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Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species

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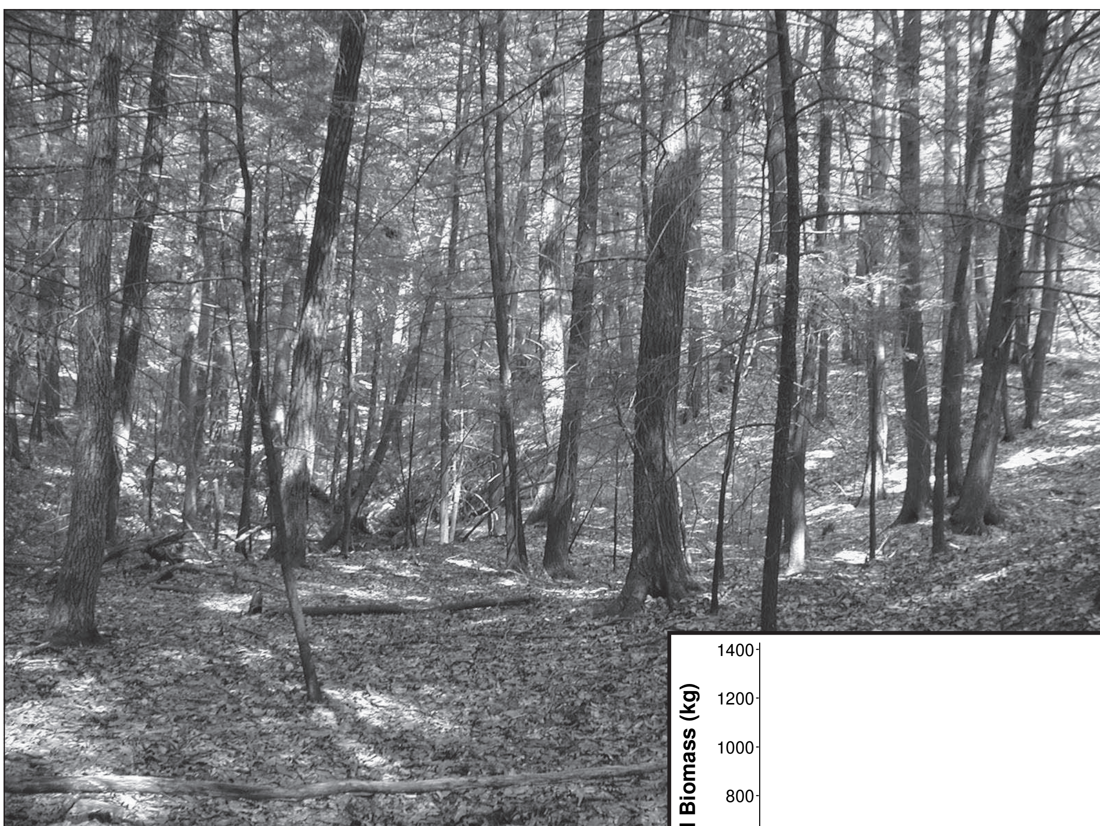

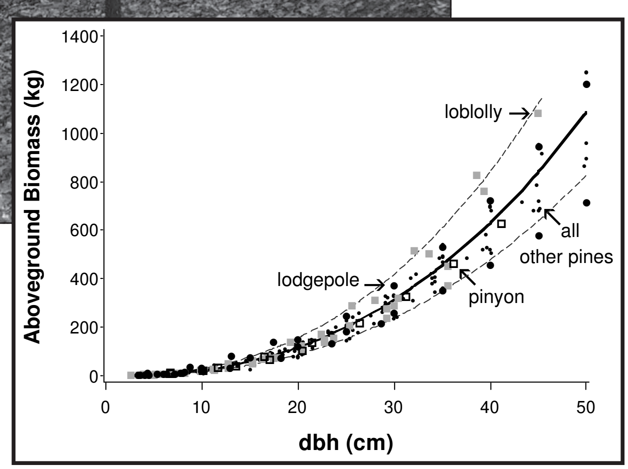

Abstract

A database consisting of 2,640 equations compiled from the literature for predicting the biomass of trees and tree components from diameter measurements of species found in North America. Bibliographic information, geographic locations, diameter limits, diameter and biomass units, equation forms, statistical errors, and coefficients are provided for each equation, along with examples of how to use the database. The CD-ROM included with this publication contains the complete database (Table 3) in spreadsheet format (Microsoft Excel 2002® with Windows XP®).

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Introduction

Estimates of dry-weight biomass for individual trees and tree components are of interest to managers, researchers, and policymakers. Such estimates can be used by land managers to estimate carbon (C) pools and fluxes on individual parcels, by policymakers to estimate forest C dynamics at large scales, or by scientists to enhance our understanding of C dynamics in conjunction with research studies.

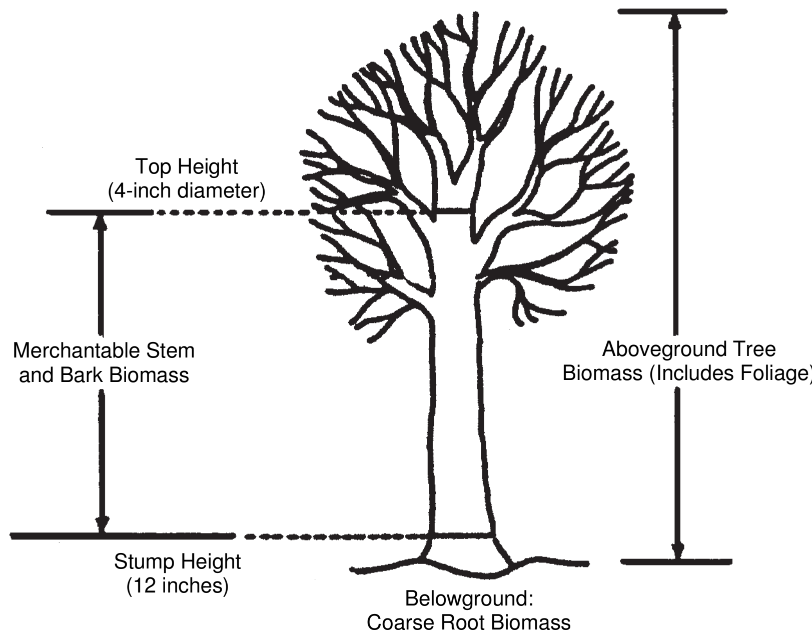

Figure 1.—Tree component biomass definitions.

"Dimensional analysis" as described by Whittaker and Woodwell (1968) is the method used most often by foresters and ecologists to predict individual tree biomass. This method relies on the consistency of an allometric relationship between plant dimensions—usually diameter at breast height (d.b.h.) and/or height—and biomass for a given species, group of species, or growth form. Using the dimensional analysis approach, a researcher samples many stems spanning the diameter and/or height range of interest, and then uses a regression model to estimate the relationship between one or more tree dimensions (as independent variables) and tree-component weights (as dependent variables).

In previous work we developed a set of generalized allometric regression equations for application to forest mensuration data at the national scale for U.S. forests (Jenkins et al. 2003) (Table 1). Developed from species-specific allometric equations published in the literature, these equations predict oven-dry biomass for individual stems based on tree d.b.h. alone. Our generalized regressions for aboveground biomass prediction are applicable to 10 species groups (5 softwood groups, 4 hardwood groups, and 1 woodland group).

We also developed equations for predicting the biomass of tree components (Table 2, Fig. 1). Due to the substantial variability among sampling and analysis techniques, the relative scarcity of component biomass equations, and the complexity of diameter-biomass relationships for tree components, these equations are applicable to two broad hardwood and softwood species groups rather than the 10 species groups used for the aboveground regressions. They are used to predict ratios between component biomass and total aboveground biomass, and must be used in conjunction with the aboveground equations to predict the biomass of four tree components: merchantable stem biomass (defined from a 12-inch stump height to 4-inch top diameter outside bark (d.o.b.)), merchantable bark biomass, total foliage, and roots (Table 2). Branch biomass was not calculated because this component can be obtained by difference. See Jenkins et al. (2003) for details on the generalized regressions and the methods used to develop them.

This Compilation

The first step in developing the generalized regressions was to search the available literature for all published allometric regression equations that predict oven-dry biomass for tree components based on d.b.h. This report includes the results of this compilation, which serves as supporting documentation for the generalized equations. We hope that this report will be a reference document for those interested in estimating oven-dry biomass based on d.b.h. for individual trees.

We used literature search engines such as the National Agricultural Library's AGRICOLA database, and included regressions published in previous compilations such as Tritton and Hornbeck (1982), Ter-Mikaelian and Korzukhin (1997), and Means et al. (1994). We also searched the bibliographies of other published papers for additional pertinent references. Regressions developed in the United States and Canada were our first priority, though regressions developed for nonnative species that are established in the United States are included. Because of the scarcity of regressions for some softwood and woodland species, we include equations developed outside North America for these species groups.

Table 1.—Parameters and equations[a] for estimating total aboveground biomass for all hardwood and softwood species in the United States (from Jenkins et al. 2003)

	Species group[b]	Parameter β_0	Parameter β_1	Data points[c]	Max d.b.h.[d]	RMSE[e]	R^2
					cm	*log units*	
Hardwood	Aspen/alder/ cottonwood/ willow	-2.2094	2.3867	230	70	0.507441	0.953
	Soft maple/birch	-1.9123	2.3651	316	66	0.491685	0.958
	Mixed hardwood	-2.4800	2.4835	289	56	0.360458	0.980
	Hard maple/oak/ hickory/ beech	-2.0127	2.4342	485	73	0.236483	0.988
Softwood	Cedar/larch	-2.0336	2.2592	196	250	0.294574	0.981
	Douglas-fir	-2.2304	2.4435	165	210	0.218712	0.992
	True fir/hemlock	-2.5384	2.4814	395	230	0.182329	0.992
	Pine	-2.5356	2.4349	331	180	0.253781	0.987
	Spruce	-2.0773	2.3323	212	250	0.250424	0.988
Woodland[f]	Juniper/oak/ mesquite	-0.7152	1.7029	61	78	0.384331	0.938

[a]Biomass equation:

$$bm = \mathrm{Exp}(\beta_0 + \beta_1 \ln dbh)$$

where

bm = total aboveground biomass (kg) for trees 2.5 cm and larger in d.b.h.

dbh = diameter at breast height (cm)

Exp = exponential function

ln = natural log base "e" (2.718282)

[b]See Table 4 for guidelines on assigning species to each species group.

[c]Number of data points generated from published equations (generally at intervals of 5 cm d.b.h.) for parameter estimation.

[d]Maximum d.b.h. of trees measured in published equations.

[e]Root mean squared error or estimate of the standard deviation of the regression error term in natural log units.

[f]Includes both hardwood and softwood species from dryland forests.

We made a concerted effort to locate the original sources of all regression equations. However, some reviews reported "unpublished" results and it was not always possible to find the full text of the original sources, particularly for those published other than in peer-reviewed journals. In these cases, we report the equations here but we describe them as "cited in" the published review. In contrast to our previous work developing the generalized equations, here we make no attempt to exclude equations that do not meet prespecified criteria. Instead, we report all equations found in the literature.

To guide the reader in using these equations, we provide information on component definitions, author-reported regression statistics such as R^2 values, diameter ranges over which the equations were developed, number of trees harvested to develop the regression, locations of harvested trees, and other pertinent notes and variables. We have attempted to be as comprehensive as possible; however, we cannot anticipate every question that might be asked by a user, and the authors of the original regressions often did not provide the information we sought. As a result, some gaps are likely. We provide

Table 2.—Parameters and equations[a] for estimating component ratios of total aboveground biomass for all hardwood and softwood species in the United States (from Jenkins et al. 2003)

Biomass component	Parameter α_0	Parameter α_1	Data points[b]	R^2
		Hardwood		
Foliage	-4.0813	5.8816	632	0.256
Coarse roots	-1.6911	0.8160	121	0.029
Stem bark	-2.0129	-1.6805	63	0.017
Stem wood	-0.3065	-5.4240	264	0.247
		Softwood		
Foliage	-2.9584	4.4766	777	0.133
Coarse roots	-1.5619	0.6614	137	0.018
Stem bark	-2.0980	-1.1432	799	0.006
Stem wood	-0.3737	-1.8055	781	0.155

[a]Biomass ratio equation:

$$ratio = \mathrm{Exp}(\alpha_0 + \frac{\alpha_1}{dbh})$$

where

ratio = ratio of component to total aboveground biomass for trees 2.5 cm and larger in d.b.h.

dbh = diameter at breast height (cm)

Exp = exponential function

ln = log base e (2.718282)

[b]Number of data points generated from published equations (generally at intervals of 5 cm d.b.h.) for parameter estimation.

detailed bibliographic information for readers who wish to learn more about a specific equation.

Most of the equations presented here were developed specifically for application to particular species at specific study sites, so they may be more accurate when used to estimate biomass at sites that closely resemble those for which they were developed. When biomass for a particular study site is the target variable, we recommend using a specific regression that is matched closely to the site rather than generalized regressions developed for large-scale application. If such an equation is not available, we recommend applying a range of site-specific equations. This approach will provide a range of biomass estimates likely to include the actual (though still unknown) biomass value for the target study site, and it will provide a simplistic estimate of the uncertainty inherent in these biomass calculations.

Database Description

This section includes definitions for the variables in the seven tables (Tables 3-9) that make up the database (Appendix B). The complete database also is available online at http://www.fs.fed.us/ne/global/. Table 3 lists more than 2,600 equations and their coefficients; each row in the table represents a separate biomass regression. (Only the first 10 pages of Table 3 are included in this report. Table 3 in its entirety is on the CD-ROM included with this publication and is available online.) Tables 4 through 9 contain supporting information.

Table 3: Equations and Parameters for Diameter-Based Biomass Equations

The printed version of the database contains only the first 10 pages of Table 3. The companion CD-ROM and electronic distributions of the database include Table 3 in its entirety along with Tables 4-9.

1. **Species** – Numeric code for the species to which the equation applies. This number corresponds to the species code listed in the online Forest Inventory and Analysis (FIA) database (FIADB) as of October 2002 and to the "FIA Species code" variable (item 1) in Table 4. FIADB is available at http://fia.fs.fed.us/dbrs_setup.html.

2. **Common name** – Common name for the species of interest (Table 4).

3. **Component ID** – Numeric code corresponding to the tree component of interest. These codes and their definitions are listed in Table 5.

4. **Equation Form ID** – Numeric code corresponding to the algebraic form of the equation used by the original author to fit the regression. These codes and their associated equation forms are listed in Table 6.

5. **Coefficients and constants (a - e)** – These columns include parameters for the regression equations as given by the authors of the original regressions. The parameter definitions refer to letter codes in Table 6.

6. **Diameter –** Independent variable used to develop the regression. Definitions:
   BA: Basal area, the cross-sectional area of the stem at breast height.
   BArc: Basal area, the cross-sectional area of the stem at the root collar.
   c.b.h.: Circumference at breast height.
   c.r.c.: Circumference at root collar.
   d.b.h.: Diameter at breast height at 4.5 feet (1.37 m) above ground level.
   d.b.h.^{2}: Square of diameter at breast height.
   d.r.c.: Diameter at root collar.
   d150: Diameter at 150 cm above ground level.

7. **Corrected for bias** – A "yes" value in this column means that the original authors developed and reported a correction factor to compensate for the potential underestimation resulting from back-transforming logarithmic predictions to arithmetic units, as suggested by Baskerville (1972), Beauchamp and Olson (1973), and Sprugel (1983). In many cases where (7) is "yes," item (8) will list CF, the bias correction factor to be used. In other cases, the authors embedded the correction factor into the equation parameters, or did not publish the value of CF since it can be obtained from the regression statistics. In such cases, the value of CF in the database will be zero even though the authors used the correction factor.

   A "no" value in this column means that: a) the equation form used is not logarithmic and does not require the correction; b) for logarithmic equation forms, the authors chose not to correct the equation; c) there is no mention of bias correction in the original publication.

8. **Bias correction (CF)** – Published value of CF, to correct for potential underestimation resulting from back-transformation of logarithmic predictions to arithmetic units. As a remedy for bias, it has been proposed that the back-transformed biomass results be multiplied by CF, defined as *exp(MSE/2)*, where MSE refers to the mean squared error of a line fit by least-squares regression. The use of CF has been criticized; because many authors include well-reasoned discussions of their choice whether to use the correction, we follow the example of the original authors. If the author reports the CF, we also report it here; if the author uses it but does not report it explicitly, we do likewise; or if the original author chooses not to address the issue, we reflect that decision as well.

9. **r and R^2** – Standard goodness-of-fit statistics, if these were reported by the authors of the original regressions.

10. **MinDiameter and MaxDiameter** – Minimum and maximum diameter values (in centimeters) for which the regression is valid. These are the minimum and maximum measurements for the trees harvested to develop the regression.

11. **Sample size** – Number of trees harvested or measured to develop the regression.

12. **Stump height** – For equations that predict the biomass of any component that includes the tree stem or the stump, this variable lists (in inches) the estimated or measured stump height. Many authors, particularly those reporting in the ecology literature, did not report this value, so we developed a series of rules to estimate it if missing. If the original authors reported stump height, it is listed here. If no stump height was given or if the authors did not mention the existence of a stump in their publication, we

assumed that the stump was 6 inches (15.24 cm) tall. Stump height was assumed to be zero if any of the following were true: 1) the methods of Whittaker and Marks (1975) or Whittaker and Woodwell (1968) were used for sampling (these authors were explicit about felling trees at groundline); 2) the authors stated that trees were "felled at groundline" as opposed to simply being "felled;" 3) the stump is described as "as short as possible;" 4) the same authors also report an equation for root biomass only (versus stump plus root biomass); 5) the authors estimated (using their own method) that portion of the stump excluded when the trees were felled; 6) the trees used to develop the regressions were small enough that it is reasonable to expect that nearly the entire stump would have been included with the aboveground biomass using standard destructive harvesting techniques adapted for research purposes.

13. **Top d.o.b.** – For equations that include a portion of the merchantable stem, describes the minimum diameter outside bark (d.o.b.) of the top of the merchantable stem. If a value was listed, it is included here. If no value was listed, or if the equation was listed as predicting the biomass of the "stem" or the "bole" with no discussion of the limiting top diameter, we assumed that the value of this parameter was zero. Some authors provided ratio equations allowing for prediction of certain bole components based on a user-defined top diameter; in these cases the value of "Ratio Equation," (item 17) is "y" and the corresponding equation is listed in Table 7.

14. **Units diameter and units biomass** – The units used by the original authors to measure the independent and dependent variables. The equation coefficients in Table 3 are reported as originally published: this means that the diameter units must correspond to the units in the Units diameter column, and that the result always is in the units listed in the Units biomass column. Abbreviations:

    mm: millimeters (= 10^{-3} meters)

    cm: centimeters (= 10^{-2} meters)

    m: meters (= 39.37 inches)

    in: inches (= 2.54 cm)

    lb: pounds (= 0.4545 kg)

    g: grams

    kg: kilograms (= 10^{6} grams)

    Mg: Megagrams (= 10^{9} grams)

15. **Component** – This column can be used to determine whether an equation was incorporated into the generalized equations published by Jenkins et al. (2003). If an equation was used in the generalized equations, the codes in this column further describe modifications to incorporate equations into the generalized equations. Values are defined as (see also Figure 1):

    na: Not used in the generalized equations, usually because component definitions were inconsistent with what was required. Exclusion for other reasons is stated in the Notes column.

    ag: Predicts total aboveground biomass; used directly in the analysis with no alteration.

    sb: Merchantable stem bark biomass with the correct definition (12-inch stump to 4-inch top); used directly with no alteration.

    sw: Merchantable stem wood biomass with the correct definition (12-inch stump to 4-inch top); used directly with no alteration.

    fl: Total foliage biomass; used directly with no alteration.

    rt: Root biomass; used directly with no alteration. Due to the scarcity of root biomass equations, root diameter limits were ignored in the summary paper (Jenkins et al. 2003).

    agm: Predicts above-stump biomass; stump biomass was added before the equation was used to predict aboveground biomass in the summary paper.

    sbm: Merchantable stem bark biomass with a portion of the stump included; stump biomass was subtracted before the equation was used to predict merchantable stem bark biomass in the summary paper.

    swm: Merchantable stem wood biomass with a portion of the stump included; stump biomass was subtracted before the equation was used to predict merchantable stem wood in the summary paper.

    flm: Predicts a portion of total foliage biomass (usually new or old foliage biomass); two or more equations (including this one) were added to predict total foliage biomass in the summary paper.

    rtm: Predicts root plus stump biomass; stump biomass was subtracted before the equation was used in the summary paper.

    rts: Complete tree biomass; aboveground biomass (as predicted by the same authors) was subtracted before the equation was used to predict root biomass in the summary paper.

16. **Component sum** – Describes the additive status for equations where the original authors published separate component equations. Definitions are:

    a: This equation predicts total aboveground or above-stump biomass, and was used directly or with modifications to account for stump biomass in the summary paper.

b: This equation predicts total belowground biomass, and was used with no alteration in the summary paper.

t: Along with other equations published for the same species by the same author, this component adds to total aboveground or total above-stump biomass. No separate aboveground or above-stump equation is presented based on the same data. For these equations, the additive result is included in the summary paper.

c: Together with other equations published for the same species by the same author, this component adds to total aboveground, above-stump, or complete-tree biomass. A separate aboveground or above-stump equation (with an "a" in this column) also is presented based on the same data. For these equations, only the aboveground or above-stump equation is included in the summary paper.

s: Together with other equations published for the same species by the same author, this component adds to total belowground biomass. No separate total belowground biomass equation is presented based on the same data. For these equations, only the additive result is included in the analysis of Jenkins et al. (2003).

r: Together with other components, this component adds to total belowground biomass. A separate total belowground biomass equation (with a "b" in this column) is also presented based on the same data. For these equations, only the additive result is used in Jenkins et al. (2003).

A blank in this column means that the equation was not used in the summary paper because the components do not add to a total or this equation does not contribute to a total, or the equation was deemed unsuitable for another reason (which would be described in the Notes column).

17. **Ratio equation** – Some authors presented methods for predicting the biomass of the merchantable stem to a user-defined top diameter. A "y" value in this column means that a separate ratio equation was presented by this author and is included in Table 7. Where available, these equations were used to estimate the biomass of the corresponding merchantable stem to a 4-inch top d.o.b.

18. **Segmented equation** – Some authors presented paired equations for the same species such that one equation was applicable at the lower end of the diameter range and a second equation was applicable at the upper end of the range. A "y" value in this column means that the equation is one-half of a segmented equation; its companion equation for the same species will have the same author and regression statistics but will be applicable over a different diameter range. In Jenkins et al. (2003), each half of a segmented equation was used for half of the total number of pseudodata predictions for a given author and species combination.

19. **Equation number** – Some authors presented several equations for the same component and species based on treatment type or study site. In such cases, each separate equation is given a number, starting sequentially with 1. When an author presented equations based on independent tree samples from different sites, all of the published equations were included in Jenkins et al. (2003). However, if the same author also presented one equation based on "pooled" data from all sites sampled, the pooled equation was used.

20. **Source** – Numbers correspond to references listed in Table 9.

21. **Notes** – Information potentially of interest to users of the equations.

Table 4: Species Key, Suggested Assignments for Species Groups to Apply Generalized Equations, and Specific Gravity Information

Table 4 includes the species-specific information relevant to users of the database, as well as species-specific information used to develop the generalized equations described in Jenkins et al. (2003).

1. **FIA species code** – Numeric code assigned to each tree species; used by FIA's FIADB database. Note that some equations were added to the database for species that are either not native or uncommon in the United States. For these species with no dedicated FIA codes, we assigned a code for use in this biomass database. As a result, the new ID's probably will not match the assigned FIA code should these species ever be added to the FIADB database. The codes for these new species are listed in bold italic. Family, genus, and species information in this database should allow users to assign the correct FIA code if necessary.

2. **Common name** – Common name used by FIA (or in common usage for species not listed by FIA) for the species.

3. **Family**

4. **Genus**

5. **Species**

6. **Species group** – The group to which the species was assigned to develop the generalized equations of Jenkins et al. (2003). If no biomass regressions are found for a particular species, this column can be used to assign species to groups when applying the generalized equations. Abbreviations are: **aa** = aspen / alder / cottonwood / willow; **cl** = cedar / larch; **df** = Douglas-fir; **mb** = soft maple / birch; **mh** = mixed hardwood; **mo** = hard maple / oak / hickory / beech; **pi** = pine; **sp** = spruce; **tf** = true fir / hemlock; **wo** = woodland species (juniper / oak / mesquite).

7. **Wood specific gravity** – Specific gravity (based on oven-dry weight and green volume) value used to convert stump volume inside bark to stump wood biomass for standardizing component definitions in Jenkins et al. (2003). Values were obtained primarily from the Forest Products Laboratory (U.S. Dep. Agric. 1974) and Markwardt (1930). Where this column is blank, data for the species (or species group) were unavailable. For groups of species (e.g., pine spp. or spruce spp.) the value is the average of specific gravity values from the literature for species that make up the group.

8. **Bark specific gravity** – Specific gravity (based on oven-dry weight and green volume) value used to convert stump bark volume to stump bark biomass for standardizing component definitions in Jenkins et al. (2003). The bibliographic source of the information is listed in the next column (and in Appendix A). Where this column is blank, data for the species (or species group) were unavailable.

9. **Bark specific gravity source** – Reference number corresponding to the bibliographic source that lists the bark specific gravity for the species. Note that information on bark specific gravity is limited. Where a value for specific gravity is included in the previous column but is not accompanied by a code referring to the source of the information, bark specific gravity was estimated based on data from the literature. Unless there was information on bark specific gravity from a closely related species or group of species, we assumed that bark and wood specific gravity were similar.

10. **Stump volume equation** – FIA species code corresponding to the equation used for predicting stump volume inside and outside bark for this species to standardize component definitions in the summary paper. Species with no value in this column were not used to develop the generalized equations in Jenkins et al. (2003). See Table 8 and Raile (1982) for stump volume equations.

Table 5: Tree Component Key

Table 5 describes the tree components included in the equation database, and serves as the key for the "Component ID" column in Table 3.

1. **Component description** – Describes the tree component predicted by the equation.

2. **Component abbreviation** – Used by the developers of the BIOPAK database (Means et al. 1994) for referring to plant component biomass. Where this column is blank, the BIOPAK database did not include equations for the component.

3. **Component ID** – Numeric code corresponding to the component; the number in this column refers to the Component ID column in Table 3.

Table 6: Equation Form Key

Table 6 includes the general equation forms in the equation database, and serves as the key for the "Equation form ID" column in Table 3.

1. **Equation form description** – This column shows the algebraic form of the equation. To use an equation plug the coefficients and constants listed in Table 3 into the equation form. Note that "dia" refers to the diameter measurement listed in Table 3, whether it is basal area, d.b.h., or circumference at the root collar.

2. **Equation form ID** – Numeric code corresponding to the equation form; the number in this column refers to the Equation form ID column in Table 3.

Table 7: Parameters for Stem Ratio Equations for Selected Stem Biomass Equations

Table 7 includes parameters for equations used to develop merchantable-stem biomass to a user-specific top diameter. These ratio equations were developed and presented by the authors of a subset of the original equations included in the database. A stem ratio equation is included here for any equation in Table 3 with a value of "y" in the "Ratio equation" column.

1. **Source** – Numeric code corresponding to the bibliographic reference where the equation was published (these numbers correspond to those in Table 9).

2. **Species** – Numeric code corresponding to the species for which the equation was developed (species codes are listed in Table 4).

3. **Component** – Numeric code corresponding to the tree component for which the ratio equation was developed. The original authors developed these ratio equations for Component ID's 6 (st, merchantable-stem wood plus bark) and 4 (sw, merchantable-stem wood) (see Table 5 for Component descriptions). The biomass of merchantable-stem bark (Component ID 5) can be found by difference.

4. **a, b, c** – Parameters for ratio equations. The equation form is:

   $\ln(\text{ratio}) = a * (d^b) * (D^c)$

where ratio = proportion of above-stump stem biomass to specific top d.o.b.

d = specified top d.o.b. (inches)

D = tree d.b.h. (inches)

a, b, c = equation parameters from Table 7

When back-transformed, the result of this equation is a number between 0 and 1. When the original total stem (or stem wood) biomass developed using the equation presented in Table 3 is multiplied by the ratio determined with this equation, the result is the stem biomass to the top d.o.b. (d) specified by the user.

Table 8: Stump Diameter Regression Coefficients, Outside and Inside Bark, for Tree Species in the Lake States

Table 8 includes parameters for equations used to estimate stump volume based on d.b.h., for tree species in the Lake States (Raile 1982). When developing the generalized equations of Jenkins et al. (2003), stump volume (and biomass) was computed in two cases. In the first, a given equation might report biomass of the above-stump portion of the tree (Component ID 3 in Tables 3 and 5); here, the biomass of the stump between ground level and stump height was computed and added to the above-stump equation to determine total above-ground biomass. In the second case, an equation reporting merchantable stem (or merchantable stem wood or bark) biomass might give a stump height of 6 inches or 3 inches. The definition of merchantable stem in Jenkins et al. (2003) specifies a 12-inch stump height. Here, the biomass of the portion of the stump between reported stump height and 1 foot was computed and subtracted from the merchantable stem biomass from the reported equation in order to standardize merchantable stem definitions for the generalized equations.

To compute stump wood biomass, we first predicted stump volume, assuming that the portion of the stump to be added or subtracted from the biomass equation result was a perfect cylinder. Due to the tapered shape of most trees, this approach likely underestimated slightly the biomass of the bottom stump portion. However, this overestimation probably was balanced nearly equally by an overestimation of the biomass of the top half of the stump portion.

To determine stump wood volume, we chose a point that bisected the length of the stump portion of interest, and used the parameters given in Table 8 to predict stump inside bark diameter (d.i.b.) at that point. We then used a standard geometric formula for predicting the volume of a cylinder to predict the wood volume of the stump portion of interest:

$\text{Volume} = pi * r^2 * h,$

where r = (stump d.i.b.)/2 and h = the length of the stump portion.

This wood volume was multiplied by the wood specific gravity for the species of interest (Table 4) to determine oven-dry stump wood biomass.

Stump bark volume was found by difference. We began by using the parameters in Table 8 to predict stump outside bark diameter (d.o.b.) at a point in the middle of the stump portion of interest. We used the standard geometric formula described previously to predict the volume of the entire stump (bark plus wood). We then subtracted the volume of the stump wood only (found using the geometric method described above) from total stump volume to determine the volume of the stump bark only. This volume was multiplied by the specific gravity of bark for the species of interest to determine oven-dry stump bark biomass.

Stump Diameter Outside Bark

1. **Species group** – Species group name corresponding to the equation (see Raile (1982) for a full list of the species included in each group).

2. **Stump volume equation code** – The FIA numeric code corresponding to the most common species used to develop the d.o.b. regression equation. See Table 4 for a list of codes and their corresponding species.

3. **Number of trees** – The number of trees used to develop the regression.

4. **Min D.B.H.** – D.b.h. (in inches) of the smallest tree used to develop the regression.

5. **Max D.B.H.** – D.b.h. (in inches) of the largest tree used to develop the regression.

6. **B** – The "species group regression parameter" for the regression equation. The equation form is:

   Stump d.o.b. = d.b.h. + B*(d.b.h.)*[(4.5 – h)/(h + 1)]

where stump d.o.b. = diameter outside bark (inches) at height h;

   B = species group regression parameter from Table 8;

   h = stump height (feet).

7. **R^2** – R^2 value for the regression equation fit by Raile (1982) to the data.

8. **SE** – Standard error (inches) of the regression.

Stump Diameter Inside Bark

1. **Species group** – Species group name corresponding to the equation.

2. **A** and **B** – Species group regression parameters for the regression equation. The equation form for the d.i.b. regressions is:

   Stump d.i.b. = A*d.b.h. + B*d.b.h.*[(4.5 – h)/(h + 1)]

where stump d.i.b. = diameter inside bark (inches) at height h;

   A and B are species group regression parameters from Table 9;

   h = stump height (feet).

3. **R^2** – R^2 value for the regression equation fit by Raile (1982) to the data.

4. **SE** – Standard error (inches) of the regression.

Table 9. Sources and General Geographic Locations for All Equations

1. **Reference number** – This number is cross referenced to the Source column in Table 3.

2. **Reference** – The literature reference (author and date) for the full citation listed in Appendix A.

3. **Origin** – Geographic location from which the trees were harvested to develop the original regressions. Where this variable is missing, the original source was unavailable or there was insufficient information in the original literature citation with which to determine the specific location of the harvested trees.

Using the Database

For clarity, we provide two examples of how one might apply the equations in the database: estimating total foliage biomass for a study plot in Maine, and estimating the potential error associated with using a particular equation for aboveground biomass for Douglas-fir.

Maine Example

Choosing appropriate equations

In this example, we have species and d.b.h. data for diverse tree species on a Maine study plot. We want to quantify the foliage biomass (dry weight, green foliage) for this plot using an allometric approach. In Table 5 we see that Component ID 18 refers to total foliage, while Component ID's 19 and 20 refer to "new" and "old" foliage, respectively. (For a tree that retains its leaves or needles for more than 1 year, note that new foliage is the current year's growth while old foliage is growth from the previous year and earlier.) Because we are most interested in the total foliage biomass, we look in the Component ID column in Table 3 for equations that correspond to Component ID 18. There are 295 "total foliage" equations for a variety of species and study sites. Our study plot is in Maine, so we want to use equations from studies conducted in that region. We check Table 9 for the geographic origins of the equations, and we find that several of the total foliage equations were developed from trees harvested in Maine: the equations from Ribe (1973) (ref 130) and Young (1980) (ref 177) probably are the most widely applicable for that state. We note that the Ribe (1973) equations have a fairly limited diameter range (for most of these equations, the minimum diameter is 2.5 cm and the maximum diameter is 15.24 cm) and that the Young (1980) equations were developed from trees harvested over a larger range of diameters. If our trees are small, we might use the Ribe (1973) equations; if our trees are intermediate in size, the Young (1980) equations might be more appropriate. If tree species in our study plot are not represented by either set of references or if our Maine plot is near the New Hampshire border, we may want to use some of the equations developed in New Hampshire, e.g., the Hocker and Earley (1983) (ref 74) or Kinerson and Bartholomew (1977) (ref 86) equations.

Applying the equations

Once we have examined the species and size distributions in our study plot to determine consistency with the equations in Table 3 and chosen a set of equations, we must estimate foliage biomass from the d.b.h. data in our study plot. For example, we are using the Ribe

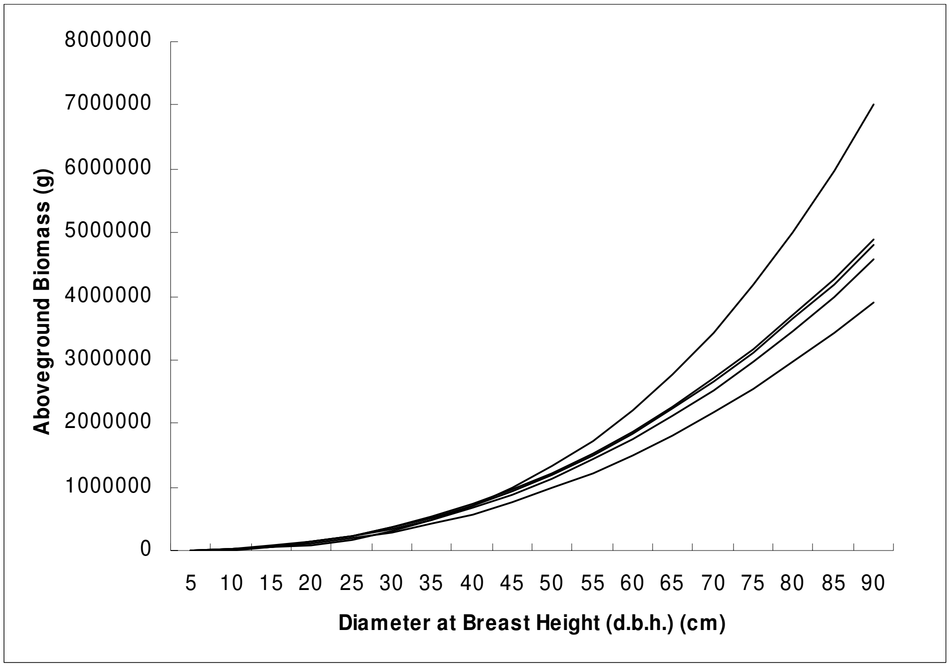

Figure 2.—Total aboveground biomass as predicted from five allometric regression equations for Douglas-fir.

(1973) equation to calculate biomass for a red maple (*Acer rubrum*) (FIA species code 316) that is 5 cm d.b.h.

This equation has Equation Form ID 1. In Table 6, we see that Equation Form ID 1 corresponds to equations with the following form: $\log_{10}$ biomass = a + b * $\log_{10}(\text{dia})^c$. We also note that "dia" in the Ribe equation refers to d.b.h. (as listed in the Diameter column in Table 3), and that Units Diameter and Units Biomass for the equation we have chosen (Table 3) are in inches and grams, respectively. Therefore, we must convert our d.b.h. measurement to inches and we recognize that the result will be in grams.

First, we convert the d.b.h. measurement to inches: 5 cm * (1 inch/ 2.54 cm) = 1.97 inches. To calculate foliage biomass, we apply the equation: $\log_{10}$ biomass = 2.1237 + (1.8015)*($\log_{10}$(1.97)) = 2.65. Since $\log_{10}$(biomass) = 2.65, to find total foliage biomass for this stem we must back-transform the logarithm to arithmetic units: biomass = $10^{2.65}$, or 451 g.

We would repeat this process for each stem and species for which we want to estimate foliage biomass. To calculate the total foliage biomass on the study plot, we sum the foliage estimates for all the trees present on the plot.

Douglas-Fir Example

In this example, we want to understand the implications of using a particular equation for predicting Douglas-fir biomass. How would our results be different if we used one equation instead of another? We suggest applying several equations to the same tree or set of trees, and quantifying the differences among the results. For example, sorting Table 3 by Species and Component ID, we see that there are six equations for total aboveground biomass (Component ID 2) for Douglas-fir (species code 202). Also, one of these equations requires estimates of diameter at the root collar (d.r.c.) rather than d.b.h. If we have only d.b.h. data, we would omit this equation from our analysis unless we had a method for predicting d.b.h. from d.r.c. In this example, we would choose the equations from Table 3 that correspond to the diameter range of interest and use all of them to quantify aboveground biomass. The differences can be expressed in terms of percentages (e.g., results from one equation are X% higher than the average of all of the appropriate equations). We also might graph the equations as in Figure 2, with the d.b.h. values on the x axis and the biomass values on the y axis. This allows us to see the differences between the estimates provided by the different equations.

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Table 3.—Equations and parameters for diameter-based biomass equations (first 10 pages only; complete version is available online)

Species	Common name	Component ID	Equation form ID	a	b	c	d	e	Diameter	Corrected for bias	Bias correction (CF)	r	R^2
0	eastern conifers	2	7	0.5	15000	2.7	364946		d.b.h.	no	0	0	0.98
0	softwoods (general)	3	1	-1.01	2.41	1			d.b.h.	no	0	0	0.99
0	softwoods (general)	3	4	4.5966	-0.2364	0.00411	2		d.b.h.	no	0	0	0.96
0	softwoods (general)	6	4	4.142	-0.227	0.003	2		d.b.h.	no	0	0	0.97
0	softwoods (general)	6	4	-6.221	-0.227	0.003	2		d.b.h.	no	0	0	0.97
0	softwoods (general)	6	2	-3.787	0	2.767	1		d.b.h.	yes	1.08	0	0.96
0	softwoods (general)	13	2	-3.461	0	2.292	1		d.b.h.	yes	1.26	0	0.95
0	softwoods (general)	18	4	4.597	-0.236	0.004	2		d.b.h.	no	0	0	0.96
0	softwoods (general)	18	2	-2.907	0	1.674	1		d.b.h.	yes	1.34	0	0.91
10	fir sp.	4	2	-3.7389	0	2.6825	1		d.b.h.	yes	0	0	0.97
10	fir sp.	5	2	-6.1918	0	2.8796	1		d.b.h.	yes	0	0	0.98
10	fir sp.	8	2	-4.8287	0	2.5585	1		d.b.h.	yes	0	0	0.95
10	fir sp.	18	2	-3.4662	0	1.9287	1		d.b.h.	yes	0	0	0.94
11	Pacific silver fir	3	4	-2029.05	6775.64	0	0		d.b.h.	no	0	0	0.98
11	Pacific silver fir	3	1	3.779	2.473	0			d.b.h.	no	0	0	0.99
11	Pacific silver fir	4	2	-3.5057	0	2.5744	1		d.b.h.	yes	0	0	0.99
11	Pacific silver fir	4	4	-1467.72	4769.21	0	0		d.b.h.	no	0	0	0.97
11	Pacific silver fir	4	1	3.636	2.618	0			d.b.h.	no	0	0	0.99
11	Pacific silver fir	4	2	-10.0897	0	2.5942	1		d.b.h.	no	0	0	0.946
11	Pacific silver fir	4	2	-9.69116	0	2.497	1		d.b.h.	no	0	0	0.932
11	Pacific silver fir	4	2	-10.7366	0	2.7623	1		d.b.h.	no	0	0	0.973

MinDiameter	MaxDiameter	Sample size	Stump height	Top d.o.b.	Units diameter	Units biomass	Component	Component sum	Ratio equation	Segmented equation	Equation number	Source	Notes
1.00	72.00	83	0		cm	kg	na	a			1	140	assume 0-inch stump height, but data from other studies so stump heights are probably mixed; 43 pine, 30 spruce, 10 fir
0.80	34.10	108	6		cm	kg	na				1	51	no stump height; tree data also used for ref 52
2.50	25.00	131	12		mm	kg	na				1	107	12-inch stump
12.50	55.00	131	12	0	mm	kg	na				1	107	12-inch stump including entire bole (no branches)
12.50	55.00	131	12	4	mm	kg	na				1	107	12-inch stump to 10 cm (4-inch) top
1.00	60.00	51	6	0	cm	kg	na	t			1	149	some tree data points may overlap with ref 23 because data sources were from same compilation; assume 6-inch stump; bias correction described as "K"; d.b.h. range estimates from text
1.00	60.00	51			cm	kg	na	t			1	149	some tree data points may overlap with ref 23 because data sources were from same compilation; bias correction described as "K"; d.b.h. range estimates from text
12.50	55.00	131	12	0	mm	kg	na				1	107	12-inch stump aboveground (whole tree including branches and foliage)
1.00	60.00	65			cm	kg	na	t			1	149	some tree data points may overlap with ref 23 because data sources were from same compilation; bias correction described as "K"; d.b.h. range estimates from text
8.7	111.0	20	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
8.7	111.0	20	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
8.7	111.0	26			cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias
8.7	111.0	25			cm	kg	fl				1	55	equation originally from ref 166; coefficients corrected for bias in ref 55
31.00	90.40	7	12		cm	kg	agm	a			1	91	logarithmic equation also presented based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7	12		cm	kg	agm				1	91	equations presented here do not require additional variables (additional equations in original reference)
11.7	90.4	14	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
31.00	90.40	7	12	1	cm	kg	na				1	91	logarithmic equation also presented based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7	12	1	cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
8.1	109.3	143	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
8.1	109.3	75	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
13.3	80.0	68	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump

Continued

Table 3.—Continued.

Species	Common name	Component ID	Equation form ID	a	b	c	d	e	Diameter	Corrected for bias	Bias correction (CF)	r	R^2
11	Pacific silver fir	5	2	-6.1166	0	2.8421	1		d.b.h.	yes	0	0	0.99
11	Pacific silver fir	5	1	3.096	1.327	0			BA	no	0	0	0.95
11	Pacific silver fir	5	1	2.957	2.654	0			d.b.h.	no	0	0	0.95
11	Pacific silver fir	5	4	-42.324	1052.28	0			BA	no	0	0	0.95
11	Pacific silver fir	5	2	-11.8442	0	2.5677	1		d.b.h.	no	0	0	0.857
11	Pacific silver fir	5	2	-10.8498	0	2.3179	1		d.b.h.	no	0	0	0.833
11	Pacific silver fir	5	2	-13.5169	0	3.0009	1		d.b.h.	no	0	0	0.918
11	Pacific silver fir	6	2	-9.46281	0	2.4762	1		d.b.h.	no	0	0	0.933
11	Pacific silver fir	6	2	-10.6483	0	2.7763	1		d.b.h.	no	0	0	0.977
11	Pacific silver fir	6	2	-9.9176	0	2.5867	1		d.b.h.	no	0	0	0.947
11	Pacific silver fir	8	2	-5.237	0	2.6261	1		d.b.h.	yes	0	0	0.96
11	Pacific silver fir	9	4	-7.558	103.675	0	0		d.b.h.	no	0	0	0.86
11	Pacific silver fir	9	1	2.019	1.317	0			d.b.h.	no	0	0	0.91
11	Pacific silver fir	10	4	-39.77	663.778	0	0		BA	no	0	0	0.82
11	Pacific silver fir	10	4	-202.413	620.411	0	0		d.b.h.	no	0	0	0.80
11	Pacific silver fir	10	1	2.665	2.493	0			d.b.h.	no	0	0	0.92
11	Pacific silver fir	18	2	-4.5487	0	2.1926	1		d.b.h.	yes	0	0	0.97
11	Pacific silver fir	23	4	-64.849	316.41	0	0		d.b.h.	no	0	0	0.91
11	Pacific silver fir	23	4	21.947	325.859	0	0		BA	no	0	0	0.87
11	Pacific silver fir	23	1	2.457	1.789	0			d.b.h.	no	0	0	0.92
11	Pacific silver fir	10,11	1	2.665	2.493	1			d.b.h.	no	0	0	0.92
12	balsam fir	1	2	0.6538	0	2.4872	1		d.b.h.	no	0	0	0.97

MinDiameter	MaxDiameter	Sample size	Stump height	Top d.o.b.	Units diameter	Units biomass	Component	Component sum	Ratio equation	Segmented equation	Equation number	Source	Notes
11.7	90.4	14	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
31.00	90.40	7	12	1	cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7	12	1	cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7	12	0	cm	kg	na				1	92	
8.1	109.3	143	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
8.1	109.3	75	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
13.3	80.0	68	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
8.1	109.3	75	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
13.3	80.0	68	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
8.1	109.3	143	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
11.7	90.4	9			cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias
31.00	90.40	7			cm	kg	na				1	91	logarithmic equation also presented based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
31.00	70.40	7			cm	kg	na				1	91	includes all branches larger than 2.54 cm; logarithmic equation also included based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	91	includes all branches larger than 2.54 cm; logarithmic equation also included based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	91	includes all branches larger than 2.54 cm; equations presented here do not require additional variables (additional equations in original reference)
11.7	90.4	9			cm	kg	fl				1	55	equation originally from ref 166; coefficients corrected for bias in ref 55
31.00	90.40	7			cm	kg	na				1	91	logarithmic equation also presented based on the same data; equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	91	equations presented here do not require additional variables (additional equations in original reference)
31.00	90.40	7			cm	kg	na				1	92	branches >=1-inch diameter
10.16	33.02	40			in	lb	na				1	75	includes roots >= 1-inch diameter

Continued

Table 3.—Continued.

Species	Common name	Component ID	Equation form ID	a	b	c	d	e	Diameter	Corrected for bias	Bias correction (CF)	r	R^2
12	balsam fir	1	2	0.8162	0	2.414	1		d.b.h.	no	0	0.996	0
12	balsam fir	1	2	7.5915	0	0.6	1		d.b.h.	no	0	0.886	0
12	balsam fir	2	1	0.086	2.53	1			d.b.h.	no	0	0.96	0
12	balsam fir	2	2	-2.2304	0	2.3263	1		d.b.h.	yes	1.02	0	0.99
12	balsam fir	2	2	-1.8337	0	2.1283	1		d.b.h.	yes	1.03	0	0.97
12	balsam fir	2	2	7.3736	0	0.6003	1		d.b.h.	no	0	0.886	0
12	balsam fir	3	2	0.4441	0	2.4975	1		d.b.h.	no	0	0	0.97
12	balsam fir	3	4	0	0	0.1746	2.1555		d.b.h.	no	0	0	0.98
12	balsam fir	3	1	-0.4081	1.6217	1			d.b.h.	yes	0	0	0.81
12	balsam fir	3	4	0	0	0.0752	2.497		d.b.h.	no	0	0	0.99
12	balsam fir	3	2	0.5958	0	2.4017	1		d.b.h.	no	0	0.996	0
12	balsam fir	4	1	0.062	2.28	1			d.b.h.	no	0	0.96	0
12	balsam fir	4	2	-4.0345	0	2.6909	1		d.b.h.	yes	1.02	0	0.96
12	balsam fir	4	2	-3.1144	0	2.3977	1		d.b.h.	yes	1.01	0	0.99
12	balsam fir	4	2	-3.2027	0	2.4228	1		d.b.h.	yes	1.02	0	0.98
12	balsam fir	4	4	0	0	0.0645	2.2962		d.b.h.	no	0	0	0.98
12	balsam fir	5	1	-0.916	2.47	1			d.b.h.	no	0	0.95	0
12	balsam fir	5	2	-5.2684	0	2.5467	1		d.b.h.	yes	1.04	0	0.93
12	balsam fir	5	2	-4.0499	0	2.1601	1		d.b.h.	yes	1.02	0	0.98
12	balsam fir	5	2	-4.4204	0	2.2391	1		d.b.h.	yes	1.06	0	0.95
12	balsam fir	6	2	-3.7775	0	2.6635	1		d.b.h.	yes	1.02	0	0.96
12	balsam fir	6	2	-2.801	0	2.3524	1		d.b.h.	yes	1.01	0	0.99
12	balsam fir	6	2	-2.9476	0	2.3932	1		d.b.h.	yes	1.02	0	0.98
12	balsam fir	6	4	0	0	0.0671	2.3381		d.b.h.	no	0	0	0.98
12	balsam fir	6	1	-0.8858	1.8728	1			d.b.h.	yes	0	0	0.80
12	balsam fir	6	2	0.3487	0	2.4117	1		d.b.h.	no	0	0.995	0
12	balsam fir	8	2	-4.3537	0	2.4263	1		d.b.h.	yes	1.14	0	0.92
12	balsam fir	12	1	0.226	2.11	1			d.b.h.	no	0	0.8	0
12	balsam fir	12	2	-4.3612	0	2.0505	1		d.b.h.	yes	1.17	0	0.88
12	balsam fir	13	1	-1.294	3.22	1			d.b.h.	no	0	0.95	0
12	balsam fir	13	2	-2.6293	0	1.7793	1		d.b.h.	yes	1.05	0	0.89
12	balsam fir	13	4	0	0	0.0909	1.8405		d.b.h.	no	0	0	0.86
12	balsam fir	13	2	-2.206	0	2.4605	1		d.b.h.	no	0	0.949	0
12	balsam fir	18	1	-1.258	3.21	1			d.b.h.	no	0	0.98	0
12	balsam fir	18	2	-4.1778	0	2.3367	1		d.b.h.	yes	1.15	0	0.92
12	balsam fir	18	2	-2.7854	0	1.6737	1		d.b.h.	yes	1.05	0	0.90
12	balsam fir	18	4	0	0	0.09982	1.6421		d.b.h.	no	0	0	0.85
12	balsam fir	18	2	-1.6452	0	2.4506	1		d.b.h.	no	0	0.944	0
12	balsam fir	24	2	-3.1432	0	2.3013	1		d.b.h.	yes	1.09	0	0.94

MinDiameter	MaxDiameter	Sample size	Stump height	Top d.o.b.	Units diameter	Units biomass	Component	Component sum	Ratio equation	Segmented equation	Equation number	Source	Notes
2.54	50.80	95			in	lb	na				1	177	no c reported; includes roots <= 1-inch
0.10	2.54	9			in	g	rts				1	177	no c reported; includes roots <= 1-inch
2.54	25.40	101	0		in	lb	ag				1	9	no bias correction; stems cut at groundline
2.50	28.30	30	0		cm	kg	ag				1	52	stump “as close to ground as possible”; to 9 cm d.o.b.
1.50	32.10	50	0		cm	kg	ag				1	82	stump as short as possible
0.10	2.54	13	0		in	g	ag				1	177	no c reported; small trees cut at ground surface
10.16	33.02	40	6		in	lb	agm				1	75	6-inch stump
0.10	40.00	200	6		cm	kg	na				1	83	Nova Scotia and New Brunswick; assume 6-inch stump (“trees were felled”)
1.00	20.00	20	6		cm	kg	agm				1	100	bias correction used by authors but not reported; assume 6-inch stump (“trees were felled”)
2.50	40.00	60	6		cm	kg	na	a			1	117	equations selected for presentation here do not require additional variables for biomass estimation (additional equations presented)
2.54	50.80	95	6		in	lb	agm				1	177	6-inch stump; no c reported
2.54	25.40	101	0	0	in	lb	na	c			1	9	no bias correction; stems cut at groundline
2.50	28.30	22	0	3.15	cm	kg	swm	c			1	52	stump “as close to ground as possible”; to 8 cm d.o.b.
2.50	28.30	30	0	0	cm	kg	na	c			1	52	stump “as close to ground as possible”; wood on total stem including top
1.50	32.10	50	0	0	cm	kg	na	c			1	82	stump as short as possible;stem top diameter not given so assume stem goes to terminal bud
0.10	40.00	200	6	0	cm	kg	na				1	83	Nova Scotia and New Brunswick; assume 6-inch stump (“trees were felled”)
2.54	25.40	101	0	0	in	lb	na	c			1	9	no bias correction; stems cut at groundline
2.50	28.30	22	0	3.15	cm	kg	sbm	c			1	52	stump “as close to ground as possible”; to 8 cm d.o.b.
2.50	28.30	30	0	0	cm	kg	na	c			1	52	stump “as close to ground as possible”; bark on total stem including top
1.50	32.10	50	0	0	cm	kg	na	c			1	82	stump as short as possible;stem top diameter not given so assume stem goes to terminal bud
2.50	28.30	22	0	3.15	cm	kg	na	c			1	52	stump “as close to ground as possible”; to 8 cm d.o.b.
2.50	28.30	30	0	0	cm	kg	na	c			1	52	stump “as close to ground as possible”; wood plus bark on total stem (incl. top)
1.50	32.10	50	0	0	cm	kg	na	c			1	82	stump as short as possible; stem top diameter not given so assume stem goes to terminal bud
0.10	40.00	200	6	0	cm	kg	na				1	83	Nova Scotia and New Brunswick; assume 6-inch stump (“trees were felled”)
1.00	20.00	20	6	0	cm	kg	na	c			1	100	bias correction used by authors but not reported; assume 6-inch stump (“trees were felled”); assume to stem tip
2.54	50.80	95	6	4	in	lb	na	c			1	177	6-inch stump to 4-inch top; no c reported
2.50	28.30	30			cm	kg	na	c			1	52	
2.54	25.40	101			in	lb	na	c			1	9	no bias correction
2.50	28.30	30			cm	kg	na	c			1	52	
2.54	25.40	101			in	lb	na				1	9	no bias correction
1.50	32.10	50			cm	kg	na				1	82	branch diameter not given
0.10	40.00	200			cm	kg	na				1	83	Nova Scotia and New Brunswick; assume 6-inch stump (“trees were felled”)
2.54	50.80	95			in	lb	na				1	177	no c reported
2.54	25.40	101			in	lb	fl				1	9	no bias correction
2.50	28.30	30			cm	kg	fl	t			1	52	
1.50	32.10	50			cm	kg	fl				1	82	
0.10	40.00	200			cm	kg	na				1	83	Nova Scotia and New Brunswick; assume 6-inch stump (“trees were felled”)
2.54	50.80	95			in	lb	fl				1	177	no c reported
2.50	28.30	30			cm	kg	na	c			1	52	does not include unmerchantable top of stem (assume 4-inch d.o.b.)

Continued

Table 3.—Continued.

Species	Common name	Component ID	Equation form ID	a	b	c	d	e	Diameter	Corrected for bias	Bias correction (CF)	r	R^2
12	balsam fir	24	2	-1.5924	0	1.8144	1		d.b.h.	yes	1.06	0	0.94
12	balsam fir	24	2	-2.0259	0	1.7433	1		d.b.h.	yes	1.05	0	0.90
12	balsam fir	24	1	-0.5856	1.3447	1			d.b.h.	yes	0	0	0.76
12	balsam fir	29	1	0.618	2.45	1			d.b.h.	no	0	0.96	0.00
12	balsam fir	29	4	-0.6653	0	0.066	2		d.b.h.	no	0	0	0.86
12	balsam fir	33	2	-1.0678	0	2.4613	1		d.b.h.	no	0	0	0.90
12	balsam fir	33	2	-0.7977	0	2.4515	1		d.b.h.	no	0	0.994	0
13	silver fir (Himalaya)	2	2	2.0656	0	0.9781	1		cbh	no	0	0	0.98
13	silver fir (Himalaya)	4	2	1.538	0	1.0088	1		cbh	no	0	0	0.97
13	silver fir (Himalaya)	5	2	-0.1066	0	0.8876	1		cbh	no	0	0	0.92
13	silver fir (Himalaya)	13	2	0.0356	0	0.9977	1		cbh	no	0	0	0.87
13	silver fir (Himalaya)	18	2	0.2464	0	0.6429	1		cbh	no	0	0	0.74
13	silver fir (Himalaya)	21	2	-0.0146	0	0.8374	1		cbh	no	0	0	0.84
13	silver fir (Himalaya)	26	2	-0.4874	0	1.0909	1		cbh	no	0	0	0.95
13	silver fir (Himalaya)	27	2	-0.651	0	0.9947	1		cbh	no	0	0	0.86
13	silver fir (Himalaya)	28	2	1.0137	0	0.4604	1		cbh	no	0	0	0.72
13	silver fir (Himalaya)	29	2	0.5244	0	0.998	1		cbh	no	0	0	0.96
15	White fir	2	2	4.36982	0	2.5043	1		d.b.h.	yes	1.014	0.981	0.00
15	White fir	4	2	-11.2634	0	2.7856	1		d.b.h.	no	0	0	0.973
15	White fir	4	2	3.11845	0	2.7011	1		d.b.h.	yes	1.032	0.994	0.00
15	White fir	5	2	-11.7086	0	2.7271	1		d.b.h.	no	0	0	0.944
15	White fir	5	2	2.36182	0	2.6201	1		d.b.h.	yes	1.03	0.994	0.00
15	White fir	6	2	-10.8036	0	2.7727	1		d.b.h.	no	0	0	0.977
15	White fir	8	2	2.82853	0	2.3418	1		d.b.h.	yes	1.158	0.926	0.00
15	White fir	18	2	3.81947	0	1.8855	1		d.b.h.	yes	1.123	0.954	0.00
15	White fir	23	2	4.47181	0	1.314	1		d.b.h.	yes	1.087	0.935	0.00
17	Grand fir	6	5	0.62	0	0.8024	0.1724		d.b.h.	no	0	0	0.99

MinDiameter	MaxDiameter	Sample size	Stump height	Top d.o.b.	Units diameter	Units biomass	Component	Component sum	Ratio equation	Segmented equation	Equation number	Source	Notes
2.50	28.30	30			cm	kg	na	c			1	52	does include unmerchantable top of stem (assume 4-inch d.o.b.)
1.50	32.10	50			cm	kg	na	c			1	82	
1.00	20.00	20			cm	kg	na	c			1	100	bias correction used by authors but not reported
2.54	25.40	89			in	lb	rto				1	10	assume all roots; eqn form log10W=consta + coeffX*log(dia) (assume both logs are base 10)
5.50	20.50	173			cm	kg	rto				1	84	roots > 1.5 mm; c not reported or used; d.b.h. range includes trees within +/- 2 se of mean d.b.h.
10.16	33.02	40	6		in	lb	rtm				1	75	to 6-inch stump; roots >= 1-inch diameter
2.54	50.80	95	6		in	lb	rtm	c			1	177	no c reported
30.00	370.00	12	0		cm	kg	ag	a			1	2	uprooted trees used so assume stump is 0-inch height
30.00	370.00	12	0	0	cm	kg	na	c			1	2	diameter range spans all species in study; actual range not given but could be smaller; no info on top diameter; assume “bole” means wood only
30.00	370.00	12	0	0	cm	kg	na	c			1	2	diameter range spans all species in study; actual range not given but could be smaller; no info on top diameter
30.00	370.00	12			cm	kg	na	c			1	2	diameter range spans all species in study; actual range not given but could be smaller
30.00	370.00	12			cm	kg	fl	c			1	2	diameter range spans all species in study; actual range not given but could be smaller
30.00	370.00	12			cm	kg	na	c			1	2	diameter range spans all species in study; actual range not given but could be smaller
30.00	370.00	12	0		cm	kg	na	r			1	2	diameter range spans all species in study; actual range not given but could be smaller; no definition for “stump roots” given; excavated to 1 m depth to 1 m radius around tree
30.00	370.00	12	0		cm	kg	na	r			1	2	diameter range spans all species in study; actual range not given but could be smaller; no definition for “lateral roots” given; excavated to 1 m depth to 1 m radius around tree
30.00	370.00	12	0		cm	kg	na	r			1	2	diameter range spans all species in study; actual range not given but could be smaller; fine roots defined as < 10 mm; excavated to 1 m depth to 1 m radius around tree
30.00	370.00	12	0		cm	kg	rt	b			1	2	diameter range spans all species in study; actual range not given but could be smaller; excavated to 1 m depth to 1 m radius around tree
7.00	98.00	12	40		cm	g	agm	a			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
14.4	158.4	56	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
7.00	98.00	12	40	0	cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
14.4	158.4	56	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
7.00	98.00	12	40	0	cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
14.4	158.4	56	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
7.00	98.00	12			cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
7.00	98.00	12			cm	g	fl	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias; “current and older leaves”
7.00	98.00	12			cm	g	na				1	171	felled at 1 meter height; coefficients as presented are corrected for bias; “current twigs and leaves”
0.00	10.16	12	6	0	in	lb	na				1	21	assume 6-inch stump (“trees were felled”); for trees < 4-inch d.b.h.; dominant trees

Continued

Table 3.—Continued.

Species	Common name	Component ID	Equation form ID	a	b	c	d	e	Diameter	Corrected for bias	Bias correction (CF)	r	R^2
17	Grand fir	6	4	-1.63	0	2.172	2		d.b.h.	no	0	0	0.87
17	Grand fir	24	2	1.0152	0	1.6839	1		d.b.h.	no	0	0	0.94
19	Subalpine fir	4	2	-9.84218	0	2.3971	1		d.b.h.	no	0	0	0.982
19	Subalpine fir	4	2	-9.79725	0	2.3891	1		d.b.h.	no	0	0	0.972
19	Subalpine fir	4	2	-9.92848	0	2.4428	1		d.b.h.	no	0	0	0.956
19	Subalpine fir	5	2	-12.3983	0	2.5006	1		d.b.h.	no	0	0	0.969
19	Subalpine fir	5	2	-11.5622	0	2.3149	1		d.b.h.	no	0	0	0.883
19	Subalpine fir	5	2	-13.5028	0	3.1413	1		d.b.h.	no	0	0	0.646
19	Subalpine fir	6	5	1.55	0	0	0.414		d.b.h.	no	0	0	0.99
19	Subalpine fir	6	2	-9.74475	0	2.4028	1		d.b.h.	no	0	0	0.982
19	Subalpine fir	6	2	-9.64298	0	2.3809	1		d.b.h.	no	0	0	0.970
19	Subalpine fir	6	2	-9.96814	0	2.5265	1		d.b.h.	no	0	0	0.988
19	Subalpine fir	35	4	7.345	0	1.255	2		d.b.h.	no	0	0	0.84
19	Subalpine fir	36	2	-6.5431	0	4.0365	1		d.b.h.	no	0	0	0.91
20	California red fir	2	2	2.61856	0	2.9121	1		d.b.h.	yes	1.025	0.981	0.00
20	California red fir	4	2	-11.1691	0	2.7621	1		d.b.h.	no	0	0	0.984
20	California red fir	4	2	2.55249	0	2.7821	1		d.b.h.	yes	1.038	0.968	0.00
20	California red fir	5	2	-12.3441	0	2.8421	1		d.b.h.	no	0	0	0.957
20	California red fir	5	2	1.4053	0	2.8468	1		d.b.h.	yes	1.073	0.945	0.00
20	California red fir	6	2	-10.7955	0	2.759	1		d.b.h.	no	0	0	0.987
20	California red fir	8	2	-1.82353	0	3.521	1		d.b.h.	yes	1.132	0.937	0.00
20	California red fir	18	2	-0.12667	0	2.9308	1		d.b.h.	yes	1.095	0.934	0.00
20	California red fir	23	2	2.65541	0	1.611	1		d.b.h.	yes	1.082	0.839	0.00
22	Noble fir	4	2	-3.7158	0	2.7592	1		d.b.h.	yes	0	0	0.99
22	Noble fir	4	2	-10.2145	0	2.6043	1		d.b.h.	no	0	0	0.984
22	Noble fir	5	2	-6.1	0	2.8943	1		d.b.h.	yes	0	0	0.99
22	Noble fir	5	2	-11.0236	0	2.4313	1		d.b.h.	no	0	0	0.922
22	Noble fir	6	2	-9.9228	0	2.5812	1		d.b.h.	no	0	0	0.984
22	Noble fir	8	2	-4.1817	0	2.3324	1		d.b.h.	yes	0	0	0.94

MinDiameter	MaxDiameter	Sample size	Stump height	Top d.o.b.	Units diameter	Units biomass	Component	Component sum	Ratio equation	Segmented equation	Equation number	Source	Notes
0.00	10.16	8	6	0	in	lb	na				2	21	assume 6-inch stump (“trees were felled”); for trees < 4-inch d.b.h.; intermediate trees
2.54	30.48	15			in	lb	na				1	21	dominant and codominant trees
15.6	68.7	17	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.6	68.7	21	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.7	46.9	11	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.6	68.7	17	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.6	68.7	21	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.7	46.9	11	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
0.00	10.16	12	6	0	in	lb	na				1	21	assume 6-inch stump; dominant trees
15.6	68.7	17	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.6	68.7	21	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.7	46.9	11	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
2.54	33.02	16			in	lb	na				1	21	assume 6-inch stump (“trees were felled”); dominant and codominant trees
2.54	33.02	16			in	lb	na				1	21	dominant and codominant trees; bias correction omitted because they contributed more bias than they eliminated
30.00	100.00	11	40		cm	g	agm	a			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
18.8	143.2	31	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
30.00	100.00	11	40	0	cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
18.8	143.2	31	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
30.00	100.00	11	40	0	cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
18.8	143.2	31	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
30.00	100.00	11			cm	g	na	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias
30.00	100.00	11			cm	g	fl	c			1	171	felled at 1 meter height; coefficients as presented are corrected for bias; “current and older leaves”
30.00	100.00	11			cm	g	na				1	171	felled at 1 meter height; coefficients as presented are corrected for bias; “current twigs and leaves”
18.8	111.0	6	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
15.9	235.5	310	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
18.8	111.0	6	6	0	cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias; assume 6-inch stump
15.9	235.5	310	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
15.9	235.5	310	6	0	cm	Mg	na				1	104	see ref 68 for original bibliographic source; no mention of bias correction; assume 6-inch stump
18.8	111.0	6			cm	kg	na				1	55	includes data from published and unpublished sources, as well as original work; coefficients corrected for bias

Table 4.—Species key, suggested assignments for species groups to apply generalized equations, and specific gravity information (see Appendix A)

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
0	conifers (general)								
10	fir spp.	Pinaceae	*Abies*	*spp.*	tf	0.357	0.375	94	
11	Pacific silver fir	Pinaceae	*Abies*	*amabilis*	tf	0.4			
12	balsam fir	Pinaceae	*Abies*	*balsamea*	tf	0.34	0.375	94	12
13	silver fir (Himalaya)	Pinaceae	*Abies*	*pindrow*	tf				
14	Bristlecone fir	Pinaceae	*Abies*	*bracteata*	tf				
15	White fir	Pinaceae	*Abies*	*concolor*	tf	0.37			
16	Fraser fir	Pinaceae	*Abies*	*fraseri*	tf	0.34	0.4	12	
17	Grand fir	Pinaceae	*Abies*	*grandis*	tf	0.35			
18	Corkbark fir	Pinaceae	*Abies*	*lasiocarpa var. arizonica*	tf	0.28			
19	Subalpine fir	Pinaceae	*Abies*	*lasiocarpa*	tf	0.31			
20	California red fir	Pinaceae	*Abies*	*magnifica*	tf	0.37			
21	Shasta red fir	Pinaceae	*Abies*	*magnifica var. shastensis*	tf	0.37			
22	Noble fir	Pinaceae	*Abies*	*procera*	tf	0.37			
41	Port-Orford-cedar	Pinaceae	*Chamaecyparis*	*lawsoniana*	cl	0.39			
42	Alaska-cedar	Pinaceae	*Chamaecyparis*	*nootkatensis*	cl	0.42			
43	Atlantic white-cedar	Pinaceae	*Chamaecyparis*	*thyoides*	cl	0.31	0.4	241	
50	Cypress	Cupressaceae	*Cupressus*	*spp.*	wo				
51	Arizona cypress	Cupressaceae	*Cupressus*	*arizonica*	wo				
58	Pinchot juniper	Cupressaceae	*Juniperus*	*pinchotti*	wo				
59	Redberry juniper	Cupressaceae	*Juniperus*	*erythrocarpa*	wo				
60	Common juniper	Cupressaceae	*Juniperus*	*communis*	wo	0.44	0.4	94	
60	redcedar	Cupressaceae	*Juniperus*	*spp.*	cl	0.44	0.4	241	
62	California juniper	Cupressaceae	*Juniperus*	*californica*	wo				
63	Alligator juniper	Cupressaceae	*Juniperus*	*deppeana*	wo	0.48			
64	Western juniper	Cupressaceae	*Juniperus*	*occidentalis*	wo				
65	Utah juniper	Cupressaceae	*Juniperus*	*osteosperma*	wo				
66	Rocky Mountain juniper	Cupressaceae	*Juniperus*	*scopulorum*	wo	0.44	0.4	94	
67	southern redcedar	Cupressaceae	*Juniperus*	*silicicola*	cl	0.44	0.4	241	
68	eastern redcedar	Cupressaceae	*Juniperus*	*virginiana*	cl	0.44	0.4	241	
69	Oneseed juniper	Cupressaceae	*Juniperus*	*monosperma*	wo				
70	larch (introduced)	Pinaceae	*Larix*	*spp.*	cl	0.48	0.4	125	
71	tamarack (native)	Pinaceae	*Larix*	*laricina*	cl	0.49	0.4	125	
72	Subalpine larch	Pinaceae	*Larix*	*lyallii*	cl	0.48			
73	Western larch	Pinaceae	*Larix*	*occidentalis*	cl	0.48			
81	Incense-cedar	Cupressaceae	*Calocedrus*	*decurrens*	cl	0.35			
90	spruce	Pinaceae	*Picea*	*spp.*	sp	0.366	0.3	94	
91	Norway spruce	Pinaceae	*Picea*	*abies*	sp	0.38	0.4	94	
92	Brewer spruce	Pinaceae	*Picea*	*breweriana*	sp				
93	Engelmann spruce	Pinaceae	*Picea*	*engelmannii*	sp	0.33	0.4	94	
94	white spruce	Pinaceae	*Picea*	*glauca*	sp	0.37	0.29	46	94
95	black spruce	Pinaceae	*Picea*	*mariana*	sp	0.38	0.351	94	95
96	blue spruce	Pinaceae	*Picea*	*pungens*	sp	0.38	0.4	94	
97	red spruce	Pinaceae	*Picea*	*rubens*	sp	0.38	0.32	94	
98	Sitka spruce	Pinaceae	*Picea*	*sitchensis*	sp	0.37			
100	pine spp.	Pinaceae	*Pinus*	*spp.*	**pi**				
101	Whitebark pine	Pinaceae	*Pinus*	*albicaulis*	pi				
102	Bristlecone pine	Pinaceae	*Pinus*	*aristata*	pi				
103	Knobcone pine	Pinaceae	*Pinus*	*attenuata*	pi				

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
104	Foxtail pine	Pinaceae	*Pinus*	*balfouriana*	pi				
105	jack pine	Pinaceae	*Pinus*	*banksiana*	pi	0.4	0.34	94	105
106	Twoneedle pinyon	Pinaceae	*Pinus*	*edulis*	pi				
107	sand pine	Pinaceae	*Pinus*	*clausa*	pi	0.46	0.45	125	
108	Lodgepole pine	Pinaceae	*Pinus*	*contorta*	pi	0.38			
109	Coulter pine	Pinaceae	*Pinus*	*coulteri*	pi				
110	shortleaf pine	Pinaceae	*Pinus*	*echinata*	pi	0.47	0.45	125	
111	slash pine	Pinaceae	*Pinus*	*elliottii*	pi	0.54	0.45	125	
112	Apache pine	Pinaceae	*Pinus*	*engelmannii*	pi				
113	Limber pine	Pinaceae	*Pinus*	*flexilis*	pi	0.37			
114	Southwestern white pine	Pinaceae	*Pinus*	*strobiformis*	pi				
115	spruce pine	Pinaceae	*Pinus*	*glabra*	pi	0.41	0.45	125	
116	Jeffrey pine	Pinaceae	*Pinus*	*jeffreyi*	pi	0.37			
117	Sugar pine	Pinaceae	*Pinus*	*lambertiana*	pi	0.34			
118	Chihuahuan pine	Pinaceae	*Pinus*	*leiophylla*	pi				
119	Western white pine	Pinaceae	*Pinus*	*monticola*	pi	0.35			
120	Bishop pine	Pinaceae	*Pinus*	*muricata*	pi				
121	longleaf pine	Pinaceae	*Pinus*	*palustris*	pi	0.54	0.45	125	
122	ponderosa pine	Pinaceae	*Pinus*	*ponderosa*	pi	0.38	0.4	125	
123	Table Mountain pine	Pinaceae	*Pinus*	*pungens*	pi	0.49	0.45	125	
124	Monterey pine	Pinaceae	*Pinus*	*radiata*	pi				
125	red pine	Pinaceae	*Pinus*	*resinosa*	pi	0.41	0.243	125	
126	pitch pine	Pinaceae	*Pinus*	*rigida*	pi	0.47	0.45	125	
127	California foothill pine	Pinaceae	*Pinus*	*sabiniana*	pi				
128	pond pine	Pinaceae	*Pinus*	*serotina*	pi	0.51	0.45	125	
129	eastern white pine	Pinaceae	*Pinus*	*strobus*	pi	0.34	0.34	129	
130	Scotch pine	Pinaceae	*Pinus*	*sylvestris*	pi	0.41	0.45	125	
131	loblolly pine	Pinaceae	*Pinus*	*taeda*	pi	0.47	0.45	125	
132	Virginia pine	Pinaceae	*Pinus*	*virginiana*	pi	0.45	0.45	125	
133	Singleleaf pinyon	Pinaceae	*Pinus*	*monophylla*	pi	0.41	0.4	94	
133	Austrian pine	Pinaceae	*Pinus*	*nigra*	pi	0.41	0.4	125	
134	Border pinyon	Pinaceae	*Pinus*	*discolor*	pi				
135	Arizona pine	Pinaceae	*Pinus*	*arizonica*	pi				
136	Border pinyon	Pinaceae	*Pinus*	*cembroides*	**pi**				
145	Roxburg pine	Pinaceae	*Pinus*	*roxburghii (Himalayas)*	**pi**				
201	Bigcone Douglas-fir	Pinaceae	*Pseudotsuga*	*macrocarpa*	df				
202	Douglas-fir	Pinaceae	*Pseudotsuga*	*menziesii*	df	0.45	0.4	94	
211	Redwood	Taxodiaceae	*Sequoia*	*sempervirens*	cl	0.36			
212	Giant sequoia	Taxodiaceae	*Sequoiadendron*	*giganteum*	cl				
221	baldcypress	Cupressaceae	*Taxodium*	*distichum*	cl	0.42	0.42	241	
222	pondcypress	Cupressaceae	*Taxodium*	*distichum var. nutans*	cl				
231	Pacific yew	Taxaceae	*Taxus*	*brevifolia*	tf	0.6			
241	northern white-cedar	Cupressaceae	*Thuja*	*occidentalis*	cl	0.29	0.29	241	
242	Western redcedar	Cupressaceae	*Thuja*	*plicata*	cl	0.31			
251	California nutmeg	Taxaceae	*Torreya*	*californica*	tf				
260	hemlock	Pinaceae	*Tsuga*	*spp.*	tf	0.38	0.34	261	
261	eastern hemlock	Pinaceae	*Tsuga*	*canadensis*	tf	0.38	0.34	261	
262	Carolina hemlock	Pinaceae	*Tsuga*	*caroliniana*	tf	0.38	0.34	261	
263	Western hemlock	Pinaceae	*Tsuga*	*heterophylla*	tf	0.42			
264	Mountain hemlock	Pinaceae	*Tsuga*	*mertensiana*	tf	0.42			

Continued

Table 4.—Continued.

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
290	timber tree	Mimosaceae	*Albizia*	*falcataria (Hawaii)*	wo				
300	acacia	various	*Acacia*	*spp.*	wo	0.6	0.5	316	
302	yellow paloverde	Caesalpinaceae	*Cercidium*	*microphyllum*	wo				
303	Australian blackwood	Fabaceae	*Acacia*	*melanoxylon (Hawaii)*	wo				
304	prickly acacia	Fabaceae	*Acacia*	*nilotica (India)*	wo				
305	earleaf acacia	Leguminosae	*Acacia*	*auriculiformis (Thailand)*	wo				
306	mangium	Fabaceae	*Acacia*	*mangium (Hawaii)*	wo				
307	black wattle	Fabaceae	*Acacia*	*mearnsii (Hawaii)*	wo				
308	willow acacia	Fabaceae	*Acacia*	*salicina*	wo				
309	black cutch	Fabaceae	*Acacia*	*catechu (India)*	wo				
310	Australian pine	Casuarinaceae	*Casuarina*	*equisetifolia (Hawaii)*	wo				
311	Florida maple	Aceraceae	*Acer*	*barbatum*	mb	0.54	0.64	318	
312	Bigleaf maple	Aceraceae	*Acer*	*macrophyllum*	mb	0.44			
313	boxelder	Aceraceae	*Acer*	*negundo*	mb	0.44	0.5	970	
314	black maple	Aceraceae	*Acer*	*nigrum*	mo	0.52	0.64	316	
315	striped maple	Aceraceae	*Acer*	*pensylvanicum*	mb	0.44	0.45	316	
316	red maple	Aceraceae	*Acer*	*rubrum*	mb	0.49	0.5805	36	316
317	silver maple	Aceraceae	*Acer*	*saccharinum*	mb	0.44	0.58	316	
318	sugar maple	Aceraceae	*Acer*	*saccharum*	mo	0.56	0.635	93	318
319	mountain maple	Aceraceae	*Acer*	*spicatum*	mb	0.44	0.45	316	
321	Rocky Mountain maple	Aceraceae	*Acer*	*glabrum*	wo	0.44	0.45	318	
322	Bigtooth maple	Aceraceae	*Acer*	*grandidentatum*	wo				
330	buckeye, horsechestnut	Hippocastanaceae	*Aesculus*	*spp.*	mh	0.33	0.5	541	
331	Ohio buckeye	Hippocastanaceae	*Aesculus*	*glabra*	mh	0.33	0.5	541	
332	yellow buckeye	Hippocastanaceae	*Aesculus*	*octandra*	mh	0.33	0.5	541	
333	California buckeye	Hippocastanaceae	*Aesculus*	*californica*	mh	0.33	0.5	541	
334	Texas buckeye	Hippocastanaceae	*Aesculus*	*glabra var. arguta*	mh				
335	horsechestnut	Hippocastanaceae	*Aesculus*	*indica (Himalayas)*	mh				
341	ailanthus	Simaroubaceae	*Ailanthus*	*altissima*	mh	0.33	0.45	316	
351	red alder	Betulaceae	*Alnus*	*spp.*	aa	0.37	0.4	316	
352	White alder	Betulaceae	*Alnus*	*rhombifolia*	aa				
353	sitka alder	Betulaceae	*Alnus*	*sinuata*	**aa**				
355	serviceberry	Rosaceae	*Amelanchier*	*spp.*	mh	0.66	0.45	316	
361	Pacific madrone	Ericaceae	*Arbutus*	*menziesii*	mh				
367	pawpaw	Annonaceae	*Asimina*	*triloba*	mh	0.47	0.45	316	
370	birch spp.	Betulaceae	*Betula*	*spp.*	mb	0.54	0.5	371	
371	yellow birch	Betulaceae	*Betula*	*alleghaniensis*	mb	0.55	0.56	371	
372	sweet birch	Betulaceae	*Betula*	*lenta*	mb	0.6	0.67	36	371
373	river birch	Betulaceae	*Betula*	*nigra*	mb	0.56	0.5	371	
374	water birch	Betulaceae	*Betula*	*occidentalis*	mb	0.53	0.5	371	
375	paper birch	Betulaceae	*Betula*	*papyrifera*	mb	0.48	0.5	375	
376	Western paper birch	Betulaceae	*Betula*	*papyrifera var. commutata*	mb				
379	gray birch	Betulaceae	*Betula*	*populifolia*	mb	0.45	0.5	375	
381	chittamwood, gum bumelia	Sapotaceae	*Bumelia*	*lanuginosa*	mh	0.47	0.45	316	
391	American hornbeam, musclewood	Betulaceae	*Carpinus*	*caroliniana*	mh	0.58	0.45	316	
395	lead tree	Fabaceae	*Leucaena*	*leucocephala (Thailand)*	mh				
400	hickory spp.	Juglandaceae	*Carya*	*spp.*	mo	0.62	0.5355	36	951
401	water hickory	Juglandaceae	*Carya*	*aquatica*	mo	0.61	0.54	951	
402	bitternut hickory	Juglandaceae	*Carya*	*cordiformis*	mo	0.6	0.54	951	
403	pignut hickory	Juglandaceae	*Carya*	*glabra*	mo	0.66	0.54	951	

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
404	pecan	Juglandaceae	*Carya*	*illinoensis*	mo	0.6	0.54	951	
405	shellbark hickory	Juglandaceae	*Carya*	*laciniosa*	mo	0.62	0.54	951	
407	shagbark hickory	Juglandaceae	*Carya*	*ovata*	mo	0.64	0.54	951	
408	black hickory	Juglandaceae	*Carya*	*texana*	mo	0.54	0.54	951	
409	mockernut hickory	Juglandaceae	*Carya*	*tomentosa*	mo	0.64	0.54	951	
421	American chestnut	Fagaceae	*Castanea*	*dentata*	mh	0.4	0.5	316	
422	Allegheny chinkapin	Fagaceae	*Castanea*	*pumila*	mh	0.4	0.5	316	
423	Ozark chinkapin	Fagaceae	*Castanea*	*ozarkensis*	mh	0.4	0.5	970	
430	chinkapin	Fagaceae	*Castanopsis*	*spp.*	mh	0.42	0.45	316	
431	Golden chinkapin	Fagaceae	*Castanopsis*	*chrysophylla*	mh				
450	catalpa	Bignoniaceae	*Catalpa*	*spp.*	mh	0.38	0.5	740	
451	southern catalpa	Bignoniaceae	*Catalpa*	*bignonioides*	mh	0.38	0.45	316	
452	northern catalpa	Bignoniaceae	*Catalpa*	*speciosa*	mh	0.38	0.5	740	
460	hackberry spp.	Ulmaceae	*Celtis*	*spp.*	mh	0.49	0.5	371	
461	sugarberry	Ulmaceae	*Celtis*	*laevigata*	mh	0.47	0.5	371	
462	hackberry	Ulmaceae	*Celtis*	*occidentalis*	mh	0.49	0.5	371	
471	eastern redbud	Leguminosae	*Ceriss*	*canadensis*	mh	0.58	0.5	316	
475	Curlleaf mountain-mahogany	Rosaceae	*Cercocarpus*	*ledifolius*	wo				
476	True mountain-mahogany	Rosaceae	*Cercocarpus*	*montanus*	wo				
477	Hairy mountain-mahogany	Rosaceae	*Cercocarpus*	*montanus var. pauciden*	wo				
478	Birchleaf mountain-mahogany	Rosaceae	*Cercocarpus*	*montanus var. glaber*	wo				
479	Littleleaf mountain-mahogany	Rosaceae	*Cercocarpus*	*intricatus*	wo				
491	flowering dogwood	Cornaceae	*Cornus*	*florida*	mh	0.64	0.5	316	
492	Pacific dogwood	Cornaceae	*Cornus*	*nuttallii*	mh	0.58			
500	hawthorn	Rosaceae	*Crataegus*	*spp.*	mh	0.62	0.45	316	
510	Eucalyptus	Myrtaceae	*Eucalyptus*	*spp.*	mh				
511	rose gum	Myrtaceae	*Eucalyptus*	*grandis (Hawaii)*	mh				
512	swamp mahogany	Myrtaceae	*Eucalyptus*	*robusta (Hawaii)*	mh				
513	sydney blue eucalyptus	Myrtaceae	*Eucalyptus*	*saligna (Hawaii)*	mh				
514	flat-topped yate	Myrtaceae	*Eucalyptus*	*occidentalis*	mh				
515	Tasmanian blue gum	Myrtaceae	*Eucalyptus*	*globulus (Hawaii)*	mh				
516	Timor mountain gum	Myrtaceae	*Eucalyptus*	*urophylla (Hawaii)*	mh				
521	common persimmon	Ebenaceae	*Diospyros*	*virginiana*	mh	0.64	0.5	316	
531	American beech	Fagaceae	*Fagus*	*grandifolia*	mo	0.56	0.5	531	
540	ash	Oleaceae	*Fraxinus*	*spp.*	mh	0.51	0.65	28	541
541	white ash	Oleaceae	*Fraxinus*	*americana*	mh	0.55	0.3855	36	541
542	Oregon ash	Oleaceae	*Fraxinus*	*latifolia*	mh	0.5			
543	black ash	Oleaceae	*Fraxinus*	*nigra*	mh	0.45	0.39	543	
544	green ash	Oleaceae	*Fraxinus*	*pennsylvanica*	mh	0.53	0.407	33	541
545	pumpkin ash	Oleaceae	*Fraxinus*	*profunda*	mh	0.48	0.39	541	
546	blue ash	Oleaceae	*Fraxinus*	*quadrangulata*	mh	0.53	0.39	541	
551	waterlocust	Leguminosae	*Gleditsia*	*aquatica*	mh	0.6	0.5	316	
552	honeylocust	Leguminosae	*Gleditsia*	*triacanthos*	mh	0.6	0.5	316	
555	loblolly-bay	Theaceae	*Gordonia*	*lasianthus*	mh	0.37	0.5	951	
571	Kentucky coffeetree	Leguminosae	*Gymnocladus*	*dioicus*	mh	0.5	0.5	316	
580	silverbell	Styracaceae	*Halesia*	*spp.*	mh	0.42	0.5		
591	American holly	Aquifoliaceae	*Ilex*	*opaca*	mh	0.5	0.5	316	
600	Walnut	Juglandaceae	*Juglans*	*spp.*	mh	0.51			
601	butternut	Juglandaceae	*Juglans*	*cinerea*	mh	0.36	0.5	531	
602	black walnut	Juglandaceae	*Juglans*	*nigra*	mh	0.51	0.5	951	

Continued

Table 4.—Continued.

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
606	walnut	Juglandaceae	*Juglans*	*regia (Himalayas)*	mh				
611	sweetgum	Hamamelidaceae	*Liquidambar*	*styraciflua*	mh	0.46	0.3903	35	951
621	yellow-poplar	Magnoliaceae	*Liriodendron*	*tulipifera*	mh	0.4	0.364	36	746
631	Tanoak	Fagaceae	*Lithocarpus*	*densiflorus*	mh				
641	Osage-orange	Moraceae	*Maclura*	*pomifera*	mh	0.76	0.45	316	
650	magnolia spp.	Magnoliaceae	*Magnolia*	*spp.*	mh	0.43	0.5	951	
651	cucumbertree	Magnoliaceae	*Magnolia*	*acuminata*	mh	0.44	0.5	951	
652	southern magnolia	Magnoliaceae	*Magnolia*	*grandiflora*	mh	0.46	0.46	951	
653	sweetbay	Magnoliaceae	*Magnolia*	*virginiana*	mh	0.45	0.5	951	
654	bigleaf magnolia	Magnoliaceae	*Magnolia*	*macrophylla*	mh	0.45	0.45	951	
660	Apple	Rosaceae	*Malus*	*spp.*	mh	0.61	0.45	316	
680	mulberry spp.	Moraceae	*Morus*	*spp.*	mh	0.59	0.5	371	
681	white mulberry	Moraceae	*Morus*	*alba*	mh	0.59	0.5	371	
682	red mulberry	Moraceae	*Morus*	*rubra*	mh	0.59	0.5	316	
691	water tupelo	Nyssaceae	*Nyssa*	*aquatica*	mh	0.46	0.3483	33	951
692	ogeechee tupelo	Nyssaceae	*Nyssa*	*ogeche*	mh	0.46	0.45	316	
693	blackgum	Nyssaceae	*Nyssa*	*sylvatica*	mh	0.46	0.4465	36	951
694	swamp tupelo	Nyssaceae	*Nyssa*	*sylvatica var. biflora*	mh	0.46	0.35	951	
701	eastern hophornbeam, ironwood	Betulaceae	*Ostrya*	*virginiana*	mh	0.63	0.45	316	
711	sourwood	Ericaceae	*Oxydendrum*	*arboreum*	mh	0.5	0.45	316	
712	Paulownia, Empress tree	Bignoniaceae	*Paulownia*	*tomentosa*	mh	0.38	0.5	316	
721	redbay	Lauraceae	*Persea*	*borbonia*	mh	0.51	0.5	371	
730	California sycamore	Platanaceae	*Platanus*	*racemosa*	mh	0.36			
731	sycamore	Platanaceae	*Platanus*	*occidentalis*	mh	0.46	0.5177	34	531
740	cottonwood	Salicaceae	*Populus*	*spp.*	aa	0.37	0.452	740	
741	balsam poplar	Salicaceae	*Populus*	*balsamifera*	aa	0.31	0.452	740	
742	eastern cottonwood	Salicaceae	*Populus*	*deltoides*	aa	0.37	0.452	740	
743	bigtooth aspen	Salicaceae	*Populus*	*grandidentata*	aa	0.36	0.452	743	
744	swamp cottonwood	Salicaceae	*Populus*	*heterophylla*	aa	0.37	0.452	740	
745	plains cottonwood	Salicaceae	*Populus*	*sargentii*	aa	0.37	0.452	740	
746	quaking aspen	Salicaceae	*Populus*	*tremuloides*	aa	0.35	0.452	94	746
747	Black cottonwood	Salicaceae	*Populus*	*balsamifera sspp. Trichocar*	aa	0.31			
748	Fremont cottonwood	Salicaceae	*Populus*	*fremontii*	aa				
752	silver poplar	Salicaceae	*Populus*	*alba*	aa	0.37	0.452	746	
753	Narrowleaf cottonwood	Salicaceae	*Populus*	*angustifolia*	aa	0.37	0.452	740	
760	cherry, plum spp.	Rosaceae	*Prunus*	*spp.*	mh	0.47	0.45	316	
761	pin cherry	Rosaceae	*Prunus*	*pensylvanica*	mh	0.36	0.45	316	
762	black cherry	Rosaceae	*Prunus*	*serotina*	mh	0.47	0.5925	145	375
763	chokecherry	Rosaceae	*Prunus*	*virginiana*	mh	0.36	0.45	316	
764	Bitter cherry	Rosaceae	*Prunus*	*emarginata*	wo	0.47	0.45	316	
764	plums, cherries, except 762	Rosaceae	*Prunus*	*spp.*	mh	0.47	0.45	316	
765	Canada plum	Rosaceae	*Prunus*	*nigra*	mh	0.47	0.45	316	
766	wild plum	Rosaceae	*Prunus*	*americana*	mh	0.47	0.45	740	
800	Oak-deciduous (woodland species)	Fagaceae	*Quercus*	*spp.*	wo				
801	California live oak	Fagaceae	*Quercus*	*agrifolia*	mo				
802	white oak	Fagaceae	*Quercus*	*alba*	mo	0.6	0.513	36	802
803	Arizona white oak, Gray oak	Fagaceae	*Quercus*	*arizonica, grisea*	wo				
804	swamp white oak	Fagaceae	*Quercus*	*bicolor*	mo	0.64	0.513	802	
805	Canyon live oak	Fagaceae	*Quercus*	*chrysolepis*	mo	0.7			
806	scarlet oak	Fagaceae	*Quercus*	*coccinea*	mo	0.6	0.6357	36	833

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
807	Blue oak	Fagaceae	*Quercus*	*douglasii*	mo				
808	Durand oak	Fagaceae	*Quercus*	*durandii*	mo	0.6	0.513	802	
809	northern pin oak	Fagaceae	*Quercus*	*ellipsoidalis*	mo	0.58	0.6	802	
810	Emory oak	Fagaceae	*Quercus*	*emoryi*	wo				
811	Engelmann oak	Fagaceae	*Quercus*	*engelmannii*	mo				
812	southern red oak	Fagaceae	*Quercus*	*falcata var. falcata*	mo	0.52	0.6465	35	833
813	cherrybark oak, swamp red oak	Fagaceae	*Quercus*	*falcata var. pagodaefolia*	mo	0.61	0.629	833	
814	Gambel oak	Fagaceae	*Quercus*	*gambelii*	wo				
815	Oregon white oak	Fagaceae	*Quercus*	*garryana*	mo	0.64			
816	bear oak, scrub oak	Fagaceae	*Quercus*	*ilicifolia*	mo	0.56	0.45	833	
817	shingle oak	Fagaceae	*Quercus*	*imbricaria*	mo	0.56	0.6	802	
818	California black oak	Fagaceae	*Quercus*	*kelloggii*	mo	0.51			
819	turkey oak	Fagaceae	*Quercus*	*laevis*	mo	0.52	0.45	316	
820	laurel oak	Fagaceae	*Quercus*	*laurifolia*	mo	0.56	0.635	33	833
821	California white oak	Fagaceae	*Quercus*	*lobata*	mo				
822	overcup oak	Fagaceae	*Quercus*	*lyrata*	mo	0.57	0.51	833	
823	bur oak	Fagaceae	*Quercus*	*macrocarpa*	mo	0.58	0.513	802	
824	blackjack oak	Fagaceae	*Quercus*	*marilandica*	mo	0.56	0.6	833	
825	swamp chestnut oak	Fagaceae	*Quercus*	*michauxii*	mo	0.6	0.513	802	
826	chinkapin oak	Fagaceae	*Quercus*	*muehlenbergii*	mo	0.6	0.513	802	
827	water oak	Fagaceae	*Quercus*	*nigra*	mo	0.56	0.622	33	833
828	Nuttall oak	Fagaceae	*Quercus*	*nuttalii*	mo	0.56	0.6	802	
829	Mexican blue oak	Fagaceae	*Quercus*	*oblongifolia*	wo				
830	pin oak	Fagaceae	*Quercus*	*palustris*	mo	0.58	0.6	833	
831	willow oak	Fagaceae	*Quercus*	*phellos*	mo	0.56	0.6	802	
832	chestnut oak	Fagaceae	*Quercus*	*prinus*	mo	0.57	0.509	36	802
833	northern red oak	Fagaceae	*Quercus*	*rubra*	mo	0.56	0.629	833	
834	Shumard oak	Fagaceae	*Quercus*	*shumardii*	mo	0.56	0.629	802	
835	post oak	Fagaceae	*Quercus*	*stellata*	mo	0.6	0.5155	35	833
836	Delta post oak	Fagaceae	*Quercus*	*stellata var. mississippiensis*	mo	0.6	0.51	833	
837	black oak	Fagaceae	*Quercus*	*velutina*	mo	0.56	0.568	36	833
838	live oak	Fagaceae	*Quercus*	*virginiana*	mo	0.8	0.51	833	
839	Interior live oak	Fagaceae	*Quercus*	*wislizeni*	mo				
840	bluejack oak	Fagaceae	*Quercus*	*incana*	mo	0.56	0.45	802	
843	Silverleaf oak	Fagaceae	*Quercus*	*hypoleucoides*	wo				
850	Oakevergreen (woodland species)	Fagaceae	*Quercus*	*spp.*	wo				
855	banj oak	Fagaceae	*Quercus*	*leucotricophora*	mo				
856	kharsu oak	Fagaceae	*Quercus*	*semecarpifolia*	mo				
899	scrub oak	Fagaceae	*Quercus*	*spp.*	mo	0.56	0.45	802	
901	black locust	Leguminosae	*Robinia*	*psuedoacacia*	mh	0.66	0.286	36	316
902	New Mexico locust	Leguminosae	*Robinia*	*neomexicana*	wo				
920	willow	Salicaceae	*Salix*	*spp.*	aa	0.36	0.415	28	316
921	peachleaf willow	Salicaceae	*Salix*	*amygdaloides*	aa	0.36	0.45	316	
922	black willow	Salicaceae	*Salix*	*nigra*	aa	0.36	0.5	316	
923	diamond willow	Salicaceae	*Salix*	*eriocephala*	aa	0.36	0.45	316	
925	Chinese tallowtree	Euphorbiaceae	*Sapium*	*sebiferum*	mh	0.47	0.45	316	
931	sassafras	Lauraceae	*Sassafras*	*albidum*	mh	0.42	0.5	316	
935	American mountain-ash	Rosaceae	*Sorbus*	*americana*	mh	0.42	0.45	316	
936	European mountain-ash	Rosaceae	*Sorbus*	*aucuparia*	mh	0.42	0.45	316	

Continued

Table 4.—Continued.

FIA ID	Common name	Family	Genus	Species	Species group	Wood specific gravity	Bark specific gravity	Bark specific gravity source	Stump volume equation
950	basswood	Tiliaceae	*Tilia*	*spp.*	mh	0.32	0.4205	951	
951	American basswood	Tiliaceae	*Tilia*	*americana*	mh	0.32	0.4205	36	951
952	white basswood	Tiliaceae	*Tilia*	*heterophylla*	mh	0.32	0.4205	951	
970	elm	Ulmaceae	*Ulmus*	*spp.*	mh	0.5	0.3775	34	970
971	winged elm	Ulmaceae	*Ulmus*	*alata*	mh	0.57	0.5	970	
972	American elm	Ulmaceae	*Ulmus*	*americana*	mh	0.46	0.5	970	
973	cedar elm	Ulmaceae	*Ulmus*	*crassifolia*	mh	0.57	0.5	970	
974	Siberian elm	Ulmaceae	*Ulmus*	*pumila*	mh	0.46	0.5	970	
975	slippery elm	Ulmaceae	*Ulmus*	*rubra*	mh	0.48	0.5	970	
976	September elm	Ulmaceae	*Ulmus*	*serotina*	mh	0.57	0.5	970	
977	rock elm	Ulmaceae	*Ulmus*	*thomasii*	mh	0.57	0.5	970	
980	tung-oil tree	Euphorbiaceae	*Aleurites*	*fordii*	mh	0.47	0.45	316	
981	California-laurel	Ericaceae	*Umbellularia*	*californica*	mh	0.47	0.45	316	
981	sparkleberry	Ericaceae	*Vaccinium*	*arboreum*	mh	0.47	0.45	316	
983	chinaberry	Meliaceae	*Melia*	*azedarach*	mh	0.47	0.45	316	
984	water-elm	Ulmaceae	*Planera*	*aquatica*	mh	0.53	0.45	970	
985	smoketree	Anacardiaceae	*Cotinus*	*obovatus*	mh	0.47	0.45	316	
986	mesquite	Leguminosae	*Prosopis*	*spp.*	wo	0.58	0.45	316	
990	Tesota (Arizona ironwood)	Leguminosae	*Olneya*	*tesota*	wo				
1000	hardwoods (general)	General	*Hardwood*	*spp.*	mh	0.5	0.5	951	

Table 5.—Tree component key

Component description	Component abbreviation[a]	Component ID
Complete tree (above + belowground)	BTT	1
Whole tree (aboveground)	BAT	2
Whole tree (above stump)		3
Stem (wood only)	BSW	4
Stem (bark only)	BSB	5
Stem (wood + bark)	BST	6
Stem top		7
Branches live	BBL	8
Branches live < 2.5 cm	BBL_1	9
Branches live 2.5-7.6 cm	BBL_2	10
Branches live > 7.6 cm	BBL_3	11
Branches dead	BBD	12
Branches total (live + dead)	BBT	13
Stem + branches (bark only)		14
Stem + branches (wood only)		15
Stem + branches (live)	BAP	16
Wood, bark, branches (live + dead; no twigs or foliage)	BAE	17
Foliage total	BFT	18
Foliage new	BFN	19
Foliage old	BFO	20
Twigs total	BBG	21
Twigs old	BBG_O	22
Foliage + twigs	BFG	23
Crown (branches + foliage + twigs)	BCT	24
Roots, coarse > 3 mm dia	BKL	25
Coarse stump roots	BSR	26
Coarse lateral roots	BLR	27
Fine roots	BFR	28
Roots total	BRT	29
Stump wood		30
Stump bark		31
Stump total		32
Stump + roots		33
Cones		34
Live crown (branches + foliage + twigs)	BCL	35
Dead crown (branches + foliage + twigs)	BCD	36
Small branches	BBS	37

[a]See BIOPAK compilation in Means et al. (1994).

Table 6.—Equation form key

Equation form description	Equation form ID
log10 biomass = a + b * (log10(dia^c))	1
ln biomass = a + b * dia + c * (ln(dia^d))	2
ln biomass = a + b * ln(dia) + c * (d + (e * ln(dia)))	3
biomass = a + b * dia + c * (dia ^ d)	4
biomass = a + (b * dia) + c * (dia ^ 2) + d * (dia ^ 3)	5
biomass = a * (exp(b + (c * ln(dia)) + (d * dia)))	6
biomass = a + ((b * (dia ^ c))/((dia ^ c) + d))	7
log100 biomass = a + (b * log10(dia))	8
ln biomass = ln(a) + (b * ln(dia))	9

Table 7.—Parameters for stem ratio equations for selected stem biomass equations (See text for explanation of equation use)

Source	Species	Component	a	b	c
33	316	st	-2.27985	4.42188	-4.59723
33	400	st	-2.70268	4.40866	-4.59728
33	544	st	-0.79675	3.05645	-2.96884
33	611	st	-2.17912	4.37749	-4.55793
33	621	st	-0.86509	4.22701	-4.11086
33	691	st	-1.66379	3.46696	-3.51675
33	693	st	-1.27291	4.23402	-4.2434
33	802	st	-1.43138	3.68884	-3.84353
33	820	st	-2.12286	4.59564	-4.83455
33	827	st	-1.28716	4.6938	-4.65009
33	316	sw	-2.20332	4.56197	-4.71937
33	400	sw	-2.7134	4.53012	-4.71976
33	544	sw	-0.81859	3.16181	-3.08978
33	611	sw	-2.13084	4.56383	-4.73251
33	621	sw	-0.86026	4.31966	-4.19801
33	691	sw	-1.65907	3.54754	-3.60457
33	693	sw	-1.37905	4.35347	-4.40059
33	802	sw	-1.47803	3.87194	-4.02826
33	820	sw	-2.51431	4.93186	-5.22179
33	827	sw	-1.26866	4.79701	-4.7429
34	316	st	-0.7675	4.32891	-4.04315
34	400	st	-8.75055	4.05001	-4.97494
34	611	st	-1.70312	4.00522	-4.07778
34	621	st	-1.7621	4.04115	-4.21537
34	731	st	-2.30869	4.75038	-4.8381
34	802	st	-1.91277	3.93041	-4.19809
34	806	st	-4.0717	3.5959	-4.3308
34	812	st	-1.9982	3.47308	-3.75484
34	832	st	-1.21241	4.73014	-4.70501
34	970	st	-1.85693	4.17785	-4.19195
34	316	sw	-0.73261	4.3608	-4.05919
34	400	sw	-8.62935	4.08077	-5.00432
34	611	sw	-1.65108	4.08554	-4.15193
34	621	sw	-1.71038	4.11441	-4.28158
34	731	sw	-2.28046	4.80799	-4.88602
34	802	sw	-1.85655	4.04282	-4.2976
34	806	sw	-4.08401	3.68907	-4.42364
34	812	sw	-2.07378	3.53706	-3.83789
34	832	sw	-1.19487	4.87213	-4.83716
34	970	sw	-0.56432	3.52387	-3.07702
35	400	st	-3.10193	4.32745	-4.7071
35	611	st	-2.07716	4.77234	-4.80657
35	621	st	-1.97288	4.84199	-4.95434
35	802	st	-2.03925	4.97981	-5.10296
35	806	st	-2.00681	4.4127	-4.66309
35	812	st	-3.83036	3.96024	-4.39942
35	835	st	-1.91071	4.10398	-4.35362
35	400	sw	-3.13482	4.40292	-4.78594
35	611	sw	-1.93715	4.91375	-4.91348
35	621	sw	-1.99918	4.96877	-5.08179
35	802	sw	-1.95384	5.13262	-5.2319

Continued

Table 7.—Continued.

Source	Species	Component	a	b	c
35	806	sw	-1.97765	4.48821	-4.73111
35	812	sw	-3.85832	4.02836	-4.47336
35	835	sw	-1.83838	4.18398	-4.41261
36	316	st	-1.43083	4.05497	-4.12303
36	372	st	-0.81251	4.21844	-4.08482
36	400	st	-4.48018	3.83474	-4.43554
36	541	st	-0.84279	3.28603	-3.33279
36	621	st	-3.54839	3.17747	-3.76535
36	693	st	-1.6209	4.27337	-4.51105
36	802	st	-12.00001	2.64614	-3.9633
36	806	st	-2.65117	3.58558	-4.09877
36	832	st	-2.25664	4.00092	-4.35574
36	833	st	-1.90345	3.95236	-4.27185
36	837	st	-4.35164	3.85984	-4.49173
36	901	st	-1.279	3.33578	-3.49181
36	951	st	-1.28273	3.87891	-3.97929
36	316	sw	-1.33864	4.16262	-4.20601
36	372	sw	-0.72051	4.31785	-4.13646
36	400	sw	-4.36489	3.93623	-4.52542
36	541	sw	-0.80589	3.3815	-3.41391
36	621	sw	-3.51229	3.24724	-3.83278
36	693	sw	-1.34282	4.39292	-4.56007
36	802	sw	-12.83857	2.72014	-4.08425
36	806	sw	-2.49944	3.64618	-4.13742
36	832	sw	-2.22131	4.1482	-4.50149
36	833	sw	-1.76424	4.05667	-4.34109
36	837	sw	-3.94567	3.93141	-4.53034
36	901	sw	-1.27952	3.42285	-3.58019
36	951	sw	-1.05926	4.01311	-4.0416

Table 8.—Stump diameter regression coefficients, outside and inside bark, for tree species of the Lake States (from Raile 1982) (See text for explanation of equation use)

Species group	Stump volume equation code	Number of trees	D.b.h. (inches) Min.	D.b.h. (inches) Max.	Outside bark B	Outside bark R^2	Outside bark SE[a]	Inside bark A	Inside bark B	Inside bark R^2	Inside bark SE[a]
Eastern white pine	125	53	6.2	33.0	0.11694	0.89	1.2	0.91385	0.11182	0.86	1.2
Red pine	129	228	3.4	23.0	0.08091	0.91	0.5	0.90698	0.08469	0.87	0.7
Jack pine	105	579	3.4	19.4	0.08076	0.87	0.5	0.90973	0.07926	0.84	0.6
White spruce	94	34	5.1	18.0	0.16903	0.86	1.2	0.95487	0.15664	0.83	1.2
Black spruce	95	103	3.6	17.9	0.12147	0.73	0.9	0.94122	0.11781	0.69	1.0
Balsam fir	12	119	4.3	15.4	0.15359	0.89	0.8	0.93793	0.14553	0.87	0.9
Hemlock	261	57	5.8	29.0	0.12667	0.85	1.3	0.91400	0.11975	0.79	1.4
Northern white-cedar	241	14	4.8	13.3	0.18850	0.89	0.9	0.94698	0.18702	0.86	1.0
White oaks	802	61	4.2	26.0	0.14872	0.84	1.3	0.91130	0.14907	0.83	1.4
Red oaks	833	214	2.5	28.7	0.12798	0.83	1.2	0.92267	0.12506	0.81	1.3
Beech	531	29	4.5	24.3	0.15113	0.79	1.8	0.96731	0.14082	0.79	1.6
Yellow birch	371	41	7.5	28.1	0.15350	0.78	2.0	0.94423	0.14335	0.80	1.7
Hard maples	318	132	2.3	31.3	0.12111	0.76	1.6	0.93818	0.11424	0.75	1.5
Soft maples	316	74	2.5	20.8	0.11585	0.77	1.2	0.94181	0.10740	0.73	1.2
White/ green ash	541	37	7.3	24.7	0.12766	0.75	1.5	0.91979	0.12152	0.72	1.6
Black ash	543	15	7.9	17.5	0.17376	0.93	0.9	0.93502	0.17071	0.94	0.8
Paper birch	375	178	3.2	22.4	0.11655	0.77	1.0	0.93763	0.10640	0.75	0.9
Bigtooth aspen	743	204	4.0	15.6	0.06834	0.82	0.5	0.91625	0.06478	0.71	0.7
Quaking aspen	746	678	2.9	20.5	0.09658	0.83	0.8	0.91882	0.08593	0.78	0.8
Basswood	950	38	6.4	26.7	0.14413	0.86	1.4	0.92442	0.14240	0.87	1.3
Cottonwood	740	7	12.8	27.8	0.17123	0.85	2.1	0.92736	0.17626	0.85	2.2
Elms	970	80	7.0	30.5	0.16638	0.84	1.6	0.93257	0.15803	0.82	1.6

[a]Inches.

Table 9.—Sources and general locations for all equations (see Appendix A)

Reference no.	Reference	Origin
1	Acker and Easter 1994	Pacific Northwest
2	Adhikari et al. 1995	Himalayas
3	Anurag et al. 1989	India
4	Bajrang et al. 1996	North Indian plains
5	Baldwin 1989	Louisiana
6	Barclay et al. 1986	Vancouver, BC
7	Barney et al. 1978	Alaska
8	Bartelink 1996	Ntherlands
9	Baskerville 1965	New Brunswick
10	Baskerville 1966	New Brunswick
11	Bergez et al. 1988	central France
12	Bickelhaupt et al. 1973	New York
13	Binkley 1983	British Columbia, Washington State
14	Binkley et al. 1984	Pacific Northwest
15	Bockheim and Lee 1984	Wisconsin
16	Boerner and Kost 1986	Ohio
17	Bormann 1990	Southeastern Alaska
18	Brenneman et al. 1978	West Virginia
19	Bridge 1979	Rhode Island
20	Briggs et al. 1989	New York
21	Brown 1978	Rocky Mountains
22	Bunyavejchewin and Kiratiprayoon 1989	Ratchaburi Province, Thailand
23	Busing et al. 1993	Tennessee
24	Campbell et al. 1985	Alberta
25	Carlyle and Malcolm 1986	Great Britain
26	Carpenter 1983	Minnesota
27	Carter and White 1971	Alabama
29	Chapman and Gower 1991	Wisconsin
30	Chaturvedi and Singh 1982	Lesser Himalayas
31	Chojnacky 1984	Nevada
32	Chojnacky and Moisen 1993	Nevada
33	Clark et al. 1985	Gulf and Atlantic Coastal Plains
34	Clark et al. 1986a	Piedmont (Southeastern U.S.)
35	Clark et al. 1986b	Upland South
36	Clark and Schroeder 1986	North Carolina, Georgia
37	Clary and Tiedemann 1987	Utah
38	Clebsch 1971	Tennessee
39	Cochran et al. 1984	Pacific Northwest
40	Crow 1971	Maine
41	Crow 1976	North-central U.S.
42	Crow 1983	Wisconsin, Michigan
43	Darling 1967	Arizona
44	Dudley and Fownes 1992	Hawaii
45	Dunlap and Shipman 1967	Pennsylvania
47	Espinosa-Bancalari and Perry 1987	Oregon
48	Fassnacht 1996	Wisconsin
49	Felker et al. 1982	California
50	Feller 1992	British Columbia
51	Freedman 1984	Nova Scotia
52	Freedman et al. 1982	Nova Scotia
53	Gary 1976	Wyoming, Colorado
54	Gholz 1980	Oregon
55	Gholz et al. 1979	Pacific Northwest
56	Gholz et al. 1991	Florida
57	Goldsmith and Hocker 1978	New Hampshire
58	Gower et al. 1987	Washington
59	Gower et al. 1993a	Wisconsin, Montana
60	Gower et al. 1993b	Southwestern Wisconsin

Continued

Table 9.—Continued.

Reference no.	Reference	Origin
61	Gower et al. 1992	New Mexico
62	Green and Grigal 1978	Minnesota
63	Grier et al. 1992	Arizona
64	Grier et al. 1984	Washington
65	Grier and Logan 1977	Oregon
66	Grigal and Kernik 1978	Minnesota
67	Harding and Grigal 1985	Minnesota
68	Harmon 1994	Pacific Northwest
69	Harrington et al. 1984	Oregon
70	Harris et al. 1973	Tennessee
71	Hegyi 1972	Ontario
72	Helgerson et al. 1988	Oregon
73	Heth and Donald 1978	Cape Province, South Africa
74	Hocker and Early 1983	New Hampshire
75	Honer 1971	Ontario
76	Ivask et al. 1988	
77	Jackson and Chittenden 1981	New Zealand
78	Johnston and Bartos 1977	Utah, Wyoming
79	Jokela et al. 1981	Minnesota
80	Jokela et al. 1986	New York
81	Ker 1980a	New Brunswick
82	Ker 1980b	Nova Scotia
83	Ker 1984	
84	Ker and van Raalte 1981	New Brunswick
85	Kimmins 1973	British Columbia
86	Kinerson and Bartholomew 1977	New Hampshire
87	King and Schnell 1972	North Carolina, Kentucky, Tennessee
88	Klopsch 1994	Pacific Northwest
89	Koerper 1994	Pacific Northwest
90	Koerper and Richardson 1980	Michigan
91	Krumlik 1974	British Columbia
92	Krumlik and Kimmins 1973	British Columbia
95	Landis and Mogren 1975	Colorado
96	Lieffers and Campbell 1984	Alberta
97	Lodhiyal et al. 1995	Central Himalayas
98	Loomis et al. 1966	Missouri Ozarks
99	Lovenstein and Berliner 1993	Israel
100	Maclean and Wein 1976	New Brunswick
101	Marshall and Wang 1995	British Columbia
102	Martin et al. 1998	North Carolina
103	McCain 1994	Pacific Northwest
104	Means et al. 1994	Pacific Northwest
105	Miller et al. 1981	Nevada, eastern California
106	Monk et al. 1970	Georgia
107	Monteith 1979	New York
108	Moore and Verspoor 1973	Quebec
109	Morrison 1990	Northern Ontario
110	Naidu et al. 1998	North Carolina
111	Nelson and Switzer 1975	Mississippi
112	Ouellet 1983	Quebec
113	Parker and Schneider 1975	Michigan
114	Pastor et al. 1984	Eastern U.S.
115	Pastor and Bockheim 1981	Wisconsin
116	Pearson et al. 1984	Wyoming
117	Perala and Alban 1994	North Central States
118	Peterson et al. 1970	Alberta
119	Phillips 1981	Southeast U.S.
120	Pollard 1972	Ontario

Continued

Table 9.—Continued.

Reference no.	Reference	Origin
121	Rajeev et al. 1998	Haryana, India
122	Ralston 1973	North Carolina
123	Ralston and Prince 1965	North Carolina
124	Ramseur and Kelly 1981	Tennessee
125	Rawat and Singh 1993	Central Himalayas
126	Reid et al. 1974	
127	Reiners 1972	Minnesota
128	Rencz and Auclair 1980	Quebec
129	Reynolds et al. 1978	New Jersey
130	Ribe 1973	Maine
131	Rogerson 1964	Mississippi
132	Rolfe et al. 1978	Southern Illinois
133	Ruark and Bockheim 1988	Northern Wisconsin
134	Ruark et al. 1987	Wisconsin
135	Sachs 1984	Pacific Northwest
136	Santantonio et al. 1977	
137	Schmitt and Grigal 1981	
138	Schnell 1976	Tennessee
139	Schnell 1978	Tennessee
140	Schroeder et al. 1997	
141	Schubert et al. 1988	Hawaii
142	Siccama et al. 1994	New Hampshire
143	Singh 1984	Northwest Territories
144	Singh and Misra 1979	Uttar Pradesh, India
146	Snell and Little 1983	Pacific Northwest
147	Snell and Max 1985	Washington
148	Sollins and Anderson 1971	Southeastern U.S.
149	Sollins et al. 1973	Tennessee
150	St. Clair 1993	Oregon
151	Standish et al. 1985	British Columbia
152	Stanek and State 1978	British Columbia
153	Swank and Schreuder 1974	North Carolina
154	Tandon et al. 1988	Haryana, India
155	Telfer 1969	
156	Teller 1988	Belgium
157	Ter-Mikaelian and Korzukhin 1997	North America
158	Thies and Cunningham 1996	Oregon
159	Tritton and Hornbeck 1982	Northeastern U.S.
160	Tuskan and Rensema 1992	North Dakota
161	van Laar 1982	South Africa
162	Van Lear et al. 1984	South Carolina
163	Vertanen et al. 1994	Kenya
164	Wade 1969	Georgia
165	Wang et al. 1995	British Columbia
166	Wang et al. 1996	British Columbia
167	Waring et al. 1978	Oregon
168	Wartluft 1977	West Virginia
169	Watson and O'Loughlin 1990	New Zealand
170	Weetman and Harland 1964	Quebec
171	Westman 1987	Sierra Nevada, California
172	Whittaker et al. 1974	New Hampshire
173	Whittaker and Niering 1975	Arizona
174	Whittaker and Woodwell 1968	New York
175	Wiant et al. 1977	West Virginia
176	Williams and McClenahan 1984	Ohio
177	Young et al. 1980	Maine

This CD-ROM includes an electronic version of the publication in Adobe pdf format. Also included are folders containing the data spreadsheets in Microsoft Excel® and Adobe® pdf formats. Windows98® or newer is required to use the Excel® spreadsheet files.

Jenkins, Jennifer C.; Chojnacky, David C.; Heath, Linda S.; Birdsey, Richard A. 2004. **Comprehensive database of diameter-based biomass regressions for North American tree species.** Gen. Tech. Rep. NE-319. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 45 p. [1 CD-ROM].

A database consisting of 2,640 equations compiled from the literature for predicting the biomass of trees and tree components from diameter measurements of species found in North America. Bibliographic information, geographic locations, diameter limits, diameter and biomass units, equation forms, statistical errors, and coefficients are provided for each equation, along with examples of how to use the database. The CD-ROM included with this publication contains the complete database (Table 3) in spreadsheet format (Microsoft Excel 2002® with Windows XP®).

Keywords: allometric equations; biomass; forest; tree components; tree species

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