United States
Department of
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North Central
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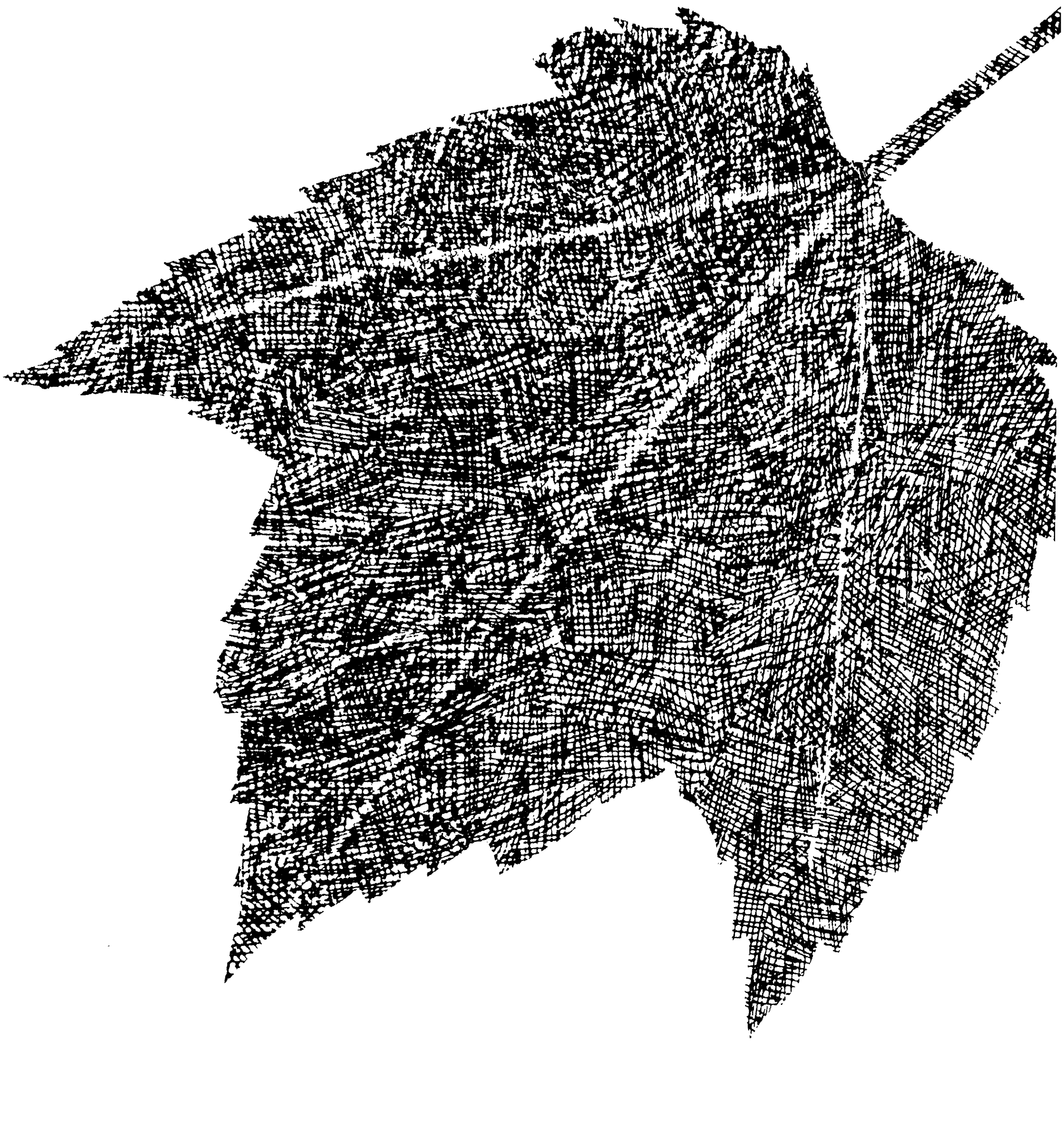
Research
Paper NC-242

Weight and Volume Equations and Tables for Red Maple in the Lake States

T. R. Crow and G. G. Erdmann



Crow, T. R.; Erdmann, G. G.
Weight and volume equations and tables for red maple in the Lake States. Res. Pap. NC-242. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1983. 14 p.

Weight and volume information based on regional sampling are provided for red maple in the Lake States. Both green weight and dry weight values are presented for biomass. Volume equations predict total stem volume, volume to 8-inch top, and volume to 4-inch top, inside and outside bark.

KEY WORDS: *Acer rubrum,* biomass, total tree weight, component weight, stand weight, stem volume.

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication February 14, 1983
December, 1983

WEIGHT AND VOLUME EQUATIONS AND TABLES FOR RED MAPLE IN THE LAKE STATES

T. R. Crow, *Research Ecologist,*
Rhinelander, Wisconsin,
and G. G. Erdmann, *Silviculturist*
Marquette, Michigan

Red maple (*Acer rubrum* L.) is a common component of second-growth forests in the Lake States. In Michigan's Upper Peninsula, it is second only to sugar maple (*Acer saccharum* L.) in terms of standing volume, and it is an important resource on more than 1 million acres of commercial forest in the region.

Changing patterns of utilization have resulted in the need for mensurational information expressed as weight or biomass (Young 1974). In addition, more traditional mensurational units such as volume need to be derived for various standards of utilization. Although regression equations are available for predicting biomass of many hardwood species including red maple, most of these predictive equations are based on limited sample numbers and sample sites. Nothing in the theory of regression analysis suggests that these equations can be applied elsewhere—they are valid for regional application only if they are based on regional sampling.

As part of a program in growth and yield research in northern hardwoods, volume and biomass information are presented here for red maple. The study objective was to predict weight and volume for red maple stands and individual trees across a range of stand ages and site qualities. The scope of the research included:

(1) developing regression estimators for whole-tree and component weights and volumes for red maple and comparing these estimators among sites;

(2) preparing weight tables from regression equations for the total tree and its components by d.b.h. and total height classes; and

(3) predicting stand weights from measurements such as basal area and mean stand height.

METHODS

To provide a regional framework for predicting red maple weight and volume, sample sites were selected in Michigan and Wisconsin that represented the population of even-aged hardwood forests in the Lake States. Six sample stands, each dominated by red maple, were selected as closely as possible to the following age and site index (at age 50) specifications:

Stand age (years)	Site index (SI)
40	≤45
70	≤45
40	50–55
70	50–55
40	≥60
70	≥60

Sugar maple was a common associate of red maple on all sites. In the 70-year-old stands, beech (*Fagus grandifolia* Ehrh.), yellow birch (*Betula alleghaniensis* Britton), basswood (*Tilia americana* L.), and hemlock (*Tsuga canadensis* (L.) Carr) were also common components. Other species frequent to the 40-year-old stands include black cherry (*Prunus serotina* Ehrh.), pin cherry (*Prunus pensylvanica* L.), paper birch (*Betula papyrifera* Marsh.), and aspen (*Populus tremuloides* Michx).

Within a sample stand, all red maple were numbered and d.b.h. measured and recorded. The numbered trees were partitioned into five d.b.h. classes (minimum diameter = 10 cm d.b.h.), with each class having an equal number of stems. Within a class, five trees were randomly selected for destructive sampling, thus providing 25 trees per site for a total of 150 samples in the study (table 1.)

The procedures used to sample biomass of individual trees have been presented elsewhere (Crow 1983). Total tree in our paper refers to aboveground weight and is the sum of live canopy, dead branches, bole, and stump. Total canopy includes live branches and leaves but excludes dead branches.

Weight/tree dimension relations were expressed in the linear form of the allometric equation: $\ln Y = a + b(\ln X) + \ln \epsilon$. D.b.h. and D^2H (D.b.h. squared times total height) were the independent variables; green weight and dry weight were the dependent variables. Both English and metric units are provided. Analysis of covariance was used to determine if significant differences existed among sets of allometric equations representing the six sites (Snedecor and Cochran 1967).

Standardized curves were also developed for each stand age (40 and 70 years) using dummy variables in a multiple regression to control spacing (Jacobs and Cunia 1980, Draper and Smith 1981).

By fitting

$$\ln Y = \ln B_0 + B_1 \ln X + \alpha_1 \ln Z_1 + \alpha_2 \ln Z_2 + \ln \epsilon,$$

where $(\ln Z_1, \ln Z_2) = (1,0)$ for SI ≤ 45

$(\ln Z_1, \ln Z_2) = (0,1)$ for SI 50-55

$(\ln Z_1, \ln Z_2) = (0,0)$ for SI ≥ 60

and substituting for the three sets of values for $\ln Z_1$ and $\ln Z_2$, three curves with the same slope but different intercepts are obtained. Uniform spacing among intercepts is obtained by regressing the intercept with site index and using the estimated intercepts in the standardized curves.

A set of asymptotic regressions is also calculated using the model, $Y = \alpha + B_P{}^Z$,

where: Y is the dependent variable that approaches an asymptotic limit as Z approaches infinity;
α represents the asymptotic values of Y;
B represents the total change in Y as Z passes from 0 to +;
P represents the factor by which the rate of change in Y reduces as Y approaches its asymptote; and
Z is the independent variable.

Schwandt's (1979) procedures for estimating the vector parameters for asymptotic regression were used to simultaneously fit the curves.

For volume predictors, two additional sampling locations were added to the six sites previously mentioned. The additional sites, both located in Michigan, included a SI = 61, 50-year-old stand and a SI = 63, 53-year-old stand. Volumes were predicted using the linear form of the allometric equation and a simple linear model with D.B.H., D.B.H.^{2}, and D^2H as the independent variables.

APPLICATION OF EQUATIONS

Differences in stand age and site index did not result in significant differences in biomass or volume equations. Regardless of the independent or dependent variable tested, no statistical differences were found at the $P \leq 0.05$ level in regression slopes or intercepts among the sample sites (Crow 1983).

These results indicate that a general biomass predictor is valid for red maple within the range of data tested (table 1). Because the sample sites represent the range of site and stand conditions for red maple in the Lake States, the general predictors are recommended for regional inventories within the Lake States (table 2). Application of a general predictor to a specific site or application outside the sample region, however, could result in substantial bias.

The error associated with weight estimates did differ substantially among components (table 2). Total tree weight or bole weight can be estimated with greater confidence than canopy weight.

Although differences among the D^2H predictors were statistically nonsignificant using the test criterion $P \leq 0.05$, plots of individual curves often indicated consistent trends among equations that were correlated to site index and stand age (fig. 1). This consistency suggests that for specific sites, greater accuracy can be obtained by including site quality and stand age in the predictive model. Under the assumption that a larger sample size would result in uniform spacing among curves in figure 1, the original equations for total weight/D^2H have been "standardized" using dummy variables to control spacing. When applying these predictors, simply select a table based on the weight units (English or metric, green weight or dry weight) and select the predictor that most closely represents your sample population in terms of stand age and site quality. Total tree weights are given in the following tables:

Table 3—green weight-metric, stand age~40 years,
Table 4—green weight-metric, stand age~70 years,
Table 5—dry weight-metric, stand age~40 years,

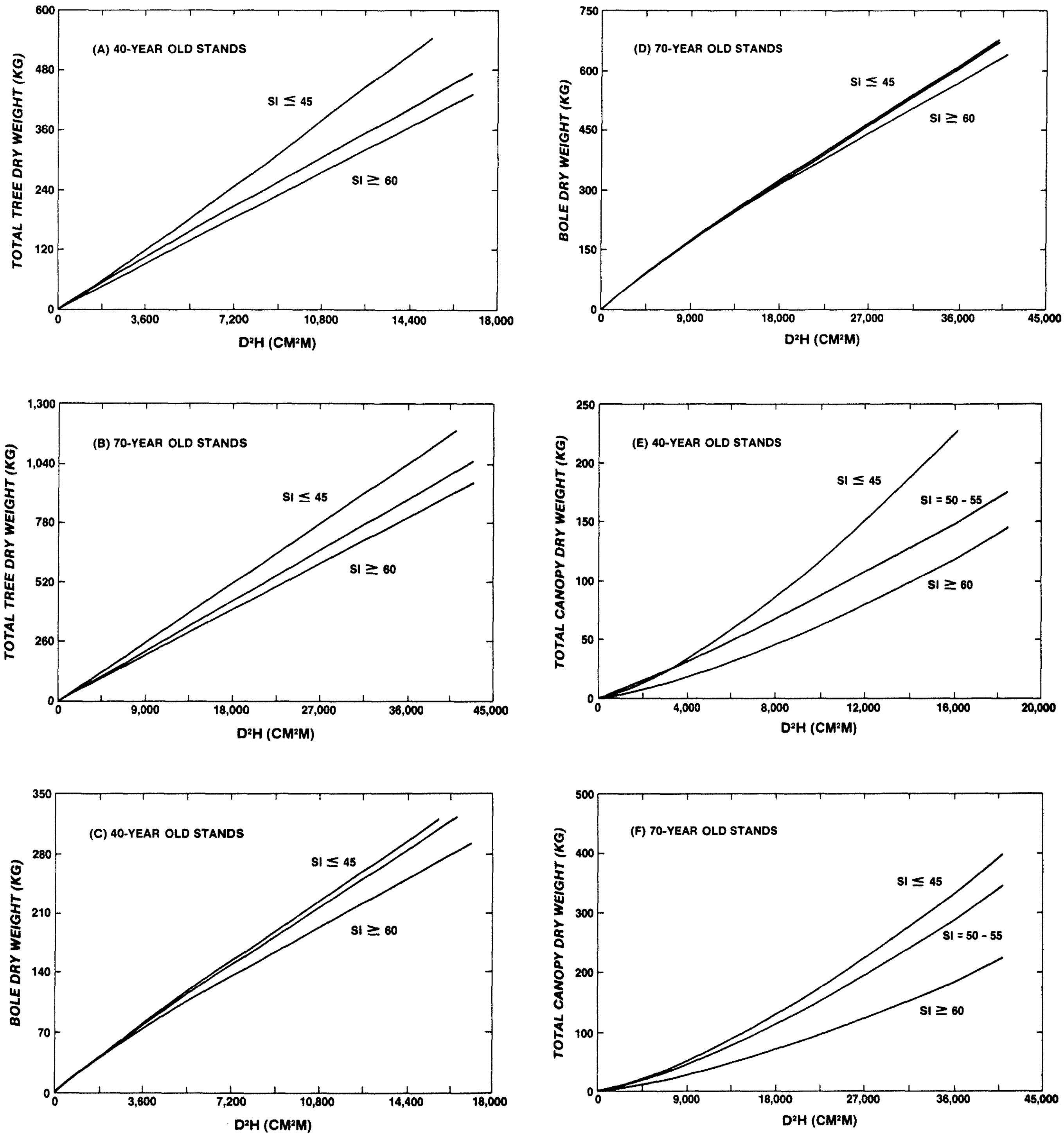


Figure 1.—*Comparison of allometric relation between D^2H and (A) total tree dry weight for 40-year-old stands; (B) total tree dry weight for 70-year-old stands; (C) bole dry weight for 40-year-old stands; (D) bole dry weight for 70-year-old stands; (E) canopy dry weight for 40-year-old stands; and (F) canopy dry weight for 70-year-old stands.*

Table 6—dry weight-metric, stand age~70 years,
Table 7—green weight—English, stand age~40 years,
Table 8—green weight—English, stand age~70 years,
Table 9—dry weight—English, stand age~40 years,
Table 10—dry weight—English, stand age~70 years.

With d.b.h.-dry weight as the variables, differences among sites were so small (fig. 2) that the individual curves provided little additional resolution and the common regression in table 2 was used to generate the values in table 11.

The term forest residuals applies to recoverable and usable materials left in the forest following harvest. Equations presented in table 12 can be used to

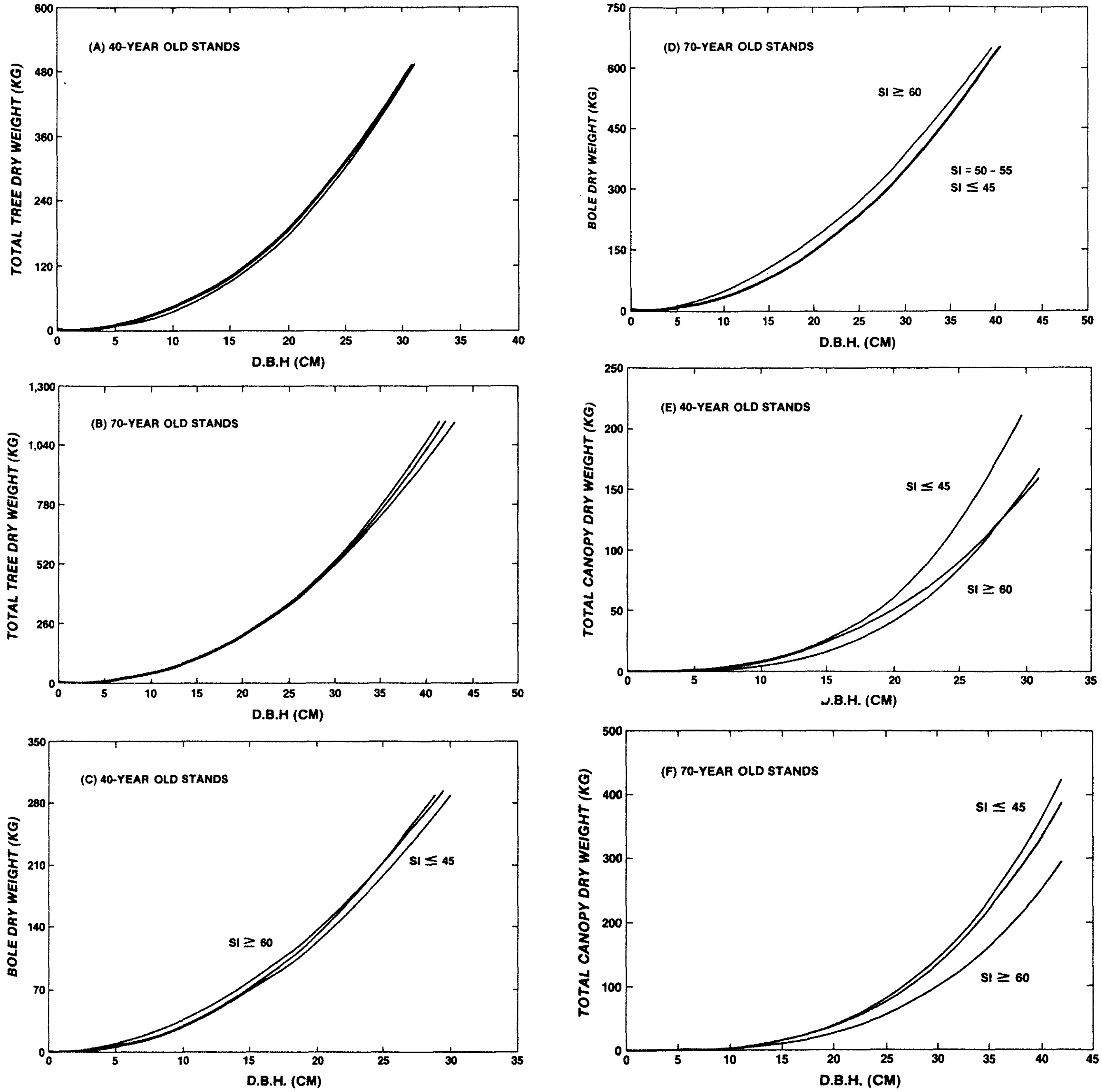


Figure 2.—*Allometric relations between d.b.h. and (A) total tree dry weight for 40-year-old stands; (B) total tree dry weight for 70-year-old stands; (C) bole dry weight for 40-year-old stands; (D) bole dry weight for 70-year-old stands; (E) total canopy for 40-year-old stands; and (F) total canopy for 70-year-old stands.*

predict residual green weight above a 4-inch top, including canopy weight.

The percentage of total weight represented by residual material differs greatly with tree size (fig. 3). The percentage of residual weight declines rapidly as tree size increases and it becomes constant at 22-24 percent in the 18 to 26 cm d.b.h. range. The increase observed for the largest size classes reflects the two-aged nature of most second-growth hardwood stands. The second-growth stands originated in most part from commercial clearcuts in which a number of smaller stems or culls were not cut. As dominants in the new stand, these residual trees often developed large crowns and thus have large residual weights. On the average, approximately a 30 percent increase in harvest yield would result for red maple if residual weight is harvested along with merchantable weight (above 1-foot stump to a 4-inch top) in a full-tree harvest.

In addition to estimates of individual tree weight, weight yields can be estimated from stand measurements. Stand weights were estimated as a function of stand basal area (B) and average total stand height (H), and were expressed as a composite index (BH) in a linear regression (fig. 4). Stand estimates were derived by summing individual tree estimates on 32-1,000 m^2 plots located on the six sample sites. Individual tree regressions developed in our study were applied to red maple. Published regressions were utilized for the other species (Zavitkovski 1971, Crow 1977). From estimates of total stand weight (dry

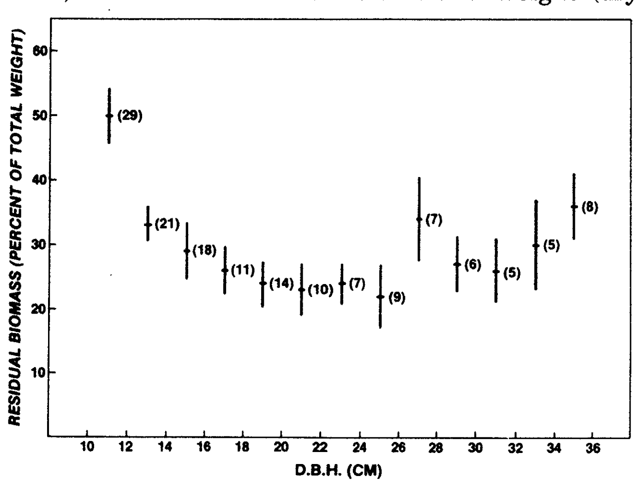


Figure 3.—*Residual biomass as a percentage of total aboveground biomass presented as mean with ± 1SD by diameter class (e.g. ⩾ 10 < 12 cm d.b.h....). Values in parentheses represent number of samples in diameter class. Residual biomass is defined as tops above 4-inch diameter inside bark, branches, and foliage.*

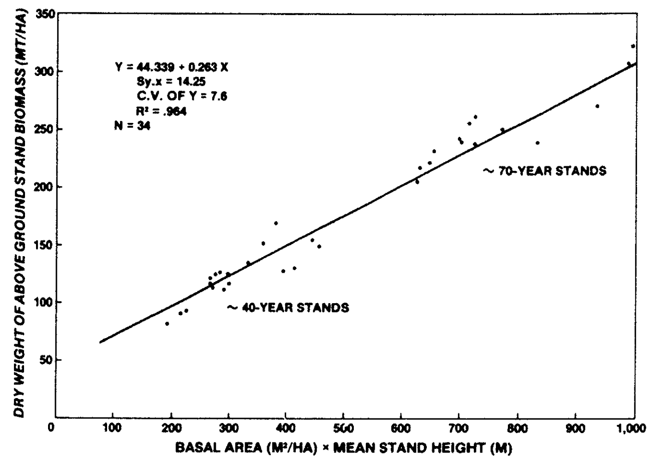


Figure 4.—*Stand dry weight expressed as a linear function of mean stand height and stand basal area for forests dominated by red maple.*

weight of stump, bole, and canopy), estimates of merchantable stem weight to various top diameters (inside bark) can be obtained by applying the ratios of merchantable weight:total weight presented in figure 5. These asymptotic equations estimate the proportions of merchantable weight as a function of average stand diameter and merchantable top diameter.

For example, a stand with 35 m^2/ha (152 ft^2/a) of basal area and a mean height (based on dominants and codominants) of 21 m (69 ft) has an estimated aboveground stand weight equal to 238 mt/ha (aboveground stand dry weight = 44.339 + 0.263 (735) om figure 4). Given an average stand diameter of 8.5 inches and a 4-inch utilization limit, the ratio of merchantable weight to total dry weight obtained in figure 5 is 0.66. Thus, 0.66 x 238 = 157 mt/ha (70 short tons/a) represents the merchantable dry weight of the stand.

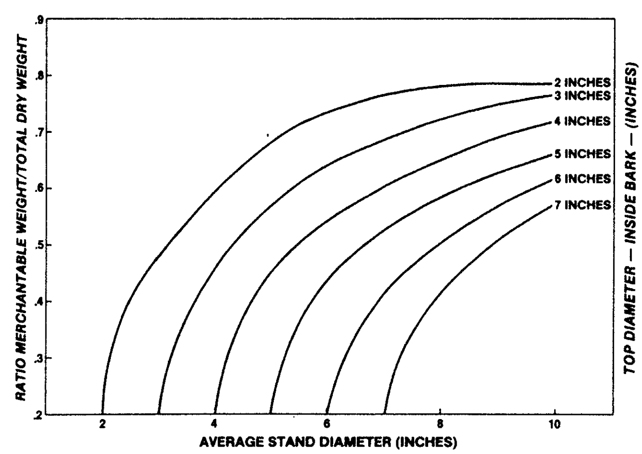


Figure 5.—*The ratio of merchantable weight to total aboveground dry weight expressed as a function of average stand d.b.h. and top diameter inside bark.*

Regression equations for estimating volume did not differ significantly among the sample sites, and thus a single predictor was developed for all sites. Stem volume inside bark and outside bark as well as volume inside bark to 8-inch and 4-inch tops can be estimated using the equations in table 13. The equation for volume to an 8-inch top is based on a variable length stem. Volume estimates to a 4-inch top are based on full 100-inch sticks, with a minimum of 4-inches inside bark for the top 100-inch stick.

LITERATURE CITED

Beauchamp, J. J.; Olson, J. S. Corrections for bias in regression estimates after logarithmic transformation. Ecology 54: 1403-1407; 1973.

Crow, T. R. Biomass and production regressions for trees and woody shrubs common to the Enterprise Forest. In: The Enterprise, Wisconsin, Radiation Forest, Radioecological Studies. Washington, D.C: ERDA; 1977: 63-67.

Crow, T. R. Comparing biomass regressions by site and stand age for red maple. Can. J. For. Res. (in press.)

Draper, N.; Smith, H. Applied regression analysis. 2nd ed. New York: John Wiley and Sons; 1981. 709 p.

Jacobs, M. W.; Cunia, T. Use of dummy variables to harmonize tree biomass tables. Can. J. For. Res. 10: 483-490; 1980.

Schwandt, D. L. Asymptotic regression with vector parameters. Res. Note 28. L'Anse, MI: Michigan Technological University, Ford Forestry Center; 1979. 10 p.

Snedecor, G. W.; Cochran, W. G. Statistical Methods. 6th ed. Ames, IA: Iowa State University Press; 1967. 593 p.

Young, H. E. Growth, yield, and inventory in terms of biomass. In: Proceedings, IUFRO Biomass Studies, IUFRO Working Party S4.01-4. Vancouver, B.C: Aug. 20-24, 1973; Orone, ME: University of Maine; 1974: 1-9.

Zavitkovski, J. Dry weight and leaf area of aspen trees in northern Wisconsin. In: Forest Biomass Studies. Orono, ME: University of Maine; 1971: 193-205.

Table 1.—*Characteristics of sample stands and sample trees*

Stand location	Stand age	Site index[1]	Red maple	Other species	Sample trees—red maple: D.b.h. Mean	D.b.h. Range	Total height Mean	Total height Range
	Years		---*Stems/ha*---		---*cm*---		---*m*---	
Wetmore, MI	40	≤45	685	537	13.7	10.0-26.6	13.85	12.63-16.60
Sugar Bush, MI	40	50-55	564	412	13.7	10.0-24.6	13.83	12.23-15.90
Eagle River, WI	40	≥60	483	407	17.1	10.0-33.2	17.70	13.65-20.74
Rock River, MI	70	≤45	607	41	24.0	10.4-46.1	19.42	12.14-22.65
Argonne, WI	70	50-55	643	167	20.5	10.5-36.2	19.74	15.10-23.10
Silver Falls, MI	70	≥60	478	305	28.5	14.0-52.2	24.92	18.08-26.84

[1]Site Index—feet at age 50.

Table 2.—*General biomass predictors for red maple in the Lake States (regression model: $\ln Y = a + b\ln X$; ln = natural logarithms; N = 150; where Y = weight, X = d.b.h. or D^2H)*

Dependent variable	Independent variable	Intercept (a)	Slope (b)	r^2	$S_{y \cdot x}$[1]	Correction factor[2]
		Dry Weight-kilograms				
Total tree	D.b.h.(cm)	-1.721	2.334	0.98	0.116	1.007
Bole wood	D.b.h.	-1.833	2.234	.97	.152	1.012
Bole bark	D.b.h.	-3.207	1.985	.95	.186	1.017
Total bole	D.b.h.	-1.637	2.207	.97	.150	1.011
Leaves	D.b.h.	-3.288	1.540	.54	.569	1.173
Branches	D.b.h.	-4.899	2.831	.85	.479	1.120
Total canopy	D.b.h.	-4.385	2.701	.84	.471	1.116
Total tree	$D^2H(cm^2m)$	-3.008	.928	.98	.139	1.009
Bole wood	D^2H	-3.158	.898	.99	.104	1.005
Bole bark	D^2H	-4.404	.801	.97	.142	1.010
Total bole	D^2H	-2.943	.888	.99	.099	1.005
Leaves	D^2H	-3.648	.556	.44	.627	1.213
Branches	D^2H	-6.128	1.087	.79	.568	1.173
Total canopy	D^2H	-5.539	1.035	.77	.559	1.166
		Dry Weight-pounds				
Total tree	D.b.h.(inches)	1.245	2.334	.98	.116	1.007
Bole wood	D.b.h.	1.040	2.234	.97	.152	1.012
Bole bark	D.b.h.	-0.566	1.985	.95	.186	1.017
Total bole	D.b.h.	1.211	2.206	.97	.150	1.011
Leaves	D.b.h.	-1.062	1.540	.54	.569	1.173
Branches	D.b.h.	-1.469	2.831	.85	.479	1.120
Total canopy	D.b.h.	-1.077	2.701	.84	.471	1.116
Total tree	$D^2H(in^2ft)$	-1.545	.923	.97	.169	1.014
Bole wood	D^2H	-1.715	.894	.98	.135	1.009
Bole bark	D^2H	-3.038	.797	.96	.161	1.129
Total bole	D^2H	-1.513	.883	.98	.131	1.008
Leaves	D^2H	-2.434	.550	.43	.631	1.217
Branches	D^2H	-4.524	1.078	.77	.585	1.184
Total canopy	D^2H	-3.976	1.027	.76	.574	1.176
		Green Weight-kilograms				
Total tree	D.b.h.(cm)	-1.249	2.320	.99	.112	1.006
Total bole	D.b.h.	-1.123	2.177	.93	.239	1.029
Branches	D.b.h.	-4.712	2.885	.86	.464	1.112
Leaves	D.b.h.	-2.617	1.592	.58	.537	1.153
Total canopy	D.b.h.	-3.942	2.688	.85	.459	1.109
Total tree	$D^2H(cm^2m)$	-2.539	.924	.98	.127	1.008
Total bole	D^2H	-2.427	.878	.95	.204	1.021
Branches	D^2H	-6.005	1.113	.80	.550	1.161
Leaves	D^2H	-3.026	.579	.48	.597	1.192
Total canopy	D^2H	-5.096	1.031	.78	.546	1.158

(Table 2 continued on next page)

(Table 2 continued)

Dependent variable	Independent variable	Intercept (a)	Slope (b)	r^2	$S_{y \cdot x}$[1]	Correction factor[2]
		Green Weight-pounds				
Total tree	D.b.h.(inches)	1.705	2.320	.99	.112	1.006
Total bole	D.b.h.	1.697	2.177	.93	.239	1.029
Branches	D.b.h.	-1.232	2.885	.86	.464	1.112
Leaves	D.b.h.	-0.343	1.592	.58	.537	1.153
Total canopy	D.b.h.	-0.645	2.688	.85	.459	1.109
Total tree	$D^2H(in^2ft)$	-1.086	.920	.97	.154	1.018
Total bole	D^2H	-1.014	.875	.94	.216	1.023
Branches	D^2H	-4.385	1.104	.79	.567	1.172
Leaves	D^2H	-1.792	.573	.47	.603	1.196
Total canopy	D^2H	-3.537	1.023	.77	.561	1.168

[1]Standard error estimate in $\log_e$ form.
[2]Correction for bias inherent in applying logarithmic transformations; $\hat{Y}_{adj} = (\exp(a + b \cdot \ln x)) \cdot K$ (Beauchamp and Olson 1973).

Table 3.—*Total tree green weight of red maple trees (stand age ~ 40 years)*

(In kilograms)

D.b.h. (cm)	Total tree height (meters) 12	14	16	18	20	22
SI ≤ 45 EQUATION: Log$_e$ (total tree wt) = -2.888 + 0.975 Log$_e$ (D^2H)						
10	56	65	74	83	92	101
12	80	93	106	119	131	144
14	108	125	143	160	178	195
16	140	163	185	208	230	253
18	176	205	233	261	290	318
20	216	251	286	321	356	391
22	260	303	345	387	429	470
24	309	359	408	458	508	557
26	361	419	477	536	594	651
28	417	484	552	619	686	753
30	477	554	631	708	785	861
SI 50-55 EQUATION: Log$_e$ (total tree wt) = -2.933 + 0.975 Log$_e$ (D^2H)						
10	54	62	71	79	88	97
12	76	89	101	113	126	138
14	103	103	137	153	170	186
16	134	155	177	199	220	242
18	168	196	223	250	277	304
20	207	240	274	307	340	373
22	249	289	330	370	410	450
24	295	343	391	438	485	533
26	345	401	456	512	567	623
28	398	463	527	592	656	720
30	456	530	603	677	750	823
SI ≥ 60 EQUATION: Log$_e$ (total tree wt) = -2.978 + 0.975 Log$_e$ (D^2H)						
10	51	59	68	76	84	92
12	73	85	97	108	120	132
14	99	115	131	146	162	178
16	128	149	169	190	210	231
18	161	187	213	239	265	291
20	198	230	262	293	325	357
22	238	277	315	353	392	430
24	282	328	373	419	464	509
26	330	383	436	490	542	595
28	381	443	504	566	627	688
30	436	506	577	647	717	787

Table 4.—*Total tree green weight of red maple trees (stand age ~ 70)*

(In kilograms)

D.b.h. (cm)	Total tree height (meters) 16	18	20	22	24	26
SI ≤ 45 EQUATION: Log$_e$ (total tree wt) = -3.211 + 1.002 Log$_e$ (D^2H)						
14	128	145	161	177	193	209
16	168	189	210	231	252	273
18	213	239	266	293	319	346
20	263	295	328	361	394	427
22	318	358	397	437	477	517
24	378	426	473	521	568	615
26	444	500	556	611	667	723
28	515	580	644	709	774	838
30	592	666	740	814	888	963
32	673	758	842	927	1011	1095
34	760	856	951	1046	1142	1237
SI 50-55 EQUATION: Log$_e$ (total tree wt) = -3.286 + 1.002 Log$_e$ (D^2H)						
14	119	134	149	164	179	194
16	156	175	195	214	234	253
18	197	222	247	271	296	321
20	244	274	305	335	366	396
22	295	332	369	406	443	480
24	351	395	439	483	527	571
26	412	464	515	567	619	670
28	478	538	598	658	718	778
30	549	618	687	755	824	893
32	625	703	781	860	938	1016
34	706	794	882	971	1059	1148
SI ≥ 60 EQUATION: Log$_e$ (total tree wt) = -3.361 + 1.002 Log$_e$ (D^2H)						
14	111	124	138	152	166	180
16	145	163	181	199	217	235
18	183	206	229	252	275	298
20	226	254	283	311	339	368
22	274	308	342	376	411	445
24	326	366	407	448	489	530
26	382	430	478	526	574	622
28	444	499	555	610	666	722
30	509	573	637	701	765	828
32	580	652	725	798	870	943
34	655	737	819	901	983	1065

Table 5.—*Total tree dry weight of red maple trees (stand age ~ 40 years)*

(In kilograms)

D.b.h. (cm)	Total tree height (meters) 12	14	16	18	20	22
SI ≤ 45 EQUATION: Log_e(total tree wt) = -3.498 + 1.002 Log_e(D.b.h.²)(Ht)						
10	37	43	49	55	61	68
12	53	62	71	80	89	97
14	72	84	96	109	121	133
16	94	110	126	142	158	173
18	120	140	160	180	200	220
20	148	172	197	222	246	271
22	179	209	239	268	298	328
24	213	248	284	320	355	391
26	250	292	333	375	417	459
28	290	338	387	435	484	532
30	333	389	444	500	555	611
SI 50-55 EQUATION: Log_e(total tree wt) = -3.581 + 1.002 Log_e(D.b.h.²)(Ht)						
10	34	40	45	51	57	62
12	49	57	65	73	81	90
14	67	78	89	100	111	122
16	87	101	116	131	145	160
18	110	128	147	165	184	202
20	136	159	181	204	227	250
22	165	192	220	247	275	302
24	196	229	261	294	327	360
26	230	268	307	345	384	422
28	267	311	356	401	445	490
30	306	358	409	460	511	562
SI ≥ 60 EQUATION: Log_e(total tree wt) = -3.663 + 1.002 Log_e (D.b.h.²)(Ht)						
10	31	36	42	47	52	57
12	45	53	60	68	75	83
14	61	72	82	92	102	112
16	80	93	107	120	134	147
18	101	118	135	152	169	186
20	125	146	167	188	209	230
22	152	177	202	228	253	278
24	180	211	241	271	301	331
26	212	247	283	318	354	389
28	246	287	328	369	410	451
30	282	329	377	424	471	518

Table 6.—*Total tree dry weight of red maple trees (stand age ~ 70 years)*

(In kilograms)

D.b.h. (cm)	Total tree height (meters) 16	18	20	22	24	26
SI ≤ 45 EQUATION: Log_e(total tree wt) = -3.698 + 1.008 $Log_e(D^2H)$						
14	83	93	104	114	125	135
16	108	122	136	150	163	177
18	138	155	172	190	207	224
20	170	192	213	234	256	277
22	206	232	258	284	310	336
24	246	277	308	339	370	401
26	289	325	361	398	434	471
28	335	377	420	462	504	547
30	385	434	482	531	580	628
32	439	494	549	605	660	716
34	496	558	621	683	746	809
SI 50-55 EQUATION: Log_e(total tree wt) = -3.788 + 1.008 $Log_e(D^2H)$						
14	76	85	95	104	114	124
16	99	112	124	137	149	162
18	126	142	157	173	189	205
20	155	175	195	214	234	254
22	188	212	236	260	283	307
24	224	253	281	309	338	366
26	264	297	330	364	397	430
28	306	345	384	422	461	500
30	352	396	441	485	530	574
32	401	451	502	553	603	654
34	453	510	567	624	682	739
SI ≥ 60 EQUATION: Log_e(total tree wt) = -3.878 + 1.008 $Log_e (D^2H)$						
14	69	78	87	95	104	113
16	91	102	113	125	136	148
18	115	129	144	158	173	187
20	142	160	178	196	214	232
22	172	194	216	237	259	281
24	205	231	257	283	309	335
26	241	271	302	332	363	393
28	280	315	351	386	421	457
30	322	362	403	443	484	525
32	366	413	459	505	551	598
34	414	466	518	571	623	675

Table 7.—*Total tree green weight of red maple trees (stand age ~ 40 years)*

(In pounds)

D.b.h. (in)	Total tree height (feet): 30	35	40	45	50	55	60	65
SI ≤ 45 EQUATION: $\log_e(\text{total tree wt}) = -1.709 + 1.025 \log_e(D^2H)$								
2	24	29	33	37	41	46	50	54
4	101	119	136	154	171	189	206	224
6	233	273	313	353	393	433	474	514
8	420	492	564	636	709	782	855	928
10	663	777	891	1,005	1,120	1,235	1,350	1,466
12	964	1,129	1,295	1,461	1,628	1,795	1,962	2,130
14	1,323	1,549	1,776	2,004	2,233	2,462	2,691	2,921
16	1,739	2,037	2,335	2,635	2,935	3,237	3,539	3,841
SI 50-55 EQUATION: $\log_e(\text{total tree wt}) = -1.882 + 1.025 \log_e(D^2H)$								
2	21	24	28	31	35	38	42	45
4	85	100	115	129	144	159	174	188
6	196	229	263	297	331	365	399	433
8	353	414	474	535	596	657	719	780
10	558	654	749	846	942	1,039	1,136	1,233
12	811	950	1,089	1,229	1,369	1,510	1,650	1,791
14	1,112	1,303	1,494	1,686	1,878	2,071	2,264	2,457
16	1,463	1,713	1,964	2,216	2,469	2,723	2,977	3,231
SI ≥ 60 EQUATION: $\log_e(\text{total tree wt}) = -2.054 + 1.025 \log_e(D^2H)$								
2	17	20	23	26	29	32	35	38
4	72	84	96	109	121	134	146	159
6	165	193	221	250	278	307	336	364
8	297	348	399	451	502	554	605	657
10	470	550	631	712	793	875	956	1,038
12	683	800	917	1,035	1,153	1,271	1,390	1,508
14	937	1,097	1,258	1,419	1,581	1,743	1,906	2,069
16	1,232	1,442	1,654	1,866	2,079	2,292	2,506	2,720

Table 8.—*Total tree green weight of red maple trees (stand age ~ 70 years)*

(In pounds)

D.b.h. (in)	Total tree height (feet): 45	50	55	60	65	70	75	80
SI ≤ 45 EQUATION: $\log_e(\text{total tree wt}) = -1.519 + 0.978 \log_e(D^2H)$								
4	136	151	166	181	195	210	225	239
6	301	335	367	399	432	464	497	529
8	529	587	644	701	758	815	872	929
10	819	908	996	1,085	1,173	1,261	1,349	1,437
12	1,170	1,297	1,423	1,550	1,676	1,802	1,928	2,053
14	1,581	1,753	1,924	2,095	2,265	2,436	2,606	2,776
16	2,053	2,276	2,498	2,720	2,942	3,163	3,384	3,604
18	2,585	2,866	3,146	3,425	3,704	3,982	4,260	4,538
SI 50-55 EQUATION: $\log_e(\text{total tree wt}) = -1.609 + 0.978 \log_e(D^2H)$								
4	125	138	152	165	179	192	205	219
6	276	305	335	365	395	424	454	484
8	484	536	588	641	693	745	797	849
10	748	829	911	991	1,072	1,153	1,233	1,314
12	1,069	1,185	1,301	1,416	1,532	1,647	1,762	1,876
14	1,445	1,602	1,758	1,915	2,071	2,226	2,382	2,537
16	1,876	2,080	2,283	2,486	2,688	2,891	3,092	3,294
18	2,363	2,619	2,875	3,130	3,385	3,639	3,894	4,147
SI ≥ 60 EQUATION: $\log_e(\text{total tree wt}) = -1.699 + 0.978 \log_e(D^2H)$								
4	114	126	139	151	163	175	188	200
6	252	279	306	334	361	388	415	442
8	442	490	538	586	633	681	728	776
10	684	758	832	906	980	1,054	1,127	1,200
12	977	1,083	1,189	1,294	1,400	1,505	1,610	1,715
14	1,321	1,464	1,607	1,750	1,892	2,035	2,177	2,318
16	1,715	1,901	2,087	2,272	2,457	2,642	2,826	3,010
18	2,159	2,394	2,627	2,861	3,094	3,326	3,558	3,790

Table 9.—*Total tree dry weight of red maple trees (stand age ~ 40 years)*

(In pounds)

D.b.h. (in)	Total tree height (feet) 30	35	40	45	50	55	60	65
SI ≤ 45 EQUATION: Log_e (total tree wt) = −1.959 + 0.996 ln (D^2H)								
2	17	19	22	25	28	30	33	36
4	66	77	88	99	110	121	132	143
6	148	173	197	222	246	271	295	320
8	263	306	350	393	437	480	524	567
10	410	478	546	614	681	749	817	885
12	589	687	785	882	980	1,077	1,175	1,275
14	801	934	1,066	1,199	1,332	1,465	1,597	1,730
16	1,045	1,218	1,391	1,565	1,738	1,911	2,084	2,257
SI 50-55 EQUATION: Log_e (total tree wt) = −2.034 + 0.996 ln (D^2H)								
2	15	18	21	23	26	28	31	33
4	61	71	82	92	102	112	122	132
6	137	160	183	206	229	251	274	297
8	244	284	325	365	405	446	486	526
10	380	443	506	569	632	695	758	821
12	546	637	728	818	909	999	1,090	1,180
14	743	866	989	1,113	1,236	1,359	1,482	1,605
16	969	1,130	1,291	1,452	1,612	1,773	1,933	2,094
SI ≥ 60 EQUATION: Log_e (total tree wt) = −2.109 + 0.996 ln (D^2H)								
2	14	17	19	21	24	26	28	31
4	57	66	76	85	95	104	113	123
6	127	149	170	191	212	233	254	275
8	226	264	301	339	376	413	451	488
10	353	411	470	528	586	645	703	762
12	507	591	675	759	843	927	1,011	1,095
14	689	804	918	1,032	1,146	1,261	1,375	1,489
16	899	1,049	1,198	1,347	1,496	1,645	1,794	1,942

Table 10.—*Total tree dry weight of red maple trees (stand age ~ 70 years)*

(In pounds)

D.b.h. (in)	Total tree height (feet) 45	50	55	60	65	70	75	80
SI ≤ 45 EQUATION: Log_e (total tree wt) = −1.990 + 0.981 ln (D^2H)								
4	87	96	106	115	125	134	143	153
6	192	213	234	255	276	297	318	338
8	338	375	412	449	485	522	559	595
10	524	581	638	695	752	809	865	922
12	750	831	913	994	1,075	1,157	1,237	1,318
14	1,015	1,125	1,235	1,345	1,455	1,565	1,675	1,784
16	1,318	1,462	1,605	1,748	1,891	2,034	2,176	2,318
18	1,661	1,842	2,023	2,203	2,383	2,562	2,742	2,921
SI 50-55 EQUATION: Log_e (total tree wt) = −2.095 + 0.981 ln (D^2H)								
4	78	87	95	104	112	121	129	138
6	173	192	211	230	249	267	286	305
8	305	338	371	404	437	470	503	536
10	472	523	575	626	677	728	779	830
12	675	749	822	895	968	1,041	1,114	1,187
14	913	1,013	1,112	1,211	1,310	1,409	1,508	1,606
16	1,187	1,316	1,445	1,574	1,703	1,831	1,959	2,087
18	1,496	1,658	1,821	1,983	2,145	2,307	2,468	2,630
SI ≥ 60 EQUATION: Log_e (total tree wt) = −2.200 + 0.981 ln (D^2H)								
4	70	78	86	93	101	109	116	124
6	156	173	190	207	224	241	257	274
8	274	304	334	364	393	423	453	482
10	425	471	517	564	610	656	701	747
12	608	674	740	806	872	937	1,003	1,069
14	822	912	1,001	1,090	1,180	1,269	1,357	1,446
16	1,069	1,185	1,301	1,417	1,533	1,648	1,764	1,879
18	1,346	1,493	1,639	1,786	1,931	2,077	2,222	2,368

Table 11.—*Total tree weight—d.b.h. (N=150)*

Green weight[1]

Equations: $\log_e$ (total tree wt-kg) = -1.249 + 2.320 $\log_e$ (D.b.h.-cm)

$\log_e$ (total tree wt-lbs) = 1.705 + 2.320 $\log_e$ (D.b.h.-in.)

D.b.h.	Weight	D.b.h.	Weight
cm	*kg*	*in.*	*lbs*
10	60	4	138
12	92	5	231
14	132	6	353
16	179	7	505
18	236	8	689
20	301	9	905
22	375	10	1,156
24	459	11	1,442
26	553	12	1,765
28	657	13	2,125
30	771	14	2,524
32	896	15	2,962
34	1,031	16	3,440
36	1,177	17	3,960
38	1,334	18	4,522
40	1,503	19	5,126
42	1,683	20	5,774

Dry weight[1]

Equations: $\log_e$ (total tree wt-kg) = -1.721 + 2.334 $\log_e$ (D.b.h.-cm)

$\log_e$ (total tree wt-lbs) = 1.245 + 2.334 $\log_e$ (D.b.h.-in.)

D.b.h.	Weight	D.b.h.	Weight
cm	*kg*	*in.*	*lbs*
10	39	4	89
12	59	5	150
14	85	6	229
16	116	7	328
18	153	8	448
20	196	9	590
22	245	10	754
24	300	11	943
26	361	12	1,155
28	430	13	1,392
30	505	14	1,655
32	587	15	1,944
34	676	16	2,260
36	773	17	2,604
38	877	18	2,975
40	988	19	3,375
42	1,107	20	3,805

[1]Correction factors have been applied to weight estimates; K=1.007.

Table 12.—*Residual weight (green) assuming 4 inch top diameter inside bark; residue = canopy weight + bole weight above 4-inch top*

Stand age/SI	Equations[1]
Y = green weight (kg); X = d.b.h. (cm)[2]	
40 ≤ 45	lnY = -0.903 + 1.811 ln D.b.h.
40 50-55	lnY = 0.111 + 1.395 ln D.b.h.
40 ≥ 60	lnY = -1.264 + 1.909 ln D.b.h.
70 ≤ 45	lnY = -2.512 + 2.338 ln D.b.h.
70 50-55	lnY = -1.746 + 2.044 ln D.b.h.
70 ≥ 60	lnY = -4.385 + 2.801 ln D.b.h.
Y = green weight (kg); X = D^2H (cm^2m)[2]	
40 ≤ 45	lnY = -2.533 + 0.811 ln D^2H
40 50-55	lnY = -0.895 + 0.595 ln D^2H
40 ≥ 60	lnY = -2.555 + 0.786 ln D^2H
70 ≤ 45	lnY = -4.179 + 0.975 ln D^2H
70 50-55	lnY = -3.492 + 0.876 ln D^2H
70 ≥ 60	lnY = -6.769 + 1.190 ln D^2H

[1]ln = natural logarithms, base e.
[2]For conversion to English units:
kg x 2.2046 = pounds
cm x 0.3937 = inches
m x 3.2808 = feet

Table 13.—*Regression equations for estimating stem volume of red maples; Y = cubic volume in m³*

Equation[1]	r^2	$S_{yy \cdot x}$	Correction factor (K)[2]
Y = volume (m³) outside bark–total stem			
X = d.b.h. (cm)			
sample number (N) = 331			
$Y = -0.012 + 0.00075(X^2)$	0.92	0.085	
$\ln Y = -7.900 + 2.207(\ln x)$	.95	.207	1.022
Y = volume (m³) outside bark–total stem			
$X = D^2H$ (cm²m)			
N = 331			
$Y = 0.042 + 0.000031(X)$	.89	.097	–
$\ln Y = -9.403 + 0.910(\ln X)$	.95	.194	1.019
Y = volume (m³) inside bark–total stem			
X = d.b.h. (cm)			
N = 331			
$Y = -0.011 + 0.00067(X^2)$	.91	.075	–
$\ln Y = -8.210 + 2.271(\ln X)$	.93	.248	1.031
Y = volume (m³) inside bark–total stem			
$X = D^2H$ (cm²m)			
N = 331			
$Y = 0.037 + 0.000028(X)$	.90	.084	–
$\ln Y = -9.759 + 0.937(\ln X)$	.94	.236	1.028
Y = volume (m³) inside bark–above 1-ft stump to 8-inch top			
X = d.b.h. (cm)			
N = 84			
$Y = -0.181 + 0.000577(X^2)$	.86	.096	–
$\ln Y = -12.544 + 3.338(\ln X)$	.83	.277	1.038
Y = volume (m³) inside bark–above 1-ft stump to 8-inch top			
$X = D^2H$ (cm²m²)			
N = 84			
$Y = -0.108 + 0.000023(X)$	.86	.096	–
$\ln Y = -15.391 + 1.437(\ln X)$	.82	.289	1.042
Y = volume (m³) inside bark–above 1-ft stump to 4-inch top			
X = d.b.h. (cm)			
N = 262			
$Y = -0.037 + 0.000057(X^2)$	.92	.064	–
$\ln Y = -9.967 + 2.732(\ln X)$	.89	.319	1.052
Y = volume (m³) inside bark–above 1-ft stump to 4-inch top			
$X = D^2H$ (cm²m)			
N = 262			
$Y = 0.0052 + 0.000024(X)$	.93	.060	–
$\ln Y = -11.970 + 1.142(\ln X)$	.90	.308	1.048

[1] $\ln = \log_e$

[2] $Yadj = (\exp(a + b \cdot \ln X)) \cdot K$

U.S. GOVERNMENT PRINTING OFFICE:1984-765-557/5136