FULL TREE WEIGHT EQUATIONS AND TABLES FOR SELECTED CENTRAL HARDWOODS

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ABSTRACT

Full tree weight equations are reported for four central hardwood species or species group. Forty trees representing a wide range in diameter for each species were felled and measurements taken for the volume of the merchantable bole and the weight of the topwood. Discs were taken from the bole and topwood to determine the weight/volume ratios. The ratios were then applied to field data to obtain total tree green weight with bark.

A regression analysis was used to develop equations for predicting weight. Twenty trees were used to derive the models and twenty trees were used for testing. The coefficients for the non-linear predicting equations presented are based on forty trees for each species.

Black oak	$GWBTT = .2112\ D^{2.154}H^{.911}$
White oak	$GWBTT = 1.6402\ D^{2.199}H^{.406}$
Red oak	$GWBTT = .06375\ D^{2.285}H^{1.099}$
Hickory	$GWBTT = .784\ D^{1.86}H^{.813}$

where GWBTT is total tree green weight above stump height, including bark and leaves, D is DBH in inches and H is total tree height in feet.

INTRODUCTION

Tables for determining volume and weight of the total tree have not been available for southern Illinois. With the advent of total tree chipping and weight scaling such tables will be necessary for forest

management. Both weight scaling and total tree chipping are practices which are currently utilized on a limited basis in the southern Illinois region.

Field work on this project commenced on May 15, 1975, with the following objectives:

1. To develop equations and tables giving total-tree volume and weight for upland hardwoods in southern Illinois.

2. To field test models developed with independent samples to determine accuracy of weight and volume equations.

Tree Measurement

On the Shawnee National Forest, forty trees in the small, medium and large DBH classes were selected from each of four species (white oak, Quercus alba L.; northern red oak, Quercus rubra L.; black oak Quercus velutina Lam.; hickory, Carya spp.). Trees were from a mixed hardwood stand on a lower, middle and upper slope with a generally southern aspect. Table 1 shows the number of trees that were sampled.

Table 1. Size class distribution of sample trees.

DBH Range (Inches)	Number of Trees			
	White Oak	Red Oak	Black Oak	Hickory
5-10.0	14	15	14	18
11-17.9	13	14	13	19
18+	13	11	13	3
Total	40	40	40	40

DBH was measured to the nearest 1/10 inch and trees were felled at a stump height of approximately one foot. Diameter inside bark (dib) measurements were made at 8.5 foot intervals along the merchantable stem to the 4-inch dib point. Merchantable and total length of the felled tree were measured to the nearest foot. The merchantable stem is as defined in FSH 2409.24 R9 timber sale preparation handbook. All material other than the merchantable stem was weighed on a portable scale. The material was segregated into three categories: less than two inches diameter (including leaves); 2-4 inches; and greater than 4 inches diameter. One-inch discs were removed, numbered, and transported to the laboratory to determine weight: volume ratios. Four discs were taken at 8.5 foot intervals along the main stem and six discs were taken from the top (three at 4-inches dib and three at 2-inches dib).

In the laboratory discs were weighed with bark and without bark. Disc volume was measured in a xylometer. Discs were then oven-dried for 48 hours and weighed. Weight was recorded to the nearest 0.1 gram and volume determined to the nearest cubic centimeter. Approximately 400 discs from each species were used to compute average weight-volume ratios.

Volume of the merchantable stem was computed from Smalian's formula (Husch 1972). Volume was converted to weight from the average disc ratio:

$$GWM = MV \times \frac{gwb}{gv}$$

where GWM is green weight of merchantable stem, MV is merchantable volume, gwb is disc green weight with bark, and gv is disc green volume.

Total tree weights were determined by adding top and bole weights:

$$GWB = GWM + GWT$$

where GWB is total tree green weight, GWM is green weight of merchantable stem, and GWT is green weight of top.

Model Development

The data for each species was divided into two sets. Half the data was used to develop models relating green weight to DBH and height, and the other half for testing, although final predictive equations utilized data from all 40 trees for each species. In order to select the most suitable model, a series of tests were conducted. Two tests were for equation fit and two were applied to the random sub-set of data to evaluate equation performance. These tests are described by Polak (1975). Tests were made only for Black Oak. The following models were evaluated:

$$GWBTT = bD^2$$

$$GWBTT = a + bD^2$$

$$GWBTT = bD^2H$$

$$GWBTT = a + bD^2H$$

$$\text{Log } GWBTT = a + b \text{ Log } D$$

$$\text{Log } GWBTT = a + b \text{ Log } D^2H$$

$$GWBTT = aD^b$$

$$GWBTT = aD^bH^c$$

where GWBTT is total tree green weight above stump (lbs.) including bark and leaves, D is tree DBH (in.), H is tree height (ft.) and a, b, c are regression constants.

The non-linear model:

$$GWBTT = aD^bH^c$$

tested as most satisfactory for predicting green weight. In this model GWBTT is green weight in pounds including bark and leaves for the total tree above stump height, D is DBH in inches, H is total tree height in feet.

Utilizing the 40 trees for each species the following predictive equations were derived.

Species	Equation	Standard error of estimate	Standard error of estimate as percent of predicted mean
Black oak	$GWB = 0.2127\ D^{2.153}H^{0.91}$	403.66	10.16
Red oak	$GWB = 0.0637\ D^{2.2853}H^{1.0988}$	447.16	13.0
White oak	$GWB = 1.3426\ D^{2.2409}H^{0.4275}$	779.78	19.0
Hickory	$GWB = 0.7840\ D^{1.86}H^{.8127}$	567.88	18.78

The following tables present total tree green weight in pounds by species, total tree height and DBH.

From this study a total of 56 equations were developed. These equations provide estimates of green weight, oven-dry weight and volume in English and metric units for the total tree, and to a 2- and 4-inch top for each species. These equations and tables are presented by Stortz (1975).

DISCUSSION

In examining the final equations, the diameter and height coefficients showed similar trends for red oak, black oak, and hickory. The height variable for white oak had less effect in prediction than did height for the other three species.

In applying these equations to new areas, an applicability check should be done to see if different site conditions cause large differences in volume and weight. Studies should be done to see if more variance exists between species than within a species for total tree weight and volume. Additional studies should be conducted for total tree weight and volume of other tree species. Future forest management will rely on total-tree volume and weight tables.

Table 2. Full tree green weight in pounds for white oak.

DBH Class Inches	Total Tree Height - Feet							
	40	48	56	64	72	80	88	96
6	360	389	416	440	463	484	504	523
8	686	742	792	839	882	923	961	998
10	1131	1223	1306	1383	1455	1522	1585	1645
12	1703	1841	1966	2082	2189	2290	2385	2476
14	2405	2600	2778	2941	3093	3235	3370	3497
16	3245	3508	3747	3967	4172	4364	4545	4718
18	4225	4567	4878	5165	5432	5682	5918	6143
20	5350	5784	6178	6541	6878	7195	7495	7779
22	6624	7161	7649	8098	8516	8909	9279	9631
24	8050	8703	9296	9842	10350	10827	11277	11705
26	9632	10413	11122	11775	12384	12954	13493	14004
28	11372	12294	13131	13903	14621	15294	15931	16534
30	13273	14349	15327	16227	17066	17852	18594	19299

Table 3. Full tree green weight in pounds for red oak.

DBH Class Inches	Total Tree Height - Feet							
	40	48	56	64	72	80	88	96
6	220	269	318	369	420	472	524	576
8	425	519	615	712	811	910	1011	1112
10	708	865	1025	1187	1351	1516	1684	1853
12	1074	1312	1554	1800	2049	2300	2554	2811
14	1528	1866	2211	2561	2914	3272	3634	3998
16	2073	2533	3000	3474	3955	4440	4930	5425
18	2713	3315	3927	4548	5176	5812	6453	7101
20	3452	4218	4996	5786	6586	7394	8210	9034
22	4292	5244	6212	7194	8188	9193	10208	11233
24	5236	6398	7579	8777	9990	11216	12454	13704
26	6288	7682	9101	10539	11995	13467	14954	16455
28	7448	9100	10780	12484	14209	15953	17714	19492
30	8720	10655	12621	14616	16635	18677	20740	22820

Table 4. Full tree green weight in pounds for black oak.

DBH Class Inches	Total Tree Height - Feet							
	40	48	56	64	72	80	88	96
6	289	341	392	443	493	543	592	640
8	536	633	729	823	916	1008	1100	1190
10	868	1024	1179	1331	1482	1631	1778	1925
12	1285	1517	1746	1971	2194	2415	2634	2851
14	1791	2115	2433	2747	3058	3366	3671	3973
16	2388	2819	3244	3663	4077	4487	4894	5297
18	3078	3633	4180	4720	5254	5783	6307	6827
20	3862	4559	5245	5923	6593	7256	7913	8565
22	4742	5597	6440	7272	8095	8909	9716	10517
24	5719	6751	7767	8771	9763	10745	11718	12684
26	6794	8021	9228	10420	11599	12766	13923	15070
28	7970	9408	10825	12223	13606	14975	16331	17677
30	9247	10915	12559	14181	15785	17373	18947	20508

Table 5. Full tree green weight in pounds for hickory.

DBH Class Inches	Total Tree Height - Feet							
	40	48	56	64	72	80	88	96
6	440	510	578	645	709	773	835	896
8	751	872	988	1101	1212	1320	1427	1531
10	1138	1320	1496	1668	1836	2000	2161	2319
12	1598	1853	2101	2342	2577	2807	3034	3256
14	2129	2469	2799	3120	3433	3740	4041	4337
16	2729	3165	3588	3999	4401	4795	5181	5560
18	3398	3941	4467	4979	5479	5969	6450	6923
20	4134	4794	5434	6057	6666	7262	7847	8422
22	4936	5724	6489	7232	7959	8670	9369	10055
24	5803	6730	7629	8503	9357	10194	11015	11822
26	6735	7811	8853	9868	10860	11831	12783	13720
28	7731	8966	10162	11327	12465	13579	14673	15748
30	8790	10193	11554	12878	14172	15439	16682	17905

LITERATURE CITED

Husch, B., C. I. Miller and T. W. Beers. 1972. Forest mensuration, 2nd Ed. Ronald Press, N.Y. 410 pp.

Polak, D. 1975. Model selection, using Quercus velutina Lam., volume and weight tables of four upland hardwood taxa in southern Illinois. M.S. Thesis, Southern Illinois University, Carbondale. 32 pp.

Stortz, L. 1975. Total tree volume and weight equations and tables for four upland hardwoods in southern Illinois. M.S. Thesis, Southern Illinois University, Carbondale. 96 pp.

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