PROVISIONAL VOLUME TABLES FOR POPLAR (POPULUS NIGRA) IN MARDAN

by

Raja Walayat Hussain
Forest Mensuration Officer
and
Muhammad Afzal Cheema
Computor

INTRODUCTION.

Populus nigra (Linn.) locally known as 'sufeda' seems to have been introduced in this country from Afghanistan by Moghul emperors. It is commonly found in Peshawar and Mardan districts of N. W. F. P. where farmers grow it along the borders of their fields and along water courses. The tree is also found in Malakand division, Gilgit agency and Hazara district and one of its best avenues is seen on the road from Abbottabad to Mansehra. Very beautiful specimens of the species are also found in Gilgit agency specially towards Punyal and Yasin side where it attains huge dimensions and seems to be 'pyramidalis' variety. When the trees attain a diameter between 5" to 10" at breast height these are felled by the farmers to meet their small constructional demands. The wood is in great demand for making of packing cases and crates etc. Since the trees have almost clear and straight boles these yield good ballies which fetch handsome revenue to the growers. The trees also have no adverse effect on their cash crop as the shade of the crowns is not dense. Closely planted, the trees along the border of the fields act as a live hedge against cattle and a useful wind break.

BASIC DATA.

During 1966 when the trees were being felled by the purchasers from Gujar Garhi block of Mardan Forest Division the data were collected from 105 trees between diameter range of 4 to 12 inches and height range of 36 to 75 feet. The trees were measured by the staff of this organization according to the standard procedure and field data were recorded on sample plot form. 7. The data remained un-utilized till last year when all necessary computation work was taken up. Volume, both overbark, were worked out for timber separately by Huber's formula whereas only overbark volume was calculated for smallwood. Other pertinent information alongwith the above was transferred on summary form.

APPLICABILITY.

Since the data could not be supplemented from other places due to financial and other difficulties and the data are deficient in large sized trees the tables, though prepared by modern statistical techniques, are provisional in nature. These can, however, be made applicable to all the areas where the species grows as the trees do not seem to exhibit much variatioı in form etc. from place to place.

METHODS AND PROCEDURES.

(a) Volume-diameter-total height relationship. (Standard volume table).

It was intended to get the data processed through electronic computer by regression techniques making use of different mathematicl functions. This would have given us a broad base for selection of the best model. This however could not be done due to certain unavoidable circumstances. Since most of data belong to lower diameter classes when differentiation into timber has not started and there is no special need to subdivide the volume into two portions, it was considered advisable to prepare the table showing total volume overbark only. To avoid use of complex mathematical models which can be worked on computer only, following alternative models describing fairly well the underlying biological phenomenon have been made use of. These have been worked out with the help of manually operated calculators. Hyperbolic and exponential models were not tested due to complicated and lengthy procedure involved in the calculation of different attributes of variables for solving them by least square method.

Total volume overbark as dependent variable was related with diameter breast height and total height (both in dependent variables) in the following mathematical function for determining the best fit by least square method:—

$$V=a+bD^2H \qquad (1)$$
$$V=a+bD^2H+cD^3 \qquad (2)$$
$$V=a+bD^2+cH+dD^2H \qquad (3)$$
$$V=a+bD^2H \qquad (4)$$

Where,

V= Total volume overbark in cubic feet calculated upto four decimal places.

D= Diameter breast height measured correctly upto one decimal place.

H= Total height in feet.

a, b, c, d = Regression coefficients.

Regression equations worked on the pattern of above models are listed in APPENDIX-I which also gives details of the precision and other indices of best fit.

After preliminary screening the following equations being of comparable accuracy were further analysed.

Serial No.	Regression equation	Standard error of the mean in % (S. E. %)	Correlation co-efficient (R/r)	Sum of squared ratio of residuals to actual volume	Variance ratio 'F'	Chi square X^2
i.	$V = -0.127559 + 0.016337 D^2 + 0.002168 D^2H$	13.73	0.9735	1.4831	924.78	11.272
ii.	$V = -1.036801 + 0.026605 D^2 + 0.017239H + 0.001973 D^2H$	13.78	0.9736	1.4619	612.52	11.475
iii.	$V = 0.034371 + 0.002368 D^2H$	13.69	0.9734	1.4638	1861.62	11.727

Both the equations (*ii*) and (*iii*) are quite similar and each one would yield precise estimates. But equation (*iii*) has been ultimately selected for preparation of volume tables on the following grounds:—

1. It shows comparatively large value for 'F'.
2. S. E. percent is comparatively low.
3. It is based on one combined variable (D^2H) and thus solution of normal equations is rendered comparatively easy.

Therefore, total volume tables over bark have been prepared based on this regression equation by one inch diameter class and five foot height class. These are tabulated in APPENDIX-II.

(b) Total height-diameter relationship.

Following four mathematical models were used for developing total height-diameter relationship:—

$$\log H = a + b \log D + c (\log D)^2 \qquad (5)$$

$$H = \frac{D^2}{a + bD + cD^2} \qquad (6)$$

$$H = a + bD \qquad (7)$$

$$H = a + b D + cD^2 \qquad (8)$$

Regression equations were computed on the pattern of above models and are given in APPENDIX-III alongwith the indices of best fit.

As is evident from APPENDIX III regression equation 2, shows a very high standard error in percent and chi square value and under-estimates heights and is, therefore, rejected. Equation 3, shows comparatively larger standard error in percent. It also yields higher estimates for higher diameters and lower correlation coefficient and, therefore, cannot be used for height estimation. Out of the remaining two, equation 4 gave height estimates of comparable accuracy upto 10 inches diameter class and for diameters more than 10 inches heights start decreasing with increase in diameter. Moreover, other attributes are of less precision than of equation 1. Since equation 1 gave comparatively better indices of precision, therefore, it was finally selected for height estimation.

Estimates of heights against diameters are given in APPENDIX-IV.

(c) Volume-diameter relationship (Local volume tables).

Local volume table was prepared by making use of regression equation used in the preparation of standard volume table viz.,

$V = 0.034371 + 0.002368D^2 H$ by plugging in the values of D and estimated height H obtained from (b) above. Volumes calculated upto three significant figures with one inch diameter class are shown in APPENDIX-IV.

CHECK OF LINEARITY.

A check was conducted for linearity between estimated and actual volumes. Following mathematical relationship was assumed to exist between the above variables:—

$$V = a + b\hat{V}$$

Where

V = Actual standard volume (cft.)

$\hat{V}$ = Estimated standard volume (cft.)

The values of 'a' intercept and 'b' regression coefficient were put to 't' test. The regression equation and values calculated of 't' for 'a' and 'b' respectively are given below.—

Regression equation	Calculated value of 't' for 'a'	Calculated value of 't' for 'b'
$V = -0.069900 + 1.008443\hat{V}$ ..	0.0044 N. S.	0.0356 N. S.

't' test of significance showed that regression line almost passes through the origin and regression coefficient 'b' does not differ significantly from 1. This also confirms the fact that estimates given by finally selected equation viz.,

$$V = 0.034371 + 0.002368D^2H$$

are quite close to the actual volumes.

HOW TO USE THE TABLES.

Figures of heights and diameters given in APPENDIX-II represent the mid-point of the height and diameter classes. For example, 5 inch diameter class includes trees of diameters at breast height from 4.6 inches to 5.5 inches and height class 20 feet includes all trees having height between the range of 18 feet to 22 feet (both inclusive). To read the volume of a tree which has 6.7 inches diameter breast height overbark and is 43 feet in height, follow the row showing 7 inch diameter class till it intersects the column against figure 45 under the row showing heights at the top of the column. The figure at the intersection of both the columns gives the value *i. e.*, 5.36 eft. in this case.

Local volume tables (APPENDIX-IV) are easy for consultation. Volume is give against each diameter class.

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LIST OF APPENDICES.

Appendix No.	Particular
I	Regression equations for total volume with their relative indices of precision.
II.	Populus nigra (Linn.) Mardan total volume overbark arranged by five foot height classes.
III.	Regression equations showing relationship between diameter and total height with their relative indices of precision.
IV.	Local volume table overbark for Populus nigra.

APPENDIX-I

Regression Equations for Total volume with their Relative Indices of Precision.

Serial No.	Regression equation	Standard error of mean volume in percent (cft.)	Correlation co-efficient (R/r)	Sum of squared ratio of residuals to actual volume	Mean tree volume (cft.)	'F' value	Chi square
1	$V = -0.127559 + 0.016337D^2 + 0.002168D^2H$ ..	13.73	0.9735	1.4831	8.5458	924.78	11.272
2	$V = 0.8025216 + 0.0012995D^2H + 0.0065638D^3$ ..	14.27	0.9713	2.5780	8.5458	852.56	14.257
3	$V = -1.036801 + 0.026605D^2 + 0.017239H + 0.001973D^2H$	13.78	0.9736	1.4619	8.5458	612.52	11.475
4	$V = 0.034371 + 0.002368D^2H$ ..	13.69	0.9734	1.4638	8.5458	1861.62	11.727

APPENDIX—II.

Total volume overbark arranged by five foot height classes in cubic feet.

Diameter class (inches)	Height Classes (Feet)															No. of trees forming valid data.
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	
2	.129	.176	.224	.271												..
3	.247	.354	.461	.567	.674	.780										..
4			.792	.982	1.17	1.36	1.55	1.74	1.93							3
5					1.81	2.11	2.40	2.70	2.99	3.29	3.59					17
6							3.44	3.87	4.30	4.72	5.15	5.58	6.00			17
7							4.68	5.36	5.84	6.42	7.00	7.58	8.16	8.74		20
8									7.61	8.37	9.13	9.89	10.6	11.4		20
9									9.62	10.6	11.5	12.5	13.5	14.4	15.4	14
10									11.9	13.1	14.2	15.4	16.6	17.8	19.0	7
11										15.8	17.2	18.7	20.1	21.5	23.0	6
12										18.8	20.5	22.2	23.9	25.6	27.3	1
13										22.0	24.0	26.0	28.0	30.0	32.0	..
14										25.6	27.9	30.2	32.5	34.8	37.2	..
15										29.3	32.0	34.7	37.3	40.0	42.7	..

(*i*) No. of trees used : 105
(*ii*) Block indicate the extent of basic data.
(*iii*) Derived from regression equation : $V = 0.034371 + 0.002368D^2H$
Where V = Volume in cubic feet.
H = Total height in feet and
D = Diameter at breast height in inches.
(*iv*) Correlation coefficient : 0.9734
(*v*) Standard error in percentage : 13.69
(*vi*) Mean tree volume : 8.5458

APPENDIX—III

Regression equations showing relationship between diameter and total height with their relative indices of precision.

Serial No.	Regression equations		Standard error of mean height in percent (feet)	Correlation co-efficient (R/r)	Mean trees height (feet)	Chi square
1	$\log H = 0.681432 + 2.079555 \log D - 0.933473 (\log D)^2$	..	6.31	0.8961	58.84	24.203
2	$H = \frac{D^2}{1.606627 - 0.021877D + 0.014368D^2}$		60.80	0.9838	58.84	6227.207
3	$H = 30.65413630 + 3.827361D$	..	7.34	0.8499	58.84	32.850
4	$H = -1.382774 + 12.780698D - 0.589326D^2$	..	6.39	0.8934	58.84	24.233

APPENDIX-IV

LOCAL VOLUME TABLE OVERBARK FOR POPULUS NIGRA.

Diameter class (inches)	Estimated height (feet)	Total volume over bark (cft.)
2	17	.195
3	29	.652
4	39	1.51
5	48	2.88
6	54	4.64
7	59	6.88
8	63	9.58
9	65	12.50
10	67	15.90
11	68	19.50
12	69	23.60
13	69	27.60
14	69	32.10
15	69	36.80