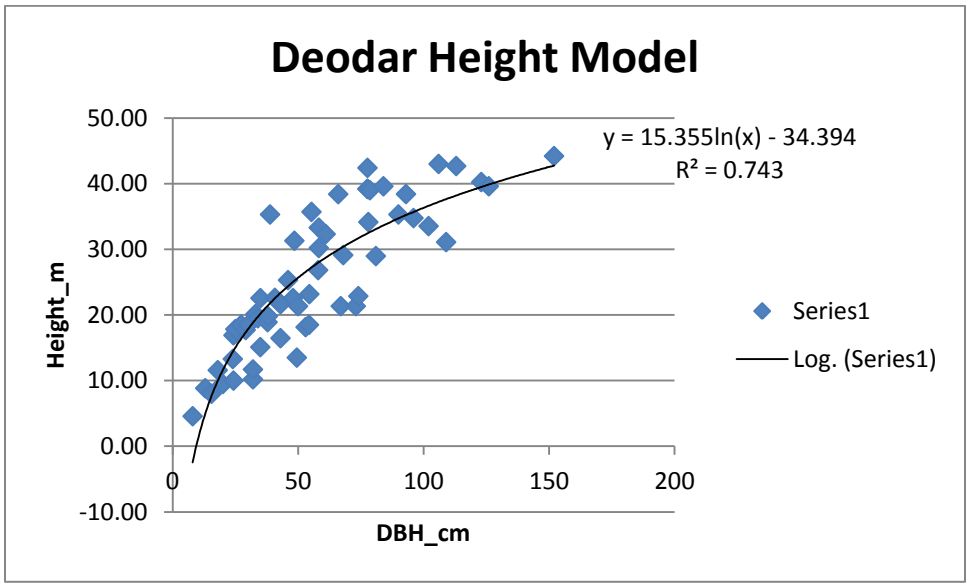

Figure 5. Deodar Height Model

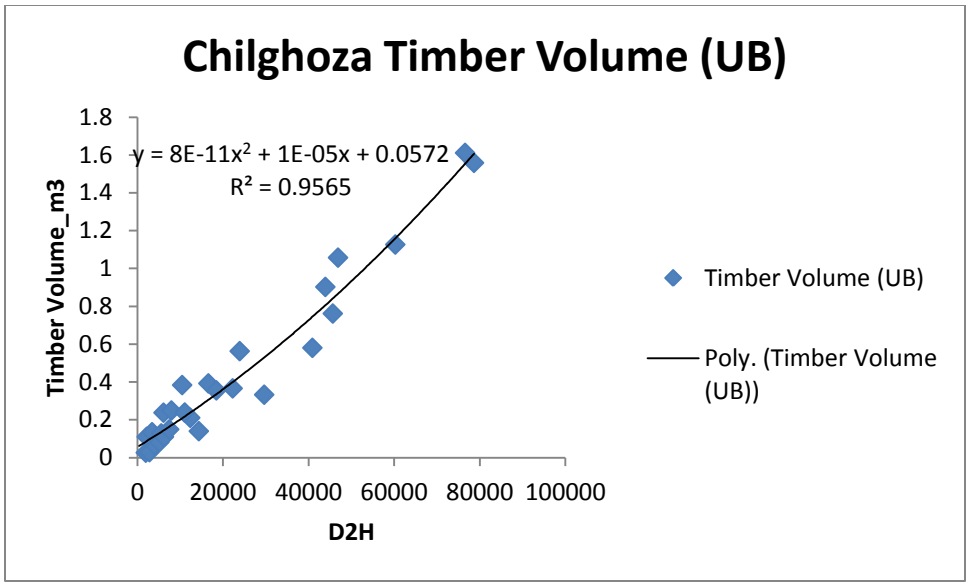

Figure 6. Chilghoza Timber Volume Model

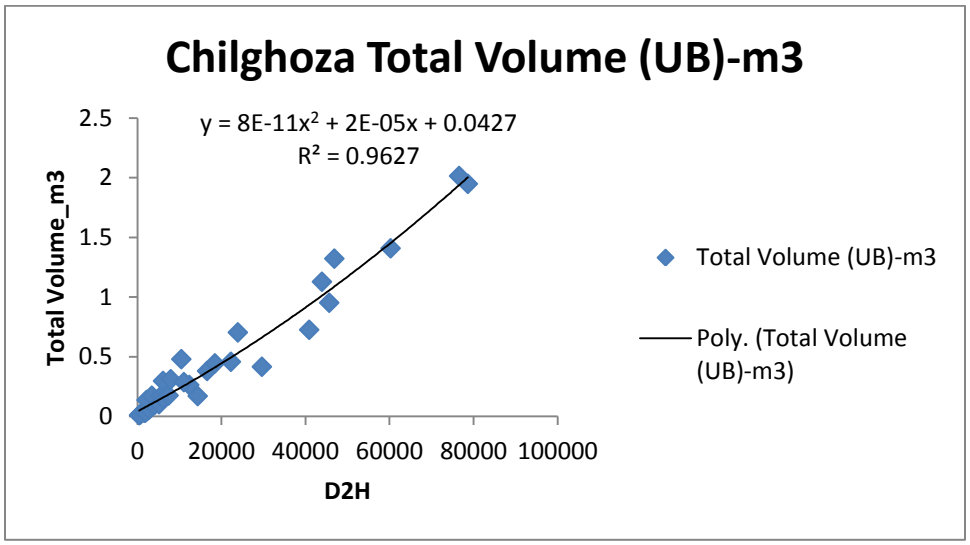

Figure 7. Chilghoza Total Volume Model

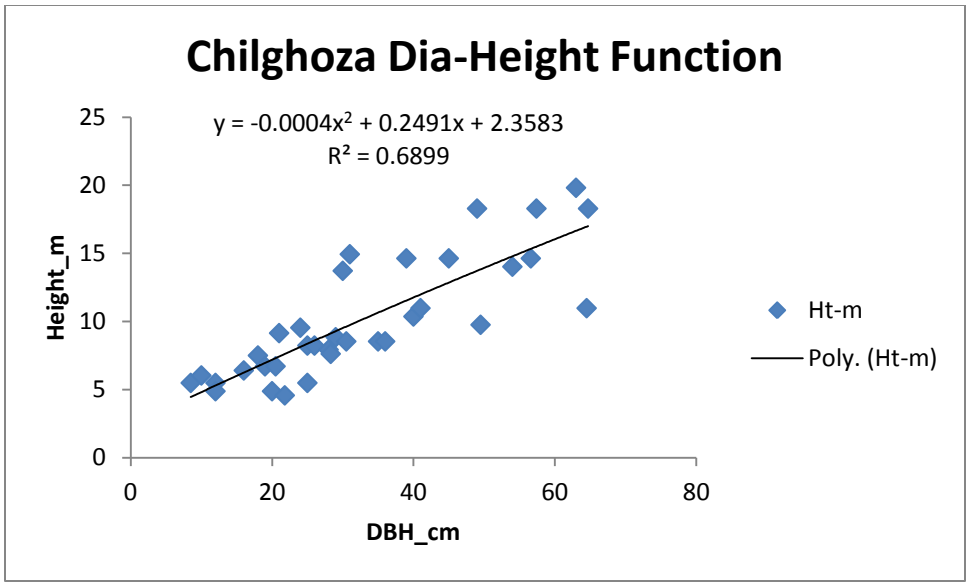

Figure 8. Chilghoza Height Model

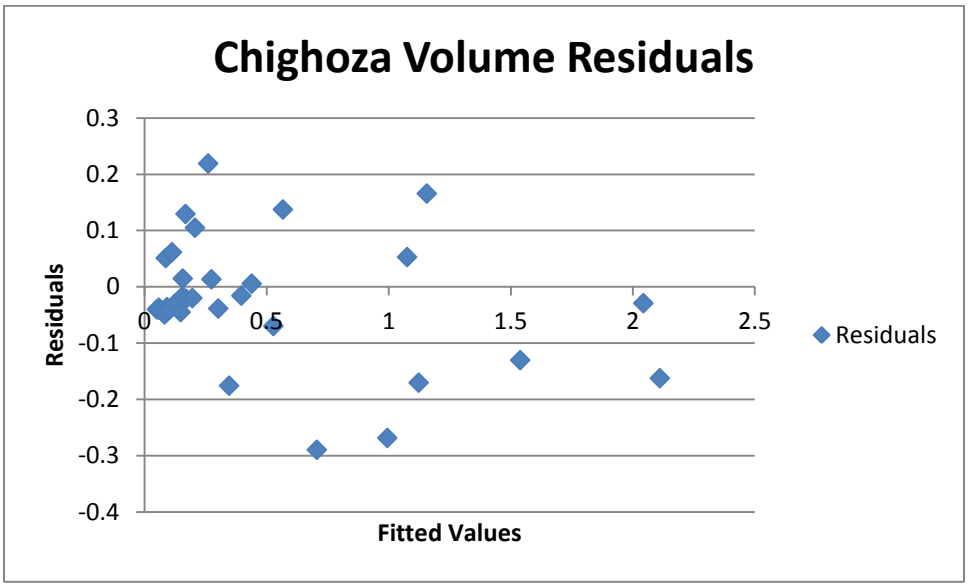

Figure 9. Residuals Scatter Plot for Chighoza Volume Model

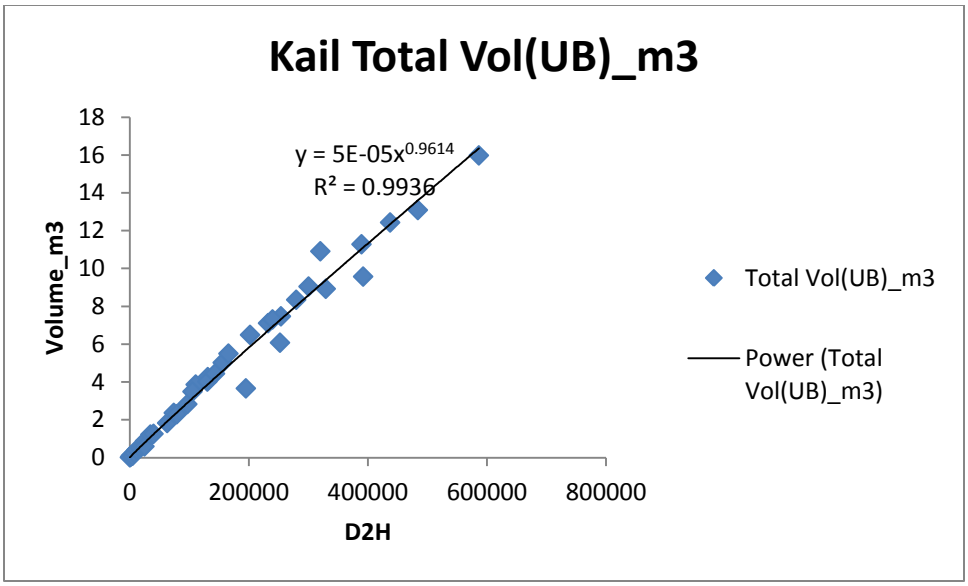

Figure 10. Kail Total Volume Model

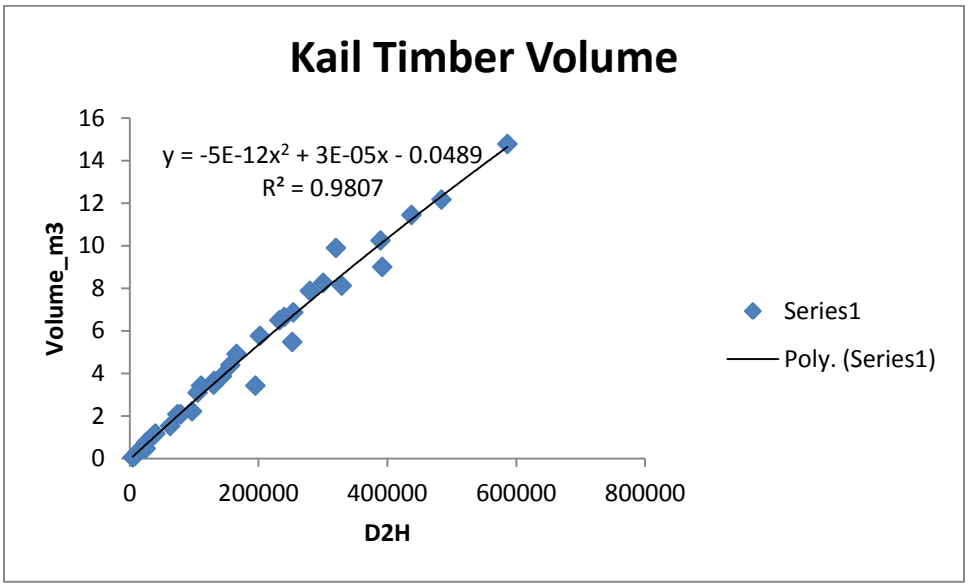

Figure 11. Kail Timber Volume Model

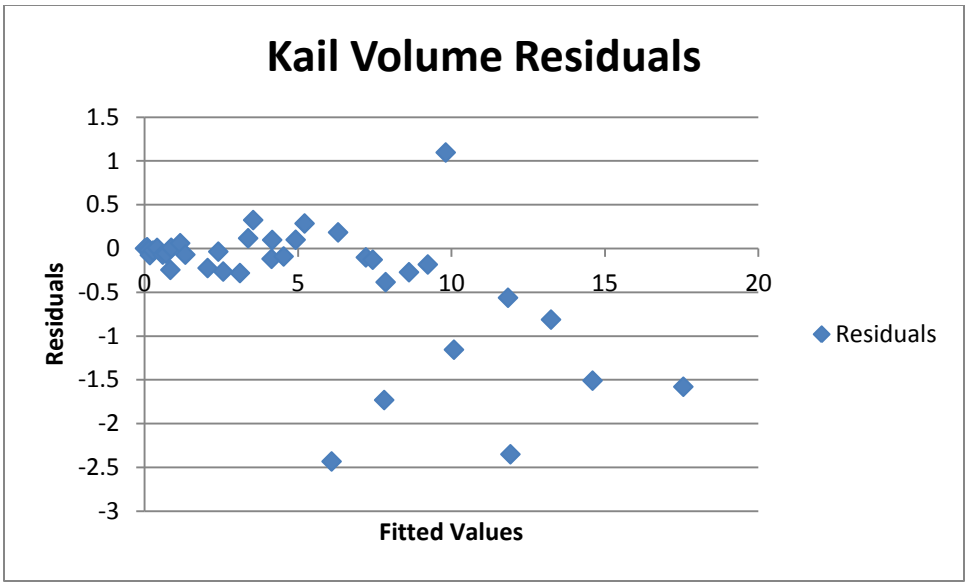

Figure 11. Residuals Scatter Plot for Kail Volume Model

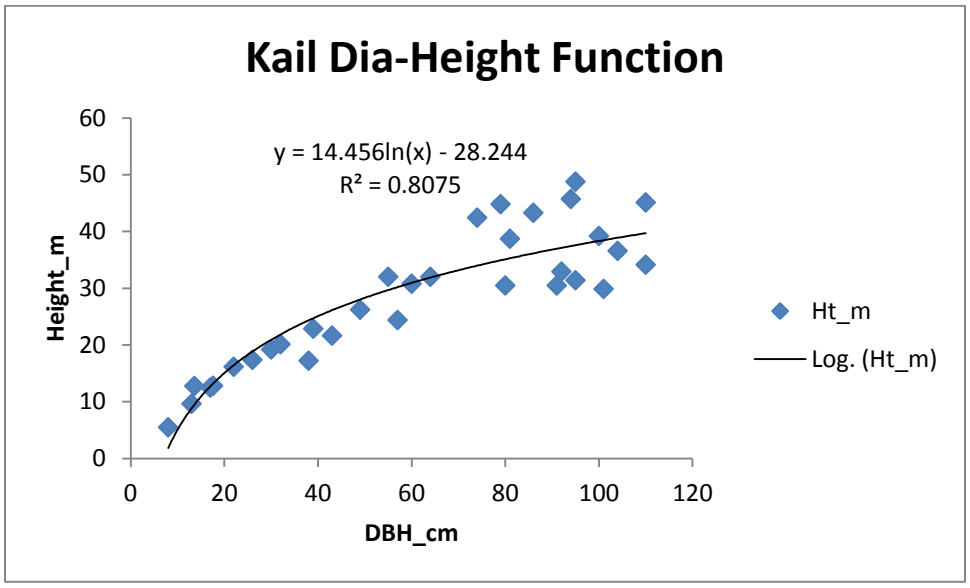

Figure 12. Kail Height Model

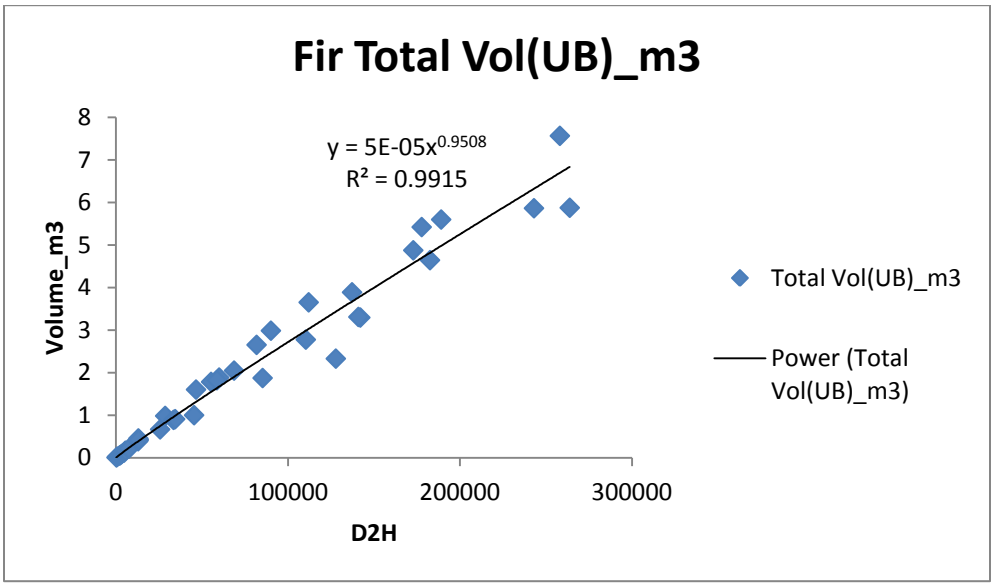

Figure 13. Fir Total Volume Model

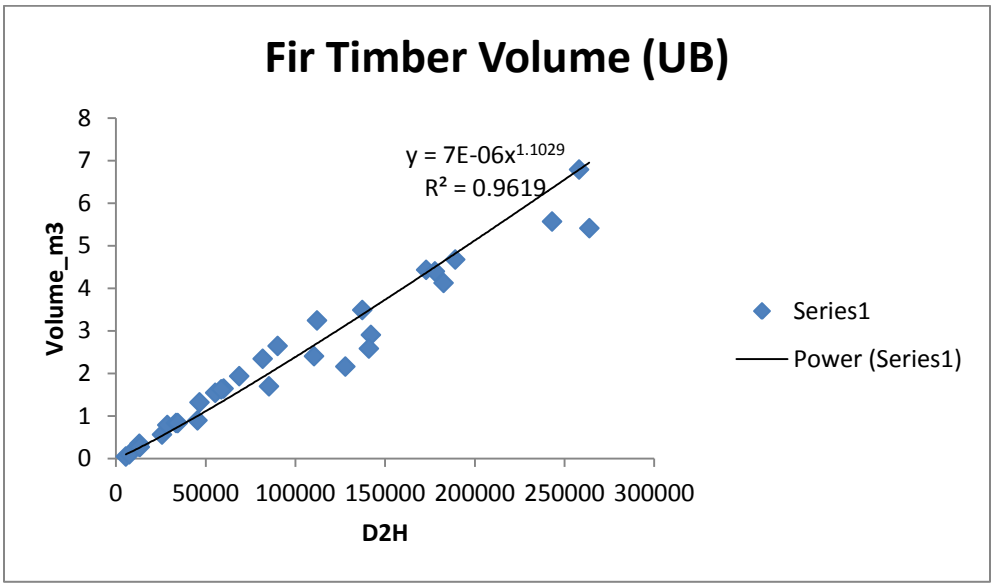

Figure 14. Fir Timber Volume Model

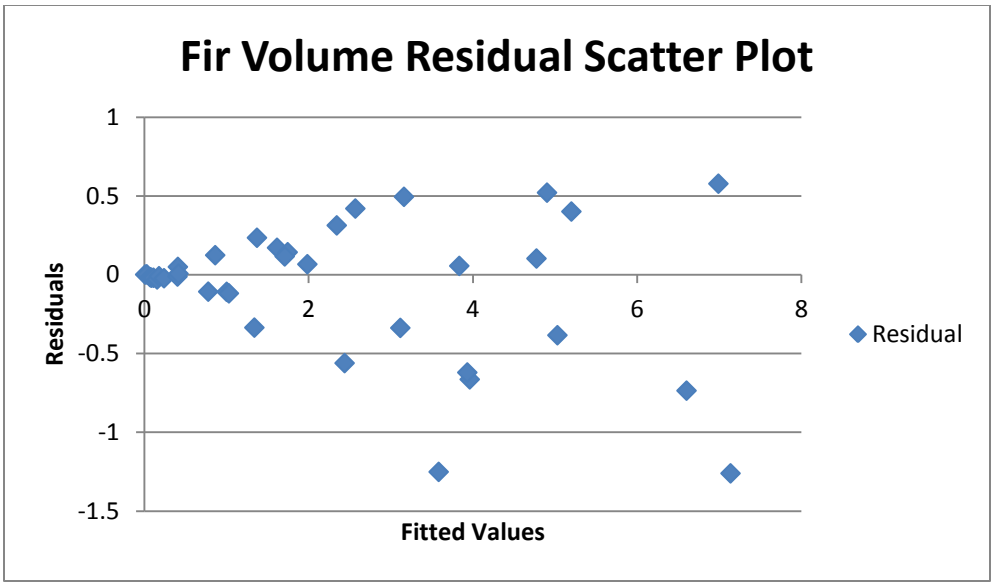

Figure 15. Residuals Scatter Plot for Fir Volume Model

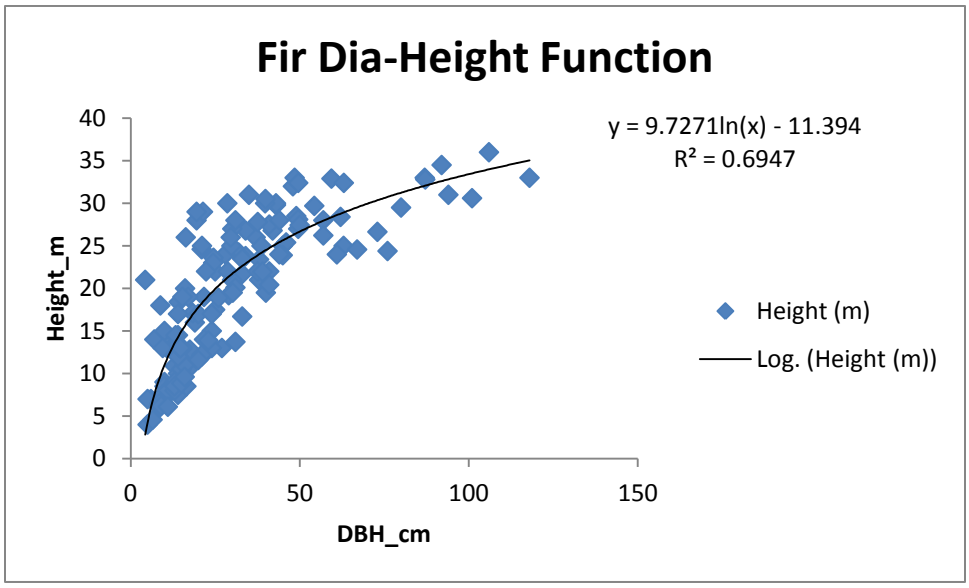

Figure 16. Fir Height Model

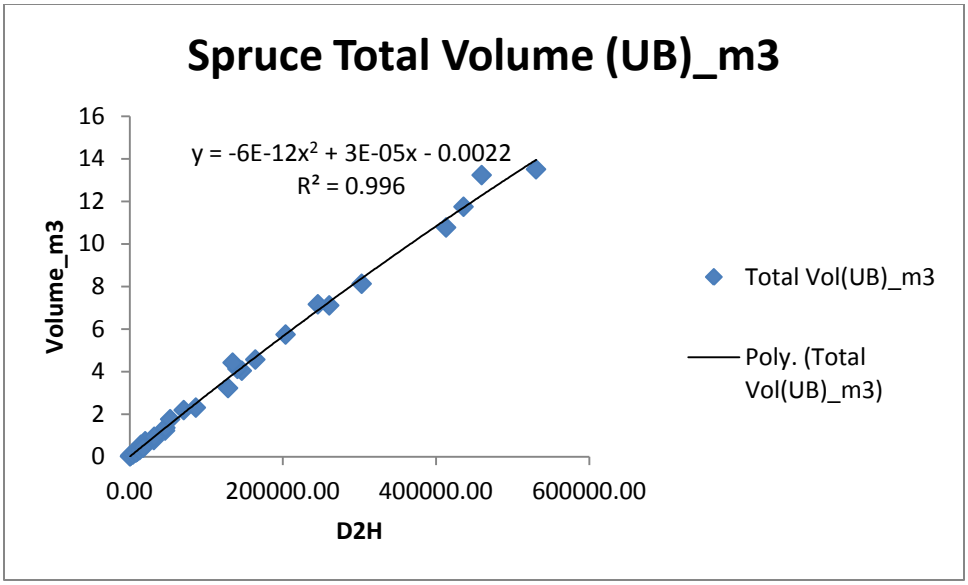

Figure 17. Spruce Total Volume Model

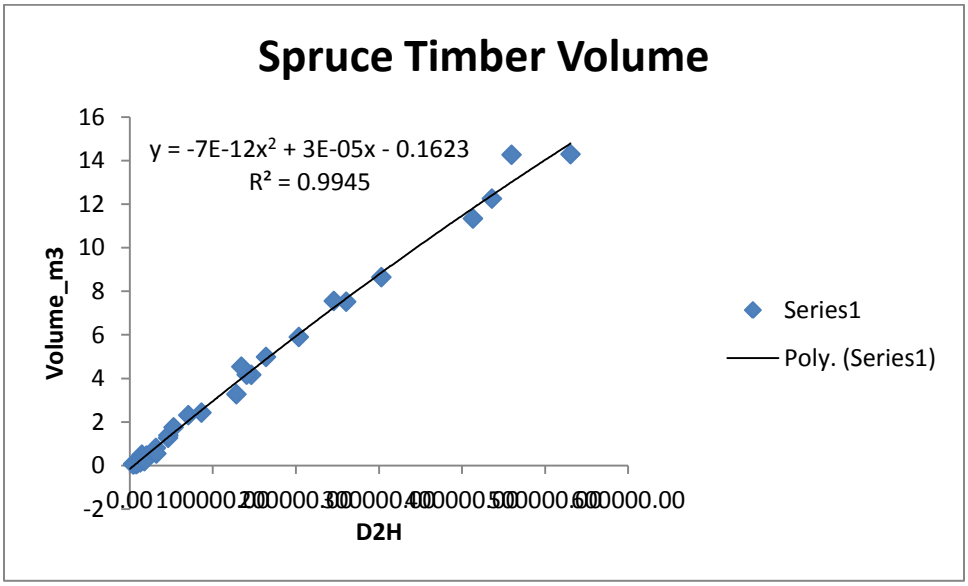

Figure 18. Spruce Timber Volume Model

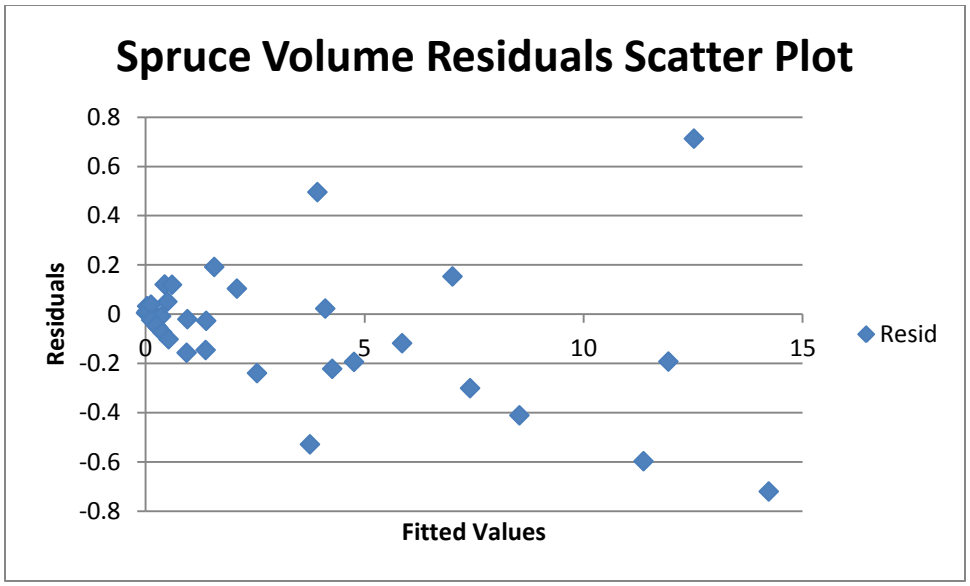

Figure 19. Residuals Scatter Plot for Spruce Volume Model

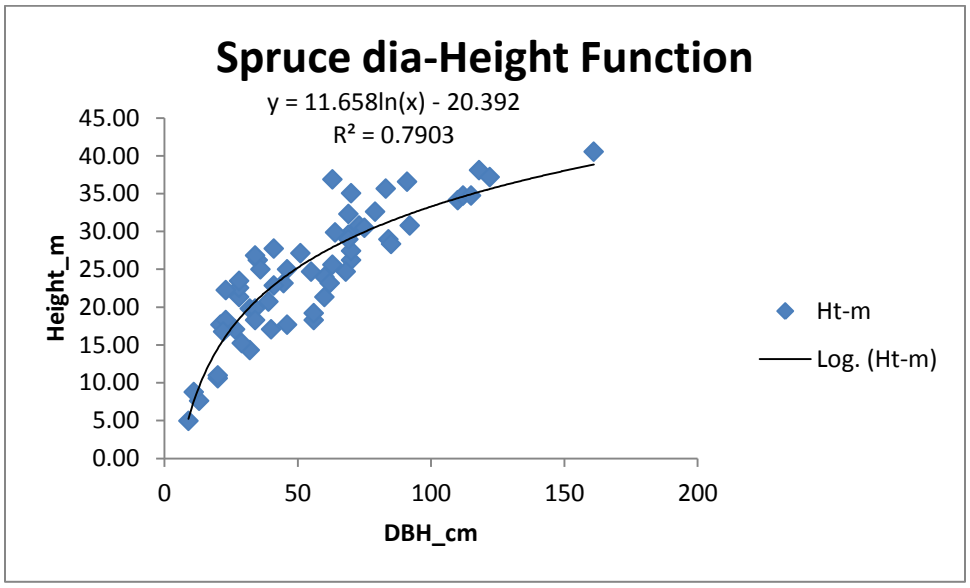

Figure 20. Spruce Height Model

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ANNEX-I

DATA COLLECTION FORM FOR PREPARATION OF VOLUME TABLE

Species_____Locality_____

X-Coordinate_____Y-Coordinate_____

Elevation_____Stand Density_____Aspect_____

Tree No_____DBH (cm)_____Height (m)_____Age_____

Clear Bole (height)_____Crown length_____Crown Width_____

Timber Data (logs upto 20 cm dia at thin end**)**

Piece No	Dia at mid point (cm)	Length (m)

Smallwood (logs from stem or branches with dia 20 cm at thick end and 5 cm at thin end)

Piece No	Dia at mid point (cm)	Length (m)