USDA FOREST SERVICE

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LOCAL NET TIMBER VOLUME EQUATIONS FOR WISCONSIN

ABSTRACT.—Describes a set of local net merchantable tree-volume equations for four regions of Wisconsin suitable for use on a digital computer.

OXFORD: 524.2(775):U681.3:524.b. KEY WORDS: forest inventory, digital computer.

As part of the 1969 forest inventory of Wisconsin, we developed local net merchantable tree volume equations for four regions of Wisconsin (fig. 1). These equations can be used on a digital computer by industrial foresters, consulting foresters, or others in need of quick net-volume-per-tree estimates where only species, diameter at breast height (d.b.h.), and tree class[1] are tallied. The equations were developed for both board-foot and cubic-foot volumes for two tree classes and several species groupings. These equations were used to compute tree volumes on that part of the Wisconsin forest survey sample where only tree d.b.h., species, and tree class were recorded.

Data collected from 20,662 trees went into the development of these volume equations. Measurements taken were tree class, d.b.h., merchantable height, and diameter at top of merchantability. For saw-log-sized trees (9.0 inches + d.b.h. for softwoods, 11.0 inches + for hardwoods), measurements were taken at both the saw log and pulpwood limits of merchantability. The field crews also measured and estimated the volume of cull material (both in cubic feet and board feet) in each tree.

The net volume in these trees was then calculated using equations developed by Robert N. Stone based on S. R. Gevorkiantz's USDA Forest Service Technical Bulletin 1104, "Composite Volume Tables for the Lake States." These equations compute gross volume in a tree from the three measurements — d.b.h., merchantable length, and diameter at the top of merchantability. This volume is then corrected for differences in bark thickness between species, and the field estimate of cull volume is subtracted to arrive at net volume. If while making a local cruise tree heights are tallied, it would be better to get bark thickness also and use either the tables in Technical Bulletin 1104 or Stone's equation.

Experience in working with volume-d.b.h. relationships suggested that the best mathematical model for this type of data was the "Gomperz" function, $Y = A \cdot B^{C^{D \cdot X}}$. Work with test deat confirmed this belief, and the model was used with part of the Wisconsin data, where the dependent variable Y is net volume and the independent variable X is d.b.h.

[1] *Forest Survey classifies live trees as either desirable, acceptable, rough, rotten, or short-log. Equations were prepared for the first two classes. Forest Survey defines "desirable" trees as live trees having no serious defects in quality limiting present or prospective use, and of relatively high vigor and containing no pathogens that may result in death or serious deterioration before rotation age. These are trees that would be favored by forest managers in silvicultural operations. "Acceptable" trees are live trees having no serious defects limiting present or prospective use but not qualifying as "desirable" due to presence of pathogens or damage that may affect quality. The great majority of the trees in Wisconsin were classed as "acceptable" with very few "desirable," so the forester wishing to use only one equation for woods-run material would be best advised to use the equation for "acceptable" trees.*

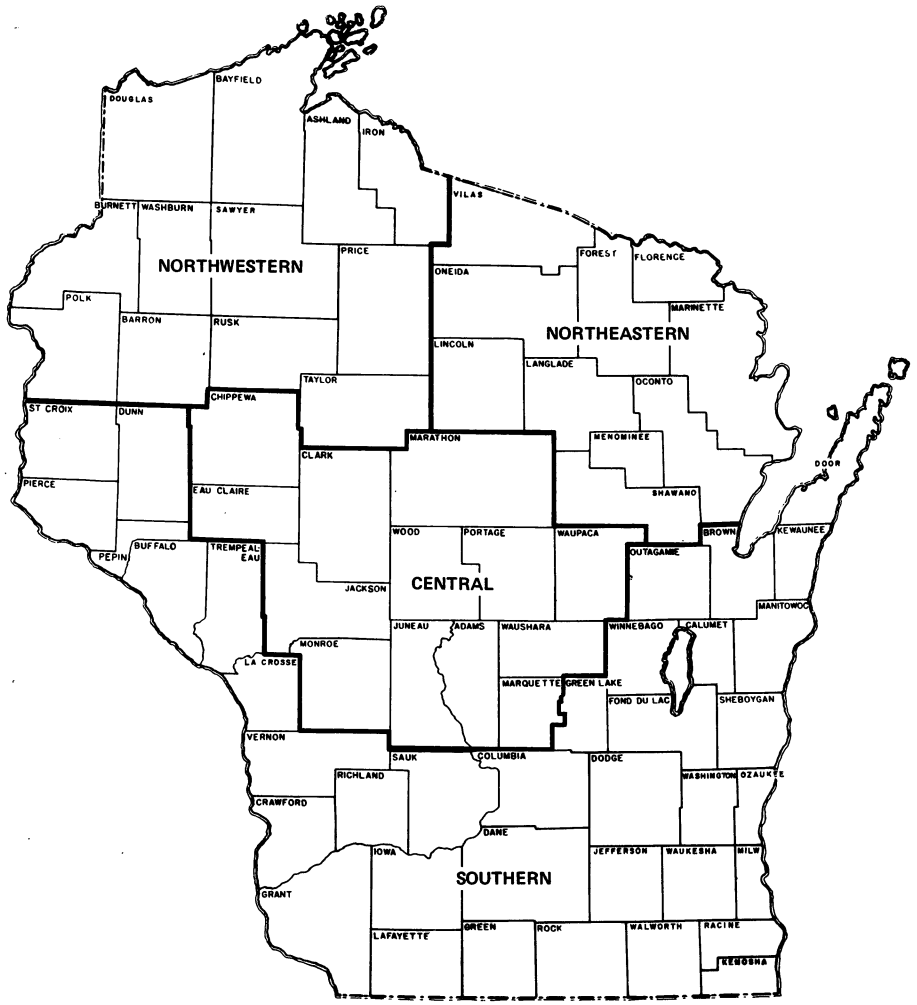

Figure 1. – Forest Survey units for which separate sets of equations were derived.

A set of these equations is available for each of the four survey units, two tree classes, and for both cubic and board feet. Within each set the equations are further broken down in species groupings. These groups were primarily determined by number of observations available for a group (a minimum number of observations is necessary to form an equation using least-squares estimate) and biological similarity of the species within a group. Tables 1 to 4 are an example of one set of tables of equations for northeastern Wisconsin. (There are four such sets of tables available.) The species included in the species groups are listed on page 4.

Table 1. – Cubic-foot volume regression coefficients for desirable trees, Northeastern Unit, Wisconsin, 1968

$$V = A \cdot B^{D \cdot DBH} \cdot C$$

Species group	Number of observations	Sampling error (Cu.ft.)	R^2	Coefficient A	B	C	D
1- 3	34	18	0.88	36,048	0.00004	1.1730	-0.1518
4-10	54	8	.97	385	.00011	1.3508	- .2868
11-14	27	7	.92	1,318	.00047	1.4621	- .1206
15-19	49	13	.97	25,157	.00004	1.1777	- .1559
20-24	91	3	.96	563	.00078	1.5500	- .1391
25-31	60	6	.97	538	.00054	1.2958	- .2497

Table 2. – Board-foot volume regression coefficients for desirable trees, Northeastern Unit, Wisconsin, 1968

$$V = A \cdot B^{C \cdot DBH} - D$$

Species group	Number of observations	Sampling error (Bd.ft.)	R^2	Coefficient A	Coefficient B	Coefficient C	Coefficient D
1- 3	33	130	0.83	257,232	0.000028	1.1713	-0.1504
4-10	36	54	.97	5,683	.000332	1.2757	- .2314
11-14	26	49	.86	42,345	.000136	1.1972	- .1711
15-20	43	92	.96	106,680	.000056	1.1828	- .1596
21-24	30	24	.92	11,165	.000365	1.2374	- .2042
25-31	30	61	.94	3,084	.000527	1.2934	- .2495

Table 3. – Cubic-foot volume regression coefficients for acceptable trees, Northeastern Unit, Wisconsin, 1968

$$V = A \cdot B^{C \cdot DBH} - D$$

Species group	Number of observations	Sampling error (Cu.ft.)	R^2	Coefficient A	Coefficient B	Coefficient C	Coefficient D
1	290	17	0.92	1,200	0.00041	1.2689	-0.2084
2	231	4	.95	127	.00039	1.8100	- .1884
3	199	2	.85	63	.00104	1.8881	- .2019
4- 5	165	2	.92	573	.00045	1.5710	- .1433
6	374	4	.49	591	.00043	1.5635	- .1418
7-10	722	5	.95	566	.00043	1.2905	- .2412
11-12	240	4	.93	777	.00087	1.4680	- .1239
13-14	107	2	.96	398	.00101	1.5270	- .1354
15	158	6	.92	118	.00019	1.8316	- .1926
16	606	7	.89	247	.00043	1.6664	- .1624
17	309	3	.93	715	.00066	1.4946	- .1291
18-21	237	6	.98	11,794	.00009	1.1839	- .1609
22-23	904	2	.93	144	.00148	1.7103	- .1696
24	933	2	.88	65	.00112	1.8973	- .2034
25-27	294	3	.97	774	.00056	1.5059	- .1307
28-31	349	8	.94	560	.00060	1.2886	- .23649

Table 4. – Board-foot volume regression coefficients for acceptable trees, Northeastern Unit, Wisconsin, 1968

$$V = A \cdot B^{C \cdot DBH} - D$$

Species group	Number of observations	Sampling error (Bd.ft.)	R^2	Coefficient A	Coefficient B	Coefficient C	Coefficient D
1	255	111	0.91	11,183	0.000244	1.2421	-0.2037
2	156	31	.88	4,303	.001038	1.2538	- .2153
3	86	15	.65	1,397	.000243	1.2173	- .1889
4-5	31	34	.74	769,248	.000005	1.1710	- .1502
6	71	15	.51	527,215	.000006	1.1734	- .1523
7	248	52	.90	6,558	.000309	1.2567	- .2173
8-10	141	28	.74	896	.000354	1.3632	- .2990
11-14	127	56	.59	17,587	.000528	1.1854	- .1618
15	94	65	.61	1,352	.000531	1.6772	- .1443
16	260	78	.70	1,439	.000201	1,3476	- .2837
17-20	138	50	.64	851	.003350	1.3218	- .2657
21-24	208	46	.92	4,977	.000430	1.2604	- .2211
25-31	212	82	.83	3,922	.000673	1.2642	- .2212

COMMON AND SCIENTIFIC NAMES for WISCONSIN SPECIES GROUPS

SOFTWOODS

1 White pine ..... *Pinus strobus*
2 Red pine ..... *Pinus resinosa*
3 Jack pine ..... *Pinus banksiana*
4 White spruce ..... *Picea glauca*
5 Black spruce ..... *Picea mariana*
6 Balsam fir ..... *Abies balsamea* var. *balsamea*
7 Hemlock ..... *Tsuga canadensis*
8 Tamarack ..... *Larix laricina*
9 Northern white-cedar ..... *Thuja occidentalis*
10 Other softwoods ..... *Juniperus virginiana*
Pinus sylvestris
All other softwoods

HARDWOODS

11 White oak ..... *Quercus alba*
Quercus bicolor
Quercus macrocarpa
Quercus muehlenbergii
Quercus prinus
12 Select red oak ..... *Quercus rubra*
Quercus shumardii
13 Other red oak ..... *Quercus coccinea*
Quercus ellipsoidalis
Quercus palustris
Quercus velutina
14 Hickory ..... *Carya cordiformis*
Carya glabra
Carya laciniosa
Carya ovata
Carya tomentosa
15 Yellow birch ..... *Betula alleghaniensis*
16 Hard maple ..... *Acer nigrum*
Acer saccharum
17 Soft maple ..... *Acer rubrum* var. *rubrum*
Acer saccharinum
18 Beech ..... *Fagus grandifolia*
19 Ash ..... *Fraxinus americana*
Fraxinus nigra
Fraxinus pennsylvanica
Fraxinus quadrangulata
20 Balsam poplar ..... *Populus balsamifera*
21 Cottonwood ..... *Populus deltoides*
22 Paper birch ..... *Betula nigra*
Betula papyrifera var. *papyrifera*
23 Bigtooth aspen ..... *Populus grandidentata*
24 Quaking aspen ..... *Populus tremuloides*
25 Basswood ..... *Tilia americana*
26 Butternut ..... *Juglans cinerea*
27 Black walnut ..... *Juglans nigra*
28 Black cherry ..... *Prunus serotina*
29 Elm ..... *Ulmus americana*
Ulmus pumila
Ulmus rubra
Ulmus thomasii
30 Other hardwoods ..... *Acer negundo*
Celtis occidentalis
Gleditsia triacanthos
Nyssa sulvatica var. *sylvatica*
Platanus occidentalis
All other hardwoods
31 Noncommercial species

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