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

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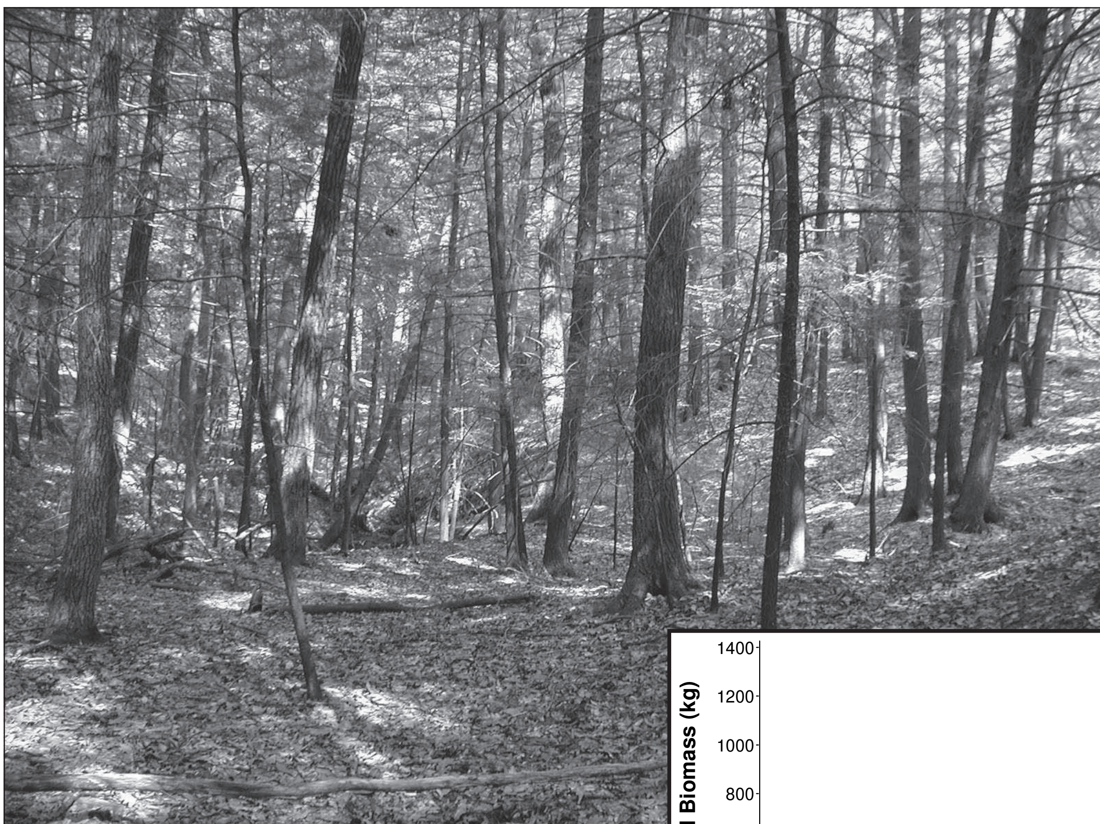

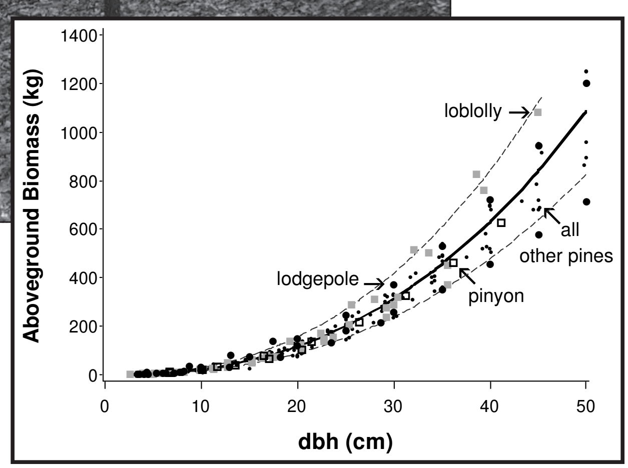

## Abstract

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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For paper copies of the complete database (including Table 3 in its entirety), contact:


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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.

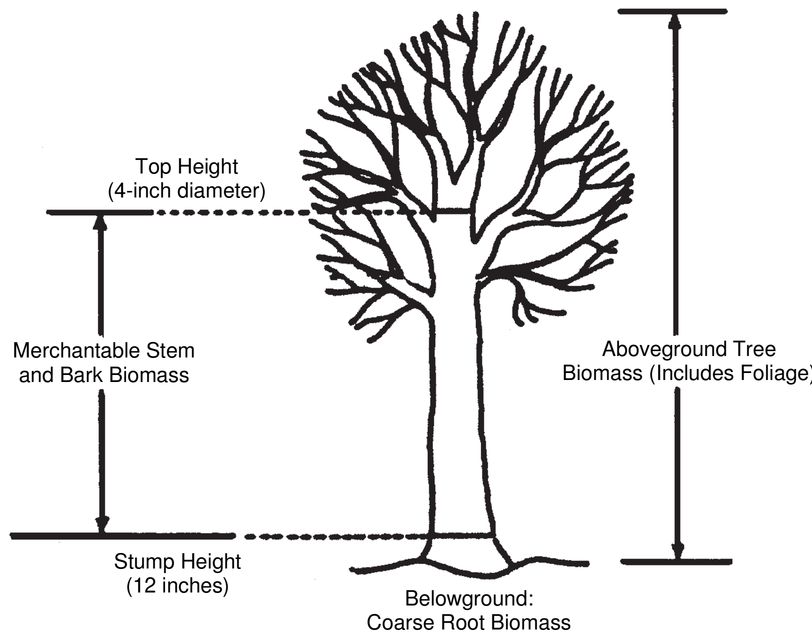


Figure 1.—Tree component biomass definitions.

"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 $\beta_0$ | $\beta_1$ | 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 $\alpha_0$ | $\alpha_1$ | 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:

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

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. **R²** – $R^2$ 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. **R²** – $R^2$ 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

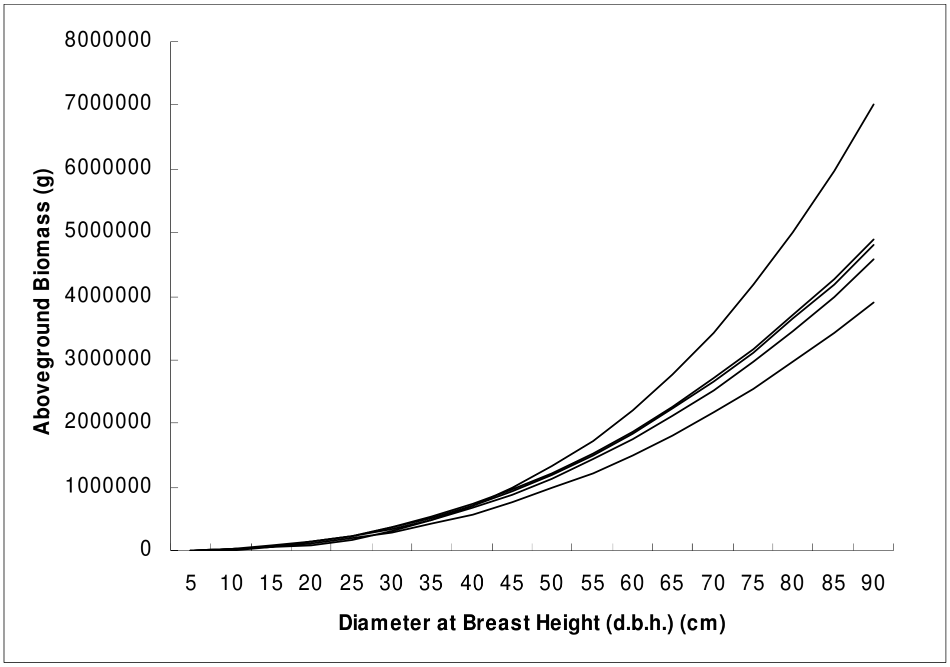


Figure 2.—Total aboveground biomass as predicted from five allometric regression equations for Douglas-fir.

(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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Citation numbers in Appendix A are cross referenced with numbers in Source column in Table 3, Appendix B. Note that this bibliography contains both published and unpublished references.


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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 | R² |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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)**

| | Stump volume | Number | D.b.h. (inches) | | Outside bark | | | Inside bark | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | equation code | of trees | Min. | Max. | B | $R^2$ | SE[a] | A | B | $R^2$ | 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 | Nertherlands |
| 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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