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Volume equations for the Northern Research Station's Forest Inventory and Analysis Program as of 2010

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Abstract

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program collects sample plot data on all forest ownerships across the United States. Its primary objective is to determine the extent, condition, volume, growth, and depletion of timber on the Nation's forest land. The standard for distributing FIA data is the Forest Inventory and Analysis Database (FIADB). FIADB data for individual States can be downloaded from the FIA DataMart at http://fia.fs.fed.us/tools-data/default.asp as Microsoft Access databases which can be used to generate estimates of forest area, number of trees, volume, biomass, growth, removals, and mortality. The methodology used to estimate live-tree gross, net, and sound volume for the 24 states inventoried by the Northern Research Station's (NRS) FIA unit is documented. Sound volume is of particular interest because it is used in live-tree biomass and carbon estimates. The NRS currently uses four volume equations for each of four geographic regions.

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INTRODUCTION

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program has been reporting forest statistics for more than 75 years. These reports are based on a statistical sample of field plots collected on all ownerships across the United States. Four regional units collect, process, and distribute FIA data: Pacific Northwest Research Station-FIA (PNWRS), Rocky Mountain Research Station-FIA (RMRS), Southern Research Station-FIA (SRS), and Northern Research Station-FIA (NRS) (Fig. 1).

The NRS-FIA began installing the new national annual inventory system in 1999. Under the annual system, 20 percent of the plots in the NRS-FIA region are measured each year. When the system is fully implemented, at least one sample plot will be taken for every 6,000 acres of forest land, constituting a pool of more than 30,000 plots. Several states have chosen to provide in-kind aid to intensify the survey thus providing more reliable estimates at the county level. All of this field data, collected to national standards with strict quality assurance and control, is in the public domain and can be obtained on the Internet.

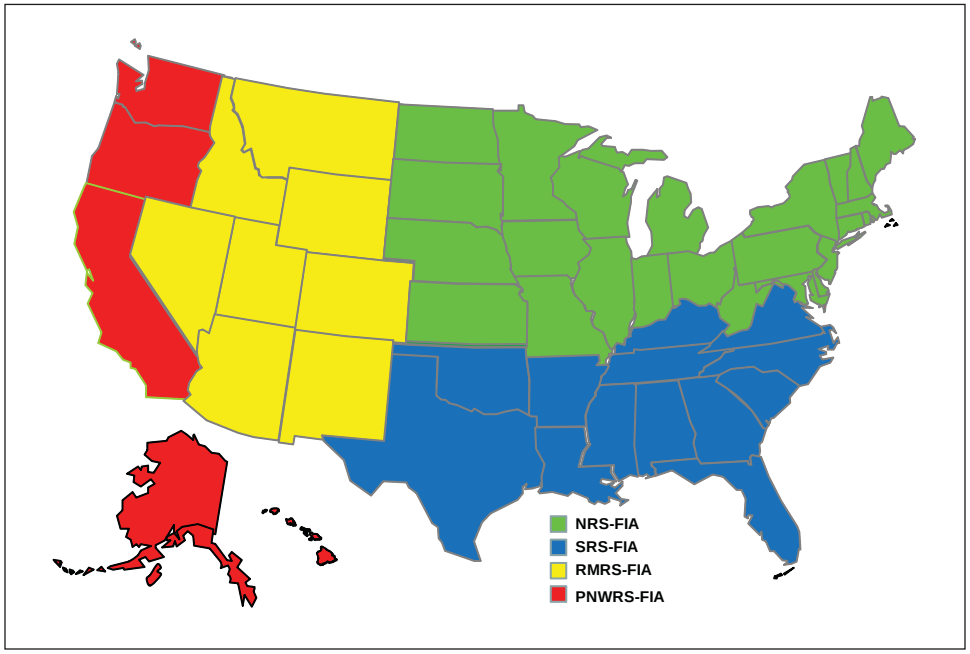

Figure 1.—Forest Inventory and Analysis regions.

The FIA program strives for transparency by making the entire FIA national core dataset available to the public. FIADB data for individual states can be downloaded from the FIA DataMart (http://fia.fs.fed.us/tools-data/default.asp) as Microsoft Access databases. These databases can be used to generate estimates of forest area, number of trees, volume, biomass, growth, removals, and mortality. In 2009 more than 10,000 FIADB state inventories were downloaded.

The next step in providing transparency is to fully document our procedures. In this report we document the methodology used in estimating live-tree gross, net, and sound volume for the 24 states inventoried by the NRS-FIA unit. Sound volume is of particular interest because it is an input to the Component Ratio Method (Heath et al. 2009) that is used in live-tree biomass and carbon estimates.

The final step in providing transparency is to facilitate the use of FIA data and procedures. The NRS-FIA volume equations have been coded into a Microsoft Access Visual Basic Application (VBA) module. This "NRS_Volume_Equations" VBA module is stored within the FIADB Microsoft Access databases that are downloadable from the FIA DataMart. Users can run the volume equations against actual FIA data or any other data they may choose to enter into the FIADB database.

METHODOLOGY

The Northern Research Station (NRS) currently uses four volume equations for the Northeast, Lake States, Central States, and Plains States (Fig. 2). The Lake States (LS) equation is used in Michigan, Minnesota, and Wisconsin. The Plains States (PS) equation is used in Kansas, Nebraska, North Dakota, and South Dakota. The Central States (CS) equation is used in Illinois, Indiana, Iowa, and Missouri. And the Northeast States (NE) equation is used in Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and West Virginia.

The models used to compute volume estimates are from various sources that include volume equations for the Northeastern States (Scott 1981), Lake States (Hahn 1984), and Central and Plains States (Hahn and Hansen 1991). According to Hansen (2002), "They were originally obtained by fitting various nonlinear models to tree-level data sets. These data sets consisted of standard FIA tree measurements (species, diameter, height, …) and 'known' volume observations.

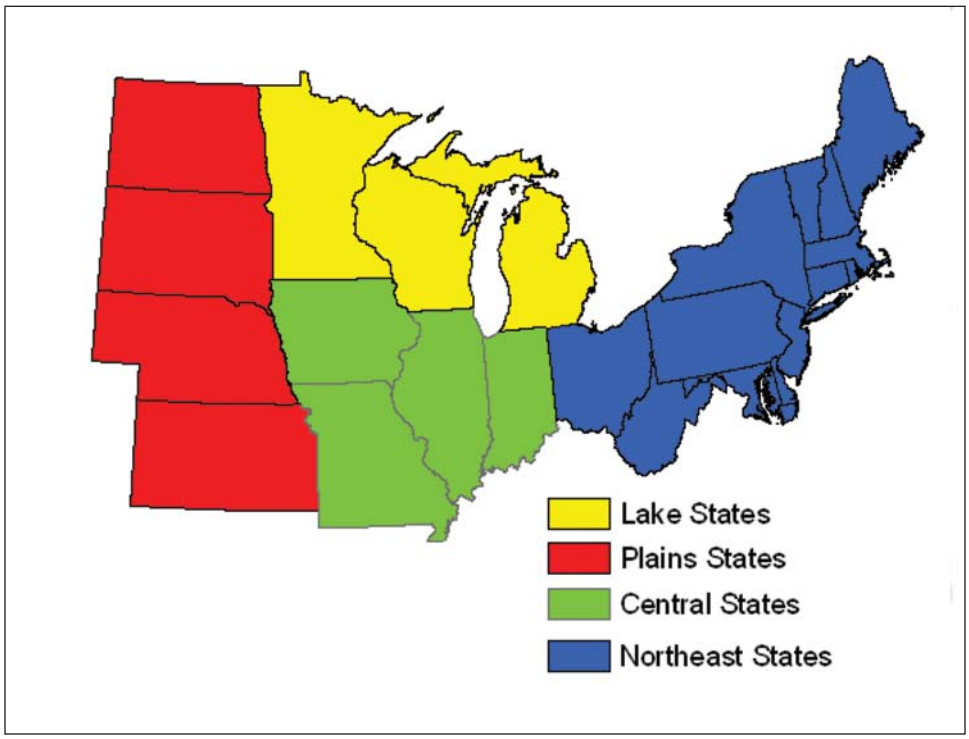

Figure 2.—Volume equations used by the Northern Research Station's FIA unit.

Typically, the ‘known’ volume observations were calculated based on detailed height and upper stem diameter measurements that had been taken on the trees and established regional volume tables or models. Differences exist in the model form, predictor attributes, and nonlinear regression methods used to fit the models. Each model was fit to a different dataset, appropriate to the region where it is being used. In general one model form is used for all species in a region. The model was fit for a specific species (or species group) and parameter estimates were obtained.”

GROSS VOLUME

Gross volume is the total volume of wood in the central stem of trees 5 inches or larger in diameter, from a 1-foot stump to a minimum 4-inch top diameter outside bark (d.o.b.), or to where the central stem breaks into limbs all of which are less than 4 inches in d.o.b. Gross volume includes rotten, missing, and form cull (volume loss due to rotten, missing, and form-cull defect has not been deducted).

The equations for gross volume are presented in Table 1. Coefficients for the equations are in Appendixes A (NE), B (LS), and C (CS and PS).

Table 1.—Gross cubic-foot volume models used by NRS-FIA

Region	Form of the model:\ VOLCFGRS = $f\ (x_1, x_2, \ldots x_n)$	Observed items $(x_1, x_2, \ldots x_n)$	Citation
NE	VOLCFGRS = $B_1 + B_2 x_1^{B_3} + B_4 x_1^{B_5} x_2^{B_6}$	x_1 = DBH x_2 = BL	Scott 1981
LS	VOLCFGRS = $(S_0 + S_1 x_1 + S_2 4 + S_3 x_1^{\,2} + S_4 x_1^{\,2} h_4 + S_5 h_4^{\,2} +$ $S_6 h_4 4^2 + S_7 x_1^{\,2} h_4^{\,3} + S_8 x_1^{\,2} h_4^{\,2} 4)(E_1 + E_2 x_1)$ where h_4 = predicted bole length = $4.5 + B_1(1 - e^{(-B_2 x_1)})^{B_3} x^{B_4}\ (1.00001 - \frac{4.0}{x_1})^{B_5} x_3^{B_6}$ Coefficients for: Stone's volume equation (Hahn 1984): S_0 through S_8 Raile's bark correction (unpublished): E_1 and E_2 Ek's height equation (Hahn 1984): B_1 through B_6	x_1 = DBH x_2 = SI x_3 = BA	Hahn 1984
CS	VOLCFGRS = $A_1(x_2)^{A_2}(1 - e^{A_3 x_1^{\,A_4}})$	x_1 = DBH x_2 = SI	Hahn & Hansen 1991
PS	VOLCFGRS = $A_1(x_2)^{A_2}(1 - e^{A_3 x_1^{\,A_4}})$	x_1 = DBH x_2 = SI	Hahn & Hansen 1991

NET VOLUME

Net cubic-foot volume is the net volume of wood in the central stem of a tree 5 inches or larger in diameter, from a 1-foot stump to a minimum 4-inch top d.o.b., or to where the central stem breaks into limbs all of which are less than 4 inches d.o.b. Net volume does not include rotten, missing, and form cull.

Various methods are used to move from gross volume to net volume (Table 2). In the Northeastern States field crews recorded the percentage of rotten and form cull (stored in the CULLCF variable on the TREE record) for each tree. For the Lake States, net volume adjustment coefficients by species group and tree class were developed by Hahn (1984). For the Central States, net volume adjustment coefficients were developed by Hahn and Hansen (1991). In the Central States model, percent cull increases with tree diameter. A diameter cap variable (DFA3 for growing-stock trees, DFB3 for rough trees, or DFC3 for rotten trees) is used to limit the increase in cull percentage to the maximum diameter under which the regression line was fit. For the Plains States, net volume adjustment coefficients by tree class and species group were developed by Hahn and Hansen (1991).

Table 2.—Net cubic-foot volume models used by NRS-FIA

Region	
NE	VOLCFNET = VOLCFGRS * (1 – cullcf / 100) Where cullcf is the value stored in the variable CULLCF for each TREE record.
LS	VOLCFNET = VOLCFGRS * (1 – cullcf/100) Where cullcf = value of Lake States cull coefficient from Appendix B. LC1 = cullcf coefficient for growing-stock trees LC2 = cullcf coefficient for rough trees LC3 = cullcf coefficient for rotten trees Note: values for LC1, LC2, and LC3 vary by species group.
CS	VOLCFNET = VOLCFGRS * (1 – cullcf/100) Where for growing-stock trees cullcf = DFA1 + DFA2 * minimum(DIA,DFA3) For rough trees cullcf = DFB1 + DFB2 * minimum(DIA,DFB3) For rotten trees cullcf = DFC1 + DFC2 * minimum(DIA,DFC3) Note: values for Central States cull coefficients (DFA1, DFA2, DFA3, DFB1, DFB2, DFB3, DFC1, DFC2, DFC3) vary by species group DIA= tree diameter
PS	VOLCFNET = VOLCFGRS * (1 – cullcf/100) Where cullcf = value of Lake States cull coefficient from Appendix C. C20 = cullcf coefficient for growing-stock trees C30 = cullcf coefficient for rough trees C40 = cullcf coefficient for rotten trees Note: values for C20, C30, and C40 vary by species group.

SOUND VOLUME

Sound cubic-foot volume is the volume of sound wood in the central stem of a tree 5 inches or larger in diameter from a 1-foot stump to a minimum 4-inch top d.o.b. or to where the central stem breaks into limbs all of which are less than 4 inches d.o.b. Sound volume does not include rotten and missing cull (volume loss due to rotten and missing cull defect has been deducted).

Two methods are used by the NRS to estimate sound volume. In the Northeastern States field crews recorded the percentage of rotten and missing cull (stored in the CULL variable on the TREE record) for each tree (Table 3). In the Lake, Central and Plains States the difference between the gross volume and the net volume is multiplied by a sound adjustment factor and added back to the net volume to estimate sound volume. The value of the sound adjustment factor varies by tree-class code.

Table 3.—Sound cubic-foot volume models used by NRS-FIA

Region	
NE	VOLCFSND = VOLCFGRS * (1 – cull/100) Where cullcf is value stored in variable CULLCF for each TREE record.
LS, CS, PS	VOLCFSND = VOLCFNET + (VOLCFGRS – VOLCFNET) * ADJFACTOR Where ADJFACTOR = 0.9 for growing-stock trees ADJFACTOR = 0.85 for rough trees ADJFACTOR = 0.25 for rotten trees

The gross, net, and sound volume equations are coded in FIA's National Information Management System (NIMS) to compile individual tree estimates; however, NIMS and the volume equations are not readily available to the public. To make the equations accessible all four sets of equations and their coefficients were loaded into a single VBA function ("NRS_VOLUME", Appendix D) that is stored in the VBA module "NRS_Volume_Equations". This module is available in every state MS Access database downloaded from the FIA DataMart.

Eleven parameters (statecd, spcd, dia, boleht, cull, cullcf, treeclcd, balive, sitree, ht, voltype) must be passed into the NRS_VOLUME function (Table 4). All of these parameters are available in the FIADB database (Miles et al. 2001) from the TREE or COND tables, with the exception of the VOLTYPE parameter, which is used to specify the type of volume (gross, net, or sound) to be returned.

Table 4.—Parameters used by function NRS_VOLUME

Parameter	Description
TREE.STATECD	State code. Bureau of the Census Federal Information Processing Standards (FIPS) two-digit code for each state. See Appendix E for Northern Research Station-FIA state codes. *Used in all 4 equations.*
TREE.SPCD	Species code. An FIA tree species code. See Appendix F for codes. *Used in all 4 equations.*
TREE.DIA	Current diameter. The current diameter (in inches) of the sample tree at the point of diameter measurement. *Used in all 4 equations*
TREE.BOLEHT	Bole height. The length (height) of a tree, recorded to a 4-inch top, where at least one 4-foot section is present. Collected only for the Northeastern States. For other states leave as 0 or null. *Used only in NE equation. Could be used with LS equation but FIA uses a height model to estimate boleht.*
TREE.CULL	Rotten and missing cull. The percentage of the cubic-foot volume in a live or dead tally tree that is rotten or missing. This calculated value includes field-recorded cull (CULL_FLD) and any additional cull due to broken top. *Used in NE equation.*
TREE.CULLCF	Cubic-foot cull. The percentage of the gross cubic-foot volume that is cull due to rot or form. Collected only for Northeastern States. *Used in NE equation.*
TREE.TREECLCD	Tree-class code. Indicates the general quality of the tree. In an annual inventory, this is the tree class for both live and dead trees at the time of current measurement. In a periodic inventory for cut and dead trees, this is the class of the tree at the time it died or was cut. Therefore, cut and dead trees collected in a periodic inventory can be coded as growing stock. *Used in LS, CS, and PS equations.* Code Description 2 Growing stock: All live trees of commercial species that meet minimum merchantability standards. In general: these trees have at least one solid 8-foot section; are reasonably free of form defect on the merchantable bole; and at least 34 percent or more of the volume is merchantable. Rough or rotten cull trees are excluded. 3 Rough cull: All live trees that do not now or prospectively have at least one solid 8-foot section, reasonably free of form defect on the merchantable bole, or have 67 percent or more of the merchantable volume cull and more than half of this cull is due to sound dead wood cubic-foot loss or severe form defect volume loss. 4 Rotten cull: All live trees with at least 67 percent of the merchantable volume cull, and where more than half of this cull is due to rotten or missing cubic-foot volume loss.
COND.BALIVE	Basal area of live trees. Basal area (in square feet per acre) of all live trees more than 1 inch in diameter (where diameter is measured at breast height for forest species and at root collar for woodland species) sampled in the condition. *Used in LS equation.*

Parameter	Description
TREE.SITREE	Calculated site index. Computed for every tree. The site index represents the average total length (in feet) that dominant and codominant trees in fully stocked, even-aged stands (of the same species as this tree) will obtain at key ages (usually 25 or 50 years). Collected only for Lake, Central, and Plains States. *Used in LS equation and PS equation for ponderosa pine.*
TREE.HT	Total height. The total length (height) of a sample tree (in feet) from the ground to the tip of the apical meristem. The total length of a tree is not always its actual length. If the main stem is broken, the actual length is measured or estimated and the missing piece is added to the actual length to estimate total length. The amount added is determined by measuring the broken piece if it can be located on the ground; otherwise, it is estimated. *Used in PS equation for ponderosa pine.*
VOLTYPE	Type of volume the user would like returned. Valid values include “GROSS”, “NET”, and “SOUND”

RESULTS AND ANALYSIS

Two Microsoft Access Structured Query Language (SQL) scripts (Appendix G) were developed to be used within the framework of an FIADB Access database to estimate sound volume in thousand cubic feet. The first SQL script labeled "VOLCFSND sound volume (thousand cuft)" uses the variable VOLCFSND that is calculated within NIMS and stored in the FIADB. This script returns total sound volume for the 2007 Iowa inventory, the 2007 Minnesota inventory, the 2007 Nebraska inventory and the 2006 New Jersey inventory. The second SQL script labeled "NRS_VOLUME sound volume (thousand cuft)" is identical to the first script except that "VOLCFSND" is replaced by the function "NRS_ VOLUME (tree.statecd, tree.spcd, tree.dia, NZ(tree.boleht,0), tree.cull, tree. cullcf, tree.treeclcd, cond.balive, tree.sitree, tree.ht, "SOUND)."

The VBA function NRS_VOLUME was tested against data from four states (Table 5) to ensure that the function's estimates match the results generated by NIMS and stored in the VOLCFSND variable of the FIADB. The 2007 Minnesota inventory was used to test the LS equation, the 2007 Iowa inventory was used to test the CS equation, the 2007 Nebraska inventory was used to test the PS equation and the 2006 New Jersey inventory was used to test the NE equation. The results for the four states using the NIMS computed estimate of volume cubic-foot sound (VOLCFSND) and the VBA function (NRS_VOLUME) are identical within rounding (Table 5).

Table 5.—All live tree sound volume on forest land (thousand cubic feet)

Equation	State	Inventory year	VOLCFSND sound volume	NRS_VOLUME sound volume
LS	Minnesota	2007	18,969,191.7	18,969,191.7
CS	Iowa	2007	4,534,381.4	4,534,381.4
PS	Nebraska	2007	1,997,600.5	1,997,600.5
NE	New Jersey	2006	4,095,756.6	4,095,756.6

The following SQL script can be used to generate estimates of individual live tree sound volume for the four states.

```
SELECT COND.STATECD,COND.COUNTYCD,COND.PLOT,TREE.SUBP,
       TREE.TREE,TREE.SPCD,TREE.DIA,TREE.BOLEHT,
       TREE.CULL,TREE.CULLCF,TREE.TREECLCD,COND.BALIVE,
       TREE.SITREE,TREE.VOLCFSND,
       NRS_VOLUME(cond.statecd,
                  tree.spcd,
                  tree.dia,
                  tree.boleht,
                  tree.cull,
                  tree.cullcf,
                  tree.treeclcd,
                  cond.balive,
                  tree.sitree,
                  tree.ht,
                  'SOUND') AS NRS_CUFTSND
  FROM COND
 INNER JOIN TREE ON (COND.CONDID = TREE.CONDID)
                AND (COND.PLT_CN = TREE.PLT_CN)
 WHERE (TREE.STATUSCD = 1)
   AND (TREE.DIA >= 5)
   AND ((COND.STATECD = 19 AND COND.INVYR = 2007) or
       (COND.STATECD = 27 AND COND.INVYR = 2007) or
       (COND.STATECD = 31 AND COND.INVYR = 2007) OR
       (COND.STATECD = 34 AND COND.INVYR = 2006))
  ORDER BY COND.STATECD, COND.COUNTYCD, COND.PLOT, TREE.SUBP,
           TREE.TREE
```

Table 6 includes the output for the trees from the first subplot in Iowa (STATECD=19, COUNTYCD=1, PLOT=20115 and SUBP=1). The only parameters needed for the CS equation are STATECD, SPCD, DIA, and TREECLCD. The variables BOLEHT, CULL, and CULLCF currently are collected only in the Northeast States and are needed only by the NE equation.

Table 6.—Individual tree sound volume using the stored variable VOLCFSND and the VBA function NRS_VOLUME

TREE	SPCD	DIA	BOLEHT	CULL	CULLCF	TREECLCD	BALIVE	SITREE	VOLCFSND	NRS_CUFTSND
4	823	7.5		0		2	110.8499	42	4.036814	4.03681390
5	823	5.4		0		3	110.8499	42	1.652757	1.65275673
6	823	8.5		0		3	110.8499	42	5.500163	5.50016258
7	823	6.8		0		2	110.8499	42	3.114062	3.11406209
8	823	6.3		0		3	110.8499	42	2.489044	2.48904403
9	823	5		0		2	110.8499	42	1.450539	1.45053879
10	823	13		0		3	110.8499	42	16.703804	16.70380416
11	823	5.4		0		3	110.8499	42	1.652757	1.65275673

CONCLUSION

The Forest Inventory and Analysis program strives for transparency. Field guides document methods and standards for data collection, and database documentation provides information on how to retrieve field and compiled data. Field and database documentation is available from the FIA Library at http://fia.fs.fed.us/library/.

Compilation procedures often are not found in self-contained manuals or guides. Those wishing to duplicate FIA compilation procedures may find it nearly impossible to accomplish because computer code often is unpublished and can change over time to accommodate additional information such as new coefficients for newly inventoried tree species. This bulletin provides a "snapshot" of how sound volume currently is calculated by the NRS-FIA and includes an example of working VBA code.

The ability to generate volume estimates based solely on field-measured variables allows researchers and land managers to use NRS-FIA compilation procedures with their own field data. Providing the code in VBA format allows users with Microsoft Access to easily modify and/or extend the code. The next step will be to make the CRM function available in VBA code so that estimates of biomass and carbon can be generated to NRS-FIA standards.

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APPENDICES

Appendix A

Northeast Volume Equation Coefficients

Scott's cubic-foot volume equation coefficients (B0 through B5) (Scott 1981)

NE group name	NE group code	FIA species codes	B0	B1	B2	B3	B4	B5
White, red pine	1	125, 129	0.11	-0.05977	2.0498	0.04965	2.0198	0.3468
Red, white, black spruce	2	90, 94, 95, 96, 97	0.17	-0.06315	2.0654	0.05122	2.0264	0.3508
Balsam fir	3	10, 12, 16	-0.10	-0.05444	2.1194	0.04821	2.0427	0.3579
Hemlock	4	260, 261	0.24	-0.05895	2.0362	0.04947	2.0172	0.3366
Hard pines, tamarack, Norway spruce	5	70, 71, 91, 100, 105, 110, 123, 126, 128, 130, 131, 132, 136, 202, 299	-0.03	-0.05604	2.0473	0.05022	2.0198	0.3242
Cedar species	6	43, 57, 68, 221, 241	0.19	-0.05904	1.9935	0.04981	2.0027	0.3214
Sugar maple	7	318	-0.19	-0.01171	1.8949	0.0134	1.9928	0.6471
Soft maple, yellow - poplar	8	621	-0.45	-0.00523	2.2323	0.01338	2.0093	0.6384
Ash species, aspen species	9	540, 541, 543, 544, 545, 546, 740, 741, 742, 743, 744, 746, 752, 753	0.06	-0.02437	1.5419	0.01299	1.9885	0.6453
black cherry	10	762	-0.04	-0.01783	1.8109	0.01358	1.9905	0.6553
Birch species	11	370, 371, 372, 373, 375, 379	-0.27	-0.00675	1.9738	0.01327	1.9967	0.6407
Beech	12	531	-0.60	-0.00711	2.2693	0.01399	2.019	0.6518
Basswood	13	950, 951, 952	-0.39	-0.00622	2.0066	0.0131	1.9939	0.6494
Red oaks, sweetgum, black gum	14	611, 693, 806, 809, 812, 813, 817, 830, 831, 833, 834, 837	-0.13	-0.00536	1.9172	0.01131	1.9975	0.6549
Chestnut oak	15	832	-0.26	0.00038	2.0000	0.01068	1.998	0.6438
Hickory	16	400, 401, 402, 403, 404, 405, 407, 409, 410	-0.27	-0.00466	2.1575	0.01174	2.0035	0.6640
Other hardwoods	17	310, 313, 314, 315, 319, 320, 321, 330, 331, 332, 341, 345, 355, 356, 357, 358, 367, 391, 421, 422, 424, 450, 452, 460, 461, 462, 471, 481, 491, 500, 502, 521, 552, 561, 571, 591, 600, 601, 602, 641, 650, 651, 653, 654, 655, 658, 660, 662, 663, 664, 680, 681, 682, 684, 691, 694, 701, 711, 712, 729, 731, 760, 761, 763, 764, 765, 766, 769, 771, 800, 802, 804, 816, 820, 822, 823, 824, 825, 826, 827, 835, 845, 901, 920, 921, 922, 923, 927, 931, 934, 935, 936, 937, 970, 971, 972, 974, 975, 977, 997, 998, 999	0.13	-0.00183	2.3600	0.00944	2.0608	0.6516
red maple, silver maple	18	316, 317	-0.45	-0.00523	2.2323	0.01338	2.0093	0.6384
Other			0.13	-0.00183	2.3600	0.00944	2.0608	0.6516

Appendix B

Lake States Volume Equation Coefficients

Stone's cubic foot volume equation coefficients (S0 through S8) (Hahn 1984)

```
S0 = (-3.0018 * (10 ^ -3))
S1 = (2.03550 * (10 ^ -3))
S2 = (-3.0018 * (10 ^ -3))
S3 = (6.23810 * (10 ^ -5))
S4 = (2.5705 *  (10 ^ -5))
S5 = (-7.009 *  (10 ^ -6))
S6 = (3.6708 *  (10 ^ -5))
S7 = (8.14 *    (10 ^ -10))
S8 = (-1.9 *    (10 ^ -9))
```

Ek's height equation coefficients (B1 through B6) (Hahn 1984)

LS group name	LS group code	FIA species codes	B1	B2	B3	B4	B5	B6
balsam fir	12	10, 12, 15, 16	14.3040	0.19894	1.4195	0.23349	0.76878	0.12399
eastern redcedar	68	68	8.2079	0.19672	1.3112	0.33978	0.76173	0.11666
tamarack (native)	71	71	13.6200	0.24255	1.2885	0.25831	0.68128	0.10771
white spruce	94	94	31.9570	0.18511	1.7020	0.00000	0.68967	0.16200
black spruce	95	95	20.0380	0.18981	1.2909	0.17836	0.57343	0.10159
jack pine	105	57, 66, 70, 91, 93, 96, 105, 130, 136, 202, 299	16.9340	0.12972	1.0000	0.20854	0.77792	0.12902
red pine	125	122, 125, 126	36.8510	0.08298	1.0000	0.00001	0.63884	0.18231
eastern white pine	129	129	16.2810	0.08621	1.0000	0.16220	0.86833	0.23316
Scotch pine	130	57, 70, 96, 130, 136	16.9340	0.12972	1.0000	0.20854	0.77792	0.12902
Virginia pine	132	110, 131, 132	36.8510	0.08298	1.0000	0.00001	0.63884	0.18231
baldcypress	221	221	16.2810	0.08621	1.0000	0.16220	0.86833	0.23316
northern white-cedar	241	241	8.2079	0.19672	1.3112	0.33978	0.76173	0.11666
eastern hemlock	261	261	6.0770	0.24950	3.8663	0.50180	0.82440	0.04820
boxelder	313	300, 313, 321, 330, 331, 332, 355, 372, 379, 381, 421, 423, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 772, 828, 927, 931, 997	6.9572	0.26564	1.0000	0.48660	0.76954	0.01617
red maple	316	316, 317	6.8600	0.27725	1.4287	0.40115	0.85299	0.12403
sugar maple	318	314, 318	5.3416	0.23044	1.1529	0.54194	0.83440	0.06372
yellow birch	371	371	7.1852	0.28384	1.4417	0.38884	0.82157	0.11411

Ek's height equation coefficients (B1 through B6) (Hahn 1984) (continued)

LS group name	LS group code	FIA species codes	B1	B2	B3	B4	B5	B6
river birch	373	373	7.2773	0.22721	1.0000	0.41179	0.76498	0.11046
paper birch	375	375	7.2773	0.22721	1.0000	0.41179	0.76498	0.11046
bitternut hickory	402	401, 402, 403, 408	6.1034	0.17368	1.0000	0.44725	1.02370	0.14610
shagbark hickory	407	400, 404, 405, 407, 409	6.1034	0.17368	1.0000	0.44725	1.02370	0.14610
hackberry	462	460, 461, 462, 463	6.8600	0.27725	1.4287	0.40115	0.85299	0.12403
American beech	531	531	7.1852	0.28384	1.4417	0.38884	0.82157	0.11411
black ash	543	543, 546	11.2910	0.25250	1.5466	0.35711	0.75060	0.06859
green ash	544	541, 544	8.1782	0.27316	1.7250	0.38694	0.75822	0.10847
black walnut	602	600, 601, 602	6.3628	0.27859	1.8677	0.49589	0.76169	0.05841
sweetgum	611	611	5.3416	0.23044	1.1529	0.54194	0.83440	0.06372
yellow-poplar	621	621	6.3628	0.27859	1.8677	0.49589	0.76169	0.05841
water tupelo	691	691, 693	5.3416	0.23044	1.1529	0.54194	0.83440	0.06372
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 358, 367, 391, 471, 500, 591, 641, 660, 663, 701, 761, 763, 765, 766, 919, 920, 921, 923, 935, 996, 999	6.9572	0.26564	1.0000	0.48660	0.76954	0.01617
American sycamore	731	731	6.3628	0.27859	1.8677	0.49589	0.76169	0.05841
balsam poplar	741	741	6.4301	0.23545	1.3380	0.47370	0.73385	0.08228
eastern cottonwood	742	740, 742, 745, 922, 929	13.6250	0.28668	1.6124	0.30651	1.02920	0.07461
bigtooth aspen	743	743	5.5346	0.22637	1.0000	0.46918	0.72456	0.11782
quaking aspen	746	744, 746, 753, 998	6.4301	0.23545	1.3380	0.47370	0.73385	0.08228
black cherry	762	762	5.3416	0.23044	1.1529	0.54194	0.83440	0.06372
white oak	802	802, 804, 823, 825, 826	9.2078	0.22208	1.0000	0.31723	0.82560	0.13465
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	3.8011	0.39213	2.9053	0.55634	0.84317	0.09593
northern red oak	833	813, 833	6.6844	0.19049	1.0000	0.43972	0.82962	0.10806
Shumard oak	834	834	6.6844	0.19049	1.0000	0.43972	0.82962	0.10806
post oak	835	822, 832, 835	9.2078	0.22208	1.0000	0.31723	0.82560	0.13465
black locust	901	901	6.9572	0.26564	1.0000	0.48660	0.76954	0.01617
American basswood	951	951, 952	6.3628	0.27859	1.8677	0.49589	0.76169	0.05841
American elm	972	970, 971, 972, 974, 975, 977	8.4580	0.27527	1.9602	0.34894	0.89213	0.12594
Other or unknown live tree	999	501, 502	6.9572	0.26564	1.0000	0.48660	0.76954	0.01617
Other softwoods			16.9340	0.12972	1.0000	0.20854	0.77792	0.12902
Other hardwoods			6.9572	0.26564	1.0000	0.48660	0.76954	0.01617

Raile's bark correction coefficients (E1 and E2) (unpublished) and Hansen's sound volume adjustment coefficients (LC1, LC2, and LC3) (unpublished)

LS group name	LS group code	FIA species codes	E1	E2		LC1	LC2	LC3
balsam fir	12	10, 12, 15, 16	99.92	0.00		2.10	11.10	63.40
eastern redcedar	68	68	110.32	0.60		3.40	22.00	52.20
tamarack (native)	71	71	105.52	0.00		2.70	16.80	58.40
white spruce	94	94	105.52	0.00		1.60	11.70	56.00
black spruce	95	95	95.77	0.50		1.40	12.10	57.70
jack pine	105	57, 66, 70, 91, 93, 96, 105, 130, 136, 202, 299	86.77	0.85		2.60	17.80	63.10
red pine	125	122, 125, 126	101.79	-0.55		1.30	11.20	74.30
eastern white pine	129	129	95.88	0.00		3.20	16.60	64.60
Scotch pine	130	130	86.77	0.85		3.40	22.00	52.20
Virginia pine	132	110, 131, 132	79.10	0.60		1.30	11.20	74.30
baldcypress	221	221	79.10	0.60		3.20	16.60	64.60
northern white-cedar	241	241	103.43	0.00		3.80	17.20	61.20
eastern hemlock	261	261	84.68	0.62		5.40	24.90	71.90
boxelder	313	300, 313, 321, 330, 331, 332, 355, 372, 379, 381, 421, 423, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 772, 828, 927, 931, 997	82.60	0.60		8.70	21.00	64.20
red maple	316	316, 317	102.19	0.00		5.80	16.80	62.30
sugar maple	318	314, 318	104.42	-0.16		6.30	17.70	61.70
yellow birch	371	371	102.41	0.00		8.90	19.70	64.00
river birch	373	373	83.62	0.60		4.50	14.30	64.90
paper birch	375	375	98.21	0.20		4.50	14.30	64.90
bitternut hickory	402	401, 402, 403, 408	85.09	0.60		4.70	15.20	65.70
shagbark hickory	407	400, 404, 405, 407, 409	85.18	0.60		4.70	15.20	65.70
hackberry	462	460, 461, 462, 463	98.95	0.00		6.30	13.20	64.00
American beech	531	531	111.73	-0.23		8.10	21.80	55.30
black ash	543	543, 546	98.44	0.00		5.30	20.20	67.20
green ash	544	541, 544	83.00	0.60		4.60	17.80	62.20
black walnut	602	600, 601, 602	114.84	-0.88		6.80	15.50	61.20
sweetgum	611	611	82.52	0.60		6.80	15.50	61.20
yellow-poplar	621	621	90.23	0.60		6.80	15.50	61.20
water tupelo	691	691, 693	81.01	0.60		6.30	17.70	61.70

Raile's bark correction coefficients (E1 and E2) (unpublished) and Hansen's sound volume adjustment coefficients (LC1, LC2, and LC3) (unpublished) (continued)

LS group name	LS group code	FIA species codes	E1	E2		L1	L2	L3
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 358, 367, 391, 471, 500, 591, 641, 660, 663, 701, 761, 763, 765, 766, 919, 920, 921, 923, 935, 996, 999	84.71	0.60		8.70	16.80	64.20
American sycamore	731	731	93.83	0.60		6.80	15.50	61.20
balsam poplar	741	741	91.51	0.37		4.50	19.00	65.20
eastern cottonwood	742	740, 742, 745, 922, 929	82.50	0.60		5.50	19.70	70.60
bigtooth aspen	743	743	91.51	0.37		4.40	20.70	59.70
quaking aspen	746	744, 746, 753, 998	91.51	0.37		5.20	21.80	61.80
black cherry	762	762	114.84	-0.88		6.80	15.50	61.20
white oak	802	802, 804, 823, 825, 826	83.95	0.60		5.50	14.00	65.60
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	84.59	0.60		6.10	10.70	66.50
northern red oak	833	813, 833	84.21	0.60		5.30	14.40	63.60
Shumard oak	834	834	84.21	0.60		5.30	14.40	63.60
post oak	835	822, 832, 835	84.24	0.60		5.50	14.00	65.60
black locust	901	901	82.60	0.60		8.70	21.00	64.20
American basswood	951	951, 952	97.07	0.00		4.40	14.00	63.30
American elm	972	970, 971, 972, 974, 975, 977	98.95	0.00		6.30	13.20	64.00
Other or unknown live tree	999	501, 502	84.71	0.60		8.70	16.80	64.20
Other softwoods			86.77	0.85		2.60	17.80	63.10
Other hardwoods			84.71	0.60		8.70	21.00	64.20

Appendix C

Central States and Plain States Volume Equation Coefficients

CS and PS group name	CS and PS group code	FIA species codes	B1
eastern redcedar	68	68	0.35933
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	0.29204
Virginia pine	132	110, 131, 132	0.30131
baldcypress	221	221	0.30797
eastern hemlock	261	12, 71, 94, 95, 241, 261	0.28516
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	0.28367
red maple	316	316, 317	0.30461
sugar maple	318	314, 318	0.30171
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	0.28367
bitternut hickory	402	401, 402, 403, 408	0.29118
shagbark hickory	407	400, 404, 405, 407, 409	0.28686
American beech	531	371, 531, 951, 952	0.35571
green ash	544	541, 543, 544, 546	0.31065
black walnut	602	602	0.30397
yellow-poplar	621	621	0.31615
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	0.28367
American sycamore	731	731	0.30304
eastern cottonwood	742	740, 742, 745	0.3494
quaking aspen	746	741, 743, 744, 746	0.31359
white oak	802	800, 802, 804, 823, 825, 826, 998	0.33464
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	0.33531
northern red oak	833	813, 833, 834	0.35216
post oak	835	822, 832, 835	0.32485
black willow	922	922, 929	0.25003
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	0.31607
Other softwoods			
Other hardwoods			

CS and PS group name	CS and PS group code	FIA species codes	A1	A2	A3	A4
eastern redcedar	68	68	112.59	0.12504	-0.0001063300	2.626
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	122.77	0.41477	-0.0000239700	2.7239
Virginia pine	132	110, 131, 132	122.58	0.20684	-0.0000576690	2.7719
baldcypress	221	221	337.22	0.11585	-0.0000081788	3.2004
eastern hemlock	261	12, 71, 94, 95, 241, 261	454.13	0.13672	-0.0000254730	2.6247
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	94.985	0.24089	-0.0000494570	2.8454
red maple	316	316, 317	431.19	0.019385	-0.0000466280	2.6776
sugar maple	318	314, 318	118.8	0.21064	-0.0000718390	2.7238
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	94.985	0.24089	-0.0000494570	2.8454
bitternut hickory	402	401, 402, 403, 408	60.548	0.29655	-0.0000653670	2.8739
shagbark hickory	407	400, 404, 405, 407, 409	84.154	0.2452	-0.0000648310	2.8221
American beech	531	371, 531, 951, 952	194.75	0.17455	-0.0000450780	2.732
green ash	544	541, 543, 544, 546	73.722	0.22835	-0.0000807850	2.7999
black walnut	602	602	137.32	0.13993	-0.0000743080	2.6999
yellow-poplar	621	621	232.88	0.20935	-0.0000337920	2.7596
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	94.985	0.24089	-0.0000494570	2.8454
American sycamore	731	731	326.3	0.19774	-0.0000324040	2.6696
eastern cottonwood	742	740, 742, 745	479.95	0.11037	-0.0000304950	2.6521
quaking aspen	746	741, 743, 744, 746	61.217	0.28402	-0.0001183800	2.631
white oak	802	800, 802, 804, 823, 825, 826, 998	138.51	0.17688	-0.0000704100	2.6666
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	151.65	0.25967	-0.0000440820	2.672
northern red oak	833	813, 833, 834	167.98	0.28275	-0.0000461660	2.5895
post oak	835	822, 832, 835	146.07	0.24217	-0.0000526930	2.6322
black willow	922	922, 929	39.018	0.38544	-0.0000877590	2.7685
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	191.45	0.16087	-0.0000420910	2.7469
Other softwoods			122.77	0.41477	-0.0000239700	2.7239
Other hardwoods			94.985	0.24089	-0.0000494570	2.8454

CS and PS group name	CS and PS group code	FIA species codes	C20	C30	C31	C40
eastern redcedar	68	68	0.63	3.27	0.9	24.64
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	0.78	0.96	1.25	24.64
Virginia pine	132	110, 131, 132	0.78	0.96	1.25	24.64
baldcypress	221	221	0	0	0	0
eastern hemlock	261	12, 71, 94, 95, 241, 261	0.78	0.96	1.25	24.64
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	2.61	10.73	3.69	55.48
red maple	316	316, 317	3.54	9.91	5.05	35.86
sugar maple	318	314, 318	0.46	6.31	7.08	35.86
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	0.46	6.31	7.08	35.86
bitternut hickory	402	401, 402, 403, 408	1.06	8.87	3.52	38.17
shagbark hickory	407	400, 404, 405, 407, 409	1.67	8.87	3.52	38.17
American beech	531	371, 531, 951, 952	2.05	6.31	7.08	35.86
green ash	544	541, 543, 544, 546	2.16	6.75	9.33	52.85
black walnut	602	602	1.04	5.08	2.16	31.15
yellow-poplar	621	621	0	0	0	0
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	0.46	5.5	7.08	46.68
American sycamore	731	731	1.72	6.77	7.08	35.86
eastern cottonwood	742	740, 742, 745	1.65	10.52	5.8	28.31
quaking aspen	746	741, 743, 744, 746	0.46	6.31	7.08	35.86
white oak	802	800, 802, 804, 823, 825, 826, 998	1.18	3.81	2.34	38.17
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	2.08	6.26	3.52	38.17
northern red oak	833	813, 833, 834	2.21	7.43	3.52	38.17
post oak	835	822, 832, 835	0.82	4.29	2.34	38.17
black willow	922	922, 929	2.3	6.77	7.08	35.86
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	0.9	2.12	1.2	35.86
Other softwoods						
Other hardwoods						

CS and PS group name	CS and PS group code	FIA species codes	DFA1	DFB1	DFC1	DFA2	DFB2	DFC2
eastern redcedar	68	68	-0.3401	4.2	47.77	0.20174	0.643	0
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	-0.7145	18.677	47.77	0.10614	0	0
Virginia pine	132	110, 131, 132	0.2113	18.677	47.77	0	0	0
baldcypress	221	221	1.4726	18.677	47.77	0	0	0
eastern hemlock	261	12, 71, 94, 95, 241, 261	1.4726	18.677	47.77	0	0	0
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	2.436	4.08	34.43	0	1.407	0.9639
red maple	316	316, 317	-0.9963	17.06	39.42	0.2168	0	0.4871
sugar maple	318	314, 318	1.2702	11.177	32.19	0.045562	0.2786	0.5293
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	2.436	4.08	34.43	0	1.407	0.9639
bitternut hickory	402	401, 402, 403, 408	1.637	19.46	44.51	0	0	0
shagbark hickory	407	400, 404, 405, 407, 409	0.2967	19.46	44.51	0.08324	0	0
American beech	531	371, 531, 951, 952	0.506	10.437	38.44	0.1287	0.4591	0
green ash	544	541, 543, 544, 546	1.69	21.78	39.42	0	0	0.4871
black walnut	602	602	2.698	11.59	49.99	0	0.974	0
yellow-poplar	621	621	0.901	21.469	49.99	0	0.1798	0
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	2.436	4.08	34.43	0	1.407	0.9639
American sycamore	731	731	-0.6859	21.469	49.99	0.09987	0.1798	0
eastern cottonwood	742	740, 742, 745	1.318	21.469	49.99	0	0.1798	0
quaking aspen	746	741, 743, 744, 746	1.318	21.469	49.99	0	0.1798	0
white oak	802	800, 802, 804, 823, 825, 826, 998	0.7264	14.66	44.51	0.00897	0	0
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	0.2623	21.06	44.51	0.09571	0	0
northern red oak	833	813, 833, 834	0.4104	21.06	44.51	0.05894	0	0
post oak	835	822, 832, 835	0.4356	14.66	44.51	0.071435	0	0
black willow	922	922, 929	1.318	21.469	49.99	0	0.1798	0
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	1.2259	18.565	39.42	0.00443	0.3632	0.4871
Other softwoods								
Other hardwoods								

CS and PS group name	CS and PS group code	FIA species codes	DFA2	DFB2	DFC2
eastern redcedar	68	68	0.20174	0.643	0
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	0.10614	0	0
Virginia pine	132	110, 131, 132	0	0	0
baldcypress	221	221	0	0	0
eastern hemlock	261	12, 71, 94, 95, 241, 261	0	0	0
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	0	1.407	0.9639
red maple	316	316, 317	0.2168	0	0.4871
sugar maple	318	314, 318	0.045562	0.2786	0.5293
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	0	1.407	0.9639
bitternut hickory	402	401, 402, 403, 408	0	0	0
shagbark hickory	407	400, 404, 405, 407, 409	0.08324	0	0
American beech	531	371, 531, 951, 952	0.1287	0.4591	0
green ash	544	541, 543, 544, 546	0	0	0.4871
black walnut	602	602	0	0.974	0
yellow-poplar	621	621	0	0.1798	0
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	0	1.407	0.9639
American sycamore	731	731	0.09987	0.1798	0
eastern cottonwood	742	740, 742, 745	0	0.1798	0
quaking aspen	746	741, 743, 744, 746	0	0.1798	0
white oak	802	800, 802, 804, 823, 825, 826, 998	0.00897	0	0
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	0.09571	0	0
northern red oak	833	813, 833, 834	0.05894	0	0
post oak	835	822, 832, 835	0.071435	0	0
black willow	922	922, 929	0	0.1798	0
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	0.00443	0.3632	0.4871
Other softwoods					
Other hardwoods					

CS and PS group name	CS and PS group code	FIA species codes	DFA3	DFB3	DFC3
eastern redcedar	68	68	16.3	16.2	50.3
eastern white pine	129	57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202	16.9	48.8	50.3
Virginia pine	132	110, 131, 132	18.4	48.8	50.3
baldcypress	221	221	44.6	48.8	50.3
eastern hemlock	261	12, 71, 94, 95, 241, 261	44.6	48.8	50.3
boxelder	313	300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997	29.7	32.5	31.2
red maple	316	316, 317	34.8	48.8	42.1
sugar maple	318	314, 318	38.8	33.6	38.2
paper birch	375	373, 375, 501, 502, 600, 601, 611, 691, 693, 762	29.7	32.5	31.2
bitternut hickory	402	401, 402, 403, 408	30.4	25.7	50.3
shagbark hickory	407	400, 404, 405, 407, 409	29.6	25.7	50.3
American beech	531	371, 531, 951, 952	33.2	34	38.4
green ash	544	541, 543, 544, 546	34.7	35.2	42.1
black walnut	602	602	33.3	24.4	41.5
yellow-poplar	621	621	44.6	45.8	41.5
eastern hophornbeam	701	315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999	29.7	32.5	31.2
American sycamore	731	731	33.7	45.8	41.5
eastern cottonwood	742	740, 742, 745	44.1	45.8	41.5
quaking aspen	746	741, 743, 744, 746	44.1	45.8	41.5
white oak	802	800, 802, 804, 823, 825, 826, 998	39.5	44.4	50.3
pin oak	830	806, 809, 812, 817, 824, 830, 831, 837	41.2	48.8	50.3
northern red oak	833	813, 833, 834	38.5	48.8	50.3
post oak	835	822, 832, 835	27.6	44.4	50.3
black willow	922	922, 929	44.1	45.8	41.5
American elm	972	460, 461, 462, 463, 970, 971, 972, 974, 975, 977	33.1	52.9	42.1
Other softwoods					
Other hardwoods					

Appendix D

VBA Function NRS_VOLUME

```
Option Compare Database
Option Explicit
Public Function NRS_VOLUME(statecd, spcd, dia, boleht, cull, cullcf, treeclcd, balive, sitree, ht, VOLTYPE)
 Dim S1, S2, S3, S4, S5, S6, S7, S8 As Double
 Dim D2H As Double
 Dim TDOB As Double
 Dim NRS_GRSVOL As Double
 Dim NRS_NETVOL As Double
 Dim NRS_CUFTSND As Double
 Dim VOLEQN As String
 Dim A1, A2, A3, A4 As Double
 Dim B0, B1, B2, B3, B4, B5, B6 As Double
 Dim E1, E2 As Double
  Dim LC1, LC2, LC3 As Double
  Dim DFA1, DFA2, DFA3, DFB1, DFB2, DFB3, DFC1, DFC2, DFC3, C20, C30, C31, C40 As Double

    Select Case statecd
    Case 9, 10, 23, 24, 25, 33, 34, 36, 39, 42, 44, 50, 54
        VOLEQN = “NE”
    Case 17, 18, 19, 29
        VOLEQN = “CS”
    Case 20, 31, 38, 46
        VOLEQN = “PS”
    Case 26, 27, 55
        VOLEQN = “LS”
    Case Else
        VOLEQN = “OTHER”
    End Select
‘NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE_NE
‘==================================================================================================================================
    ‘Northeastern state volcfsnd calculations
    If VOLEQN = “NE” Then
    Select Case spcd
    ‘NE spgrp 1: White, red pine
    Case 125, 129
    B0 = 0.11: B1 = -0.05977: B2 = 2.0498: B3 = 0.04965: B4 = 2.0198: B5 = 0.3468
    ‘NE spgrp 2: Red, white, black spruce
    Case 90, 94, 95, 96, 97
    B0 = 0.17: B1 = -0.06315: B2 = 2.0654: B3 = 0.05122: B4 = 2.0264: B5 = 0.3508
    ‘NE spgrp 3: Balsam fir
    Case 10, 12016
        B0 = -0.1: B1 = -0.05444: B2 = 2.1194: B3 = 0.04821: B4 = 2.0427: B5 = 0.3579
    ‘NE spgrp 4: Hemlock
    Case 260, 261
        B0 = 0.24: B1 = -0.05895: B2 = 2.0362: B3 = 0.04947: B4 = 2.0172: B5 = 0.3366
    ‘NE spgrp 5: Hard pines, tamarack, Norway spruce
    Case 70, 71, 91, 100, 105, 110, 123, 126, 128, 130, 131, 132, 136, 202, 299
```

```
    B0 = -0.03: B1 = -0.05604: B2 = 2.0473: B3 = 0.05022: B4 = 2.0198: B5 = 0.3242
‘NE spgrp 6: Cedar species
Case 43, 57, 68, 221, 241
    B0 = 0.19: B1 = -0.05904: B2 = 1.9935: B3 = 0.04981: B4 = 2.0027: B5 = 0.3214
‘NE spgrp 7: Sugar maple
Case 318
    B0 = -0.19: B1 = -0.01171: B2 = 1.8949: B3 = 0.0134: B4 = 1.9928: B5 = 0.6471
‘NE spgrp 8: Soft maple, yellow - poplar
Case 621
    B0 = -0.45: B1 = -0.00523: B2 = 2.2323: B3 = 0.01338: B4 = 2.0093: B5 = 0.6384
‘NE spgrp 9: Ash species, aspen species
Case 540, 541, 543, 544, 545, 546, 740, 741, 742, 743, 744, 746, 752, 753
    B0 = 0.06: B1 = -0.02437: B2 = 1.5419: B3 = 0.01299: B4 = 1.9885: B5 = 0.6453
‘NE spgrp 10: black cherry
Case 762
    B0 = -0.04: B1 = -0.01783: B2 = 1.8109: B3 = 0.01358: B4 = 1.9905: B5 = 0.6553
‘NE spgrp 11: Birch species
Case 370, 371, 372, 373, 375, 379
    B0 = -0.27: B1 = -0.00675: B2 = 1.9738: B3 = 0.01327: B4 = 1.9967: B5 = 0.6407
‘NE spgrp 12: Beech
Case 531
    B0 = -0.6: B1 = -0.00711: B2 = 2.2693: B3 = 0.01399: B4 = 2.019: B5 = 0.6518
‘NE spgrp 13: Basswood
Case 950, 951, 952
    B0 = -0.39: B1 = -0.00622: B2 = 2.0066: B3 = 0.0131: B4 = 1.9939: B5 = 0.6494
‘NE spgrp 14: Red oaks, sweetgum, black gum
Case 611, 693, 806, 809, 812, 813, 817, 830, 831, 833, 834, 837
    B0 = -0.13: B1 = -0.00536: B2 = 1.9172: B3 = 0.01131: B4 = 1.9975: B5 = 0.6549
‘NE spgrp 15: Chestnut oak
Case 832
    B0 = -0.26: B1 = 0.00038: B2 = 2#: B3 = 0.01068: B4 = 1.998: B5 = 0.6438
‘NE spgrp 16: Hickory
Case 400, 401, 402, 403, 404, 405, 407, 409, 410
    B0 = -0.27: B1 = -0.00466: B2 = 2.1575: B3 = 0.01174: B4 = 2.0035: B5 = 0.664
‘NE spgrp 17: Other hardwoods
Case 310, 313, 314, 315, 319, 320, 321, 330, 331, 332, 341, 345, 355, 356, 357, _
     358, 367, 391, 421, 422, 424, 450, 452, 460, 461, 462, 471, 481, 491, 500, _
     502, 521, 552, 561, 571, 591, 600, 601, 602, 641, 650, 651, 653, 654, 655, _
     658, 660, 662, 663, 664, 680, 681, 682, 684, 691, 694, 701, 711, 712, 729, _
     731, 760, 761, 763, 764, 765, 766, 769, 771, 800, 802, 804, 816, 820, 822, _
     823, 824, 825, 826, 827, 835, 845, 901, 920, 921, 922, 923, 927, 931, 934, _
     935, 936, 937, 970, 971, 972, 974, 975, 977, 997, 998, 999
    B0 = 0.13: B1 = -0.00183: B2 = 2.36: B3 = 0.00944: B4 = 2.0608: B5 = 0.6516
 ‘NE spgrp 18: red maple, silver maple
Case 316, 317
      B0 = -0.45: B1 = -0.00523: B2 = 2.2323: B3 = 0.01338: B4 = 2.0093: B5 = 0.6384

Case Else
    B0 = 0.13: B1 = -0.00183: B2 = 2.36: B3 = 0.00944: B4 = 2.0608: B5 = 0.6516
End Select
NRS_GRSVOL = B0 + B1 * dia ^ B2 + B3 * dia ^ B4 * boleht ^ B5
NRS_CUFTSND = NRS_GRSVOL * (1 - cull / 100)
```

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    NRS_NETVOL = NRS_GRSVOL * (1 - cullcf / 100)

'LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS_LS
'==========================================================================================================================

ElseIf VOLEQN = "LS" Then
E1 = 100#
E2 = 0#
      Select Case spcd
    'Grp 012: balsam fir
    Case 10, 12, 15, 16
        B1 = 14.304: B2 = 0.19894: B3 = 1.4195: B4 = 0.23349: B5 = 0.76878: B6 = 0.12399: E1 = 99.92: E2 = 0
        LC1 = 2.1: LC2 = 11.1: LC3 = 63.4
    'Grp 068: eastern redcedar
    Case 68
        B1 = 8.2079: B2 = 0.19672: B3 = 1.3112: B4 = 0.33978: B5 = 0.76173: B6 = 0.11666: E1 = 110.32: E2 = 0.6
        LC1 = 3.4: LC2 = 22#: LC3 = 52.2
    'Grp 071:
    Case 71
        B1 = 13.62: B2 = 0.24255: B3 = 1.2885: B4 = 0.25831: B5 = 0.68128: B6 = 0.10771: E1 = 105.52: E2 = 0
        LC1 = 2.7: LC2 = 16.8: LC3 = 58.4
    'Grp 094
    Case 94
        B1 = 31.957: B2 = 0.18511: B3 = 1.702: B4 = 0: B5 = 0.68967: B6 = 0.162: E1 = 105.52: E2 = 0
        LC1 = 1.6: LC2 = 11.7: LC3 = 56#
    'Grp 095
    Case 95
        B1 = 20.038: B2 = 0.18981: B3 = 1.2909: B4 = 0.17836: B5 = 0.57343: B6 = 0.10159: E1 = 95.77: E2 = 0.5
        LC1 = 1.4: LC2 = 12.1: LC3 = 57.7
    'Grp 105
    Case 66, 91, 93, 105, 202, 299
        B1 = 16.934: B2 = 0.12972: B3 = 1: B4 = 0.20854: B5 = 0.77792: B6 = 0.12902: E1 = 86.77: E2 = 0.85
        LC1 = 2.6: LC2 = 17.8: LC3 = 63.1
    'Grp 125
    Case 122, 125, 126
        B1 = 36.851: B2 = 0.08298: B3 = 1: B4 = 0.00001: B5 = 0.63884: B6 = 0.18231: E1 = 101.79: E2 = -0.55
        LC1 = 1.3: LC2 = 11.2: LC3 = 74.3
    'Grp 129
    Case 129
        B1 = 16.281: B2 = 0.08621: B3 = 1: B4 = 0.1622: B5 = 0.86833: B6 = 0.23316: E1 = 95.88: E2 = 0
        LC1 = 3.2: LC2 = 16.6: LC3 = 64.6
    'Grp 130
    Case 57, 70, 96, 130, 136
        B1 = 16.934: B2 = 0.12972: B3 = 1: B4 = 0.20854: B5 = 0.77792: B6 = 0.12902: E1 = 86.77: E2 = 0.85
        LC1 = 3.4: LC2 = 22#: LC3 = 52.2
    'Grp 132
    Case 110, 131, 132
        B1 = 36.851: B2 = 0.08298: B3 = 1: B4 = 0.00001: B5 = 0.63884: B6 = 0.18231: E1 = 79.1: E2 = 0.6
        LC1 = 1.3: LC2 = 11.2: LC3 = 74.3
    'Grp 221
    Case 221
        B1 = 16.281: B2 = 0.08621: B3 = 1: B4 = 0.1622: B5 = 0.86833: B6 = 0.23316: E1 = 79.1: E2 = 0.6
```

LC1 = 3.2: LC2 = 16.6: LC3 = 64.6
‘Grp 241
Case 241
B1 = 8.2079: B2 = 0.19672: B3 = 1.3112: B4 = 0.33978: B5 = 0.76173: B6 = 0.11666: E1 = 103.43: E2 = 0
LC1 = 3.8: LC2 = 17.2: LC3 = 61.2
‘Grp 261
Case 261
B1 = 6.077: B2 = 0.2495: B3 = 3.8663: B4 = 0.5018: B5 = 0.8244: B6 = 0.0482: E1 = 84.68: E2 = 0.62
LC1 = 5.4: LC2 = 24.9: LC3 = 71.9
‘Grp 313
Case 300, 313, 321, 330, 331, 332, 355, 372, 379, 381, 421, 423, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 772, 828, 901, 927, 931, 997
B1 = 6.9572: B2 = 0.26564: B3 = 1: B4 = 0.4866: B5 = 0.76954: B6 = 0.01617: E1 = 82.6: E2 = 0.6
LC1 = 8.7: LC2 = 21#: LC3 = 64.2
‘Grp 316
Case 316, 317
B1 = 6.86: B2 = 0.27725: B3 = 1.4287: B4 = 0.40115: B5 = 0.85299: B6 = 0.12403: E1 = 102.19: E2 = 0
LC1 = 5.8: LC2 = 16.8: LC3 = 62.3
‘Grp 318
Case 314, 318
B1 = 5.3416: B2 = 0.23044: B3 = 1.1529: B4 = 0.54194: B5 = 0.8344: B6 = 0.06372: E1 = 104.42: E2 = -0.16
LC1 = 6.3: LC2 = 17.7: LC3 = 61.7
‘Grp 371
Case 371
B1 = 7.1852: B2 = 0.28384: B3 = 1.4417: B4 = 0.38884: B5 = 0.82157: B6 = 0.11411: E1 = 102.41: E2 = 0
LC1 = 8.9: LC2 = 19.7: LC3 = 64#
‘Grp 373
Case 373
B1 = 7.2773: B2 = 0.22721: B3 = 1: B4 = 0.41179: B5 = 0.76498: B6 = 0.11046: E1 = 83.62: E2 = 0.6
LC1 = 4.5: LC2 = 14.3: LC3 = 64.9
‘Grp 375
Case 375
B1 = 7.2773: B2 = 0.22721: B3 = 1: B4 = 0.41179: B5 = 0.76498: B6 = 0.11046: E1 = 98.21: E2 = 0.2
LC1 = 4.5: LC2 = 14.3: LC3 = 64.9
‘Grp 402
Case 401, 402, 403, 408
B1 = 6.1034: B2 = 0.17368: B3 = 1: B4 = 0.44725: B5 = 1.0237: B6 = 0.1461: E1 = 85.09: E2 = 0.6
LC1 = 4.7: LC2 = 15.2: LC3 = 65.7
‘Grp 407
Case 400, 404, 405, 407, 409
B1 = 6.1034: B2 = 0.17368: B3 = 1: B4 = 0.44725: B5 = 1.0237: B6 = 0.1461: E1 = 85.18: E2 = 0.6
LC1 = 4.7: LC2 = 15.2: LC3 = 65.7
‘Grp 462
Case 460, 461, 462, 463
B1 = 6.86: B2 = 0.27725: B3 = 1.4287: B4 = 0.40115: B5 = 0.85299: B6 = 0.12403: E1 = 98.95: E2 = 0
LC1 = 6.3: LC2 = 13.2: LC3 = 64# ‘ was LC1 = 5.8: LC2 = 16.8: LC3 = 62.3
‘Grp 531
Case 531
B1 = 7.1852: B2 = 0.28384: B3 = 1.4417: B4 = 0.38884: B5 = 0.82157: B6 = 0.11411: E1 = 111.73: E2 = -0.23
LC1 = 8.1: LC2 = 21.8: LC3 = 55.3
‘Grp 543
Case 543, 546
B1 = 11.291: B2 = 0.2525: B3 = 1.5466: B4 = 0.35711: B5 = 0.7506: B6 = 0.06859: E1 = 98.44: E2 = 0

LC1 = 5.3: LC2 = 20.2: LC3 = 67.2
‘Grp 544
Case 541, 544
B1 = 8.1782: B2 = 0.27316: B3 = 1.725: B4 = 0.38694: B5 = 0.75822: B6 = 0.10847: E1 = 83: E2 = 0.6
LC1 = 4.6: LC2 = 17.8: LC3 = 62.2
‘Grp 602
Case 600, 601, 602
B1 = 6.3628: B2 = 0.27859: B3 = 1.8677: B4 = 0.49589: B5 = 0.76169: B6 = 0.05841: E1 = 114.84: E2 = -0.88
LC1 = 6.8: LC2 = 15.5: LC3 = 61.2
‘Grp 611
Case 611
B1 = 5.3416: B2 = 0.23044: B3 = 1.1529: B4 = 0.54194: B5 = 0.8344: B6 = 0.06372: E1 = 82.52: E2 = 0.6
LC1 = 6.8: LC2 = 15.5: LC3 = 61.2
‘Grp 621
Case 621
B1 = 6.3628: B2 = 0.27859: B3 = 1.8677: B4 = 0.49589: B5 = 0.76169: B6 = 0.05841: E1 = 90.23: E2 = 0.6
LC1 = 6.8: LC2 = 15.5: LC3 = 61.2
‘Grp 691
Case 691, 693
B1 = 5.3416: B2 = 0.23044: B3 = 1.1529: B4 = 0.54194: B5 = 0.8344: B6 = 0.06372: E1 = 81.01: E2 = 0.6
LC1 = 6.3: LC2 = 17.7: LC3 = 61.7
‘Grp 701
Case 315, 319, 341, 345, 356, 357, 358, 367, 391, 471, 500, 591, 641, 660, 663, 701, 761, 763, 765, 766, 919, 920, 921, 923, 935, 996, 999
B1 = 6.9572: B2 = 0.26564: B3 = 1: B4 = 0.4866: B5 = 0.76954: B6 = 0.01617: E1 = 84.71: E2 = 0.6
LC1 = 8.7: LC2 = 16.8: LC3 = 64.2
‘Grp 731
Case 731
B1 = 6.3628: B2 = 0.27859: B3 = 1.8677: B4 = 0.49589: B5 = 0.76169: B6 = 0.05841: E1 = 93.83: E2 = 0.6
LC1 = 6.8: LC2 = 15.5: LC3 = 61.2
‘Grp 741
Case 741
B1 = 6.4301: B2 = 0.23545: B3 = 1.338: B4 = 0.4737: B5 = 0.73385: B6 = 0.08228: E1 = 91.51: E2 = 0.37
LC1 = 4.5: LC2 = 19#: LC3 = 65.2
‘Grp 742
Case 740, 742, 745, 922, 929
B1 = 13.625: B2 = 0.28668: B3 = 1.6124: B4 = 0.30651: B5 = 1.0292: B6 = 0.07461: E1 = 82.5: E2 = 0.6
LC1 = 5.5: LC2 = 19.7: LC3 = 70.6
‘Grp 743
Case 743
B1 = 5.5346: B2 = 0.22637: B3 = 1: B4 = 0.46918: B5 = 0.72456: B6 = 0.11782: E1 = 91.51: E2 = 0.37
LC1 = 4.4: LC2 = 20.7: LC3 = 59.7
‘Grp 746
Case 741, 744, 746, 753, 998
B1 = 6.4301: B2 = 0.23545: B3 = 1.338: B4 = 0.4737: B5 = 0.73385: B6 = 0.08228: E1 = 91.51: E2 = 0.37
LC1 = 5.2: LC2 = 21.8: LC3 = 61.8
‘Grp 762
Case 762
B1 = 5.3416: B2 = 0.23044: B3 = 1.1529: B4 = 0.54194: B5 = 0.8344: B6 = 0.06372: E1 = 114.84: E2 = -0.88
LC1 = 6.8: LC2 = 15.5: LC3 = 61.2
‘Grp 802
Case 802, 804, 823, 825, 826
B1 = 9.2078: B2 = 0.22208: B3 = 1: B4 = 0.31723: B5 = 0.8256: B6 = 0.13465: E1 = 83.95: E2 = 0.6

```
    LC1 = 5.5: LC2 = 14#: LC3 = 65.6
  'Grp 830
  Case 806, 809, 812, 817, 824, 830, 831, 837
    B1 = 3.8011: B2 = 0.39213: B3 = 2.9053: B4 = 0.55634: B5 = 0.84317: B6 = 0.09593: E1 = 84.59: E2 = 0.6
    LC1 = 6.1: LC2 = 10.7: LC3 = 66.5
  'Grp 833
  Case 813, 833
    B1 = 6.6844: B2 = 0.19049: B3 = 1: B4 = 0.43972: B5 = 0.82962: B6 = 0.10806: E1 = 84.21: E2 = 0.6
    LC1 = 5.3: LC2 = 14.4: LC3 = 63.6
  'Grp 834
  Case 834
    B1 = 6.6844: B2 = 0.19049: B3 = 1: B4 = 0.43972: B5 = 0.82962: B6 = 0.10806: E1 = 84.21: E2 = 0.6
    LC1 = 5.3: LC2 = 14.4: LC3 = 63.6
  'Grp 835
  Case 822, 832, 835
    B1 = 9.2078: B2 = 0.22208: B3 = 1: B4 = 0.31723: B5 = 0.8256: B6 = 0.13465: E1 = 84.24: E2 = 0.6
    LC1 = 5.5: LC2 = 14#: LC3 = 65.6
  'Grp 951
  Case 951, 952
    B1 = 6.3628: B2 = 0.27859: B3 = 1.8677: B4 = 0.49589: B5 = 0.76169: B6 = 0.05841: E1 = 97.07: E2 = 0
    LC1 = 4.4: LC2 = 14#: LC3 = 63.3
  'Grp 972
  Case 970, 971, 972, 974, 975, 977
    B1 = 8.458: B2 = 0.27527: B3 = 1.9602: B4 = 0.34894: B5 = 0.89213: B6 = 0.12594: E1 = 98.95: E2 = 0
    LC1 = 6.3: LC2 = 13.2: LC3 = 64#
  'Grp 999
  Case 501, 502
    B1 = 6.9572: B2 = 0.26564: B3 = 1: B4 = 0.4866: B5 = 0.76954: B6 = 0.01617: E1 = 84.71: E2 = 0.6
    LC1 = 8.7: LC2 = 16.8: LC3 = 64.2
Case Else
   If spcd < 300 Then ' use coefficients from LSspgrp 017 Other softwoods
        B1 = 16.934: B2 = 0.12972: B3 = 1#: B4 = 0.20854: B5 = 0.77792: B6 = 0.12902: E1 = 86.77: E2 = 0.85
        LC1 = 2.6: LC2 = 17.8: LC3 = 63.1
       Else         ' use coefficients from LSspgrp 049 Other hardwoods
        B1 = 6.9572: B2 = 0.26564: B3 = 1#: B4 = 0.4866: B5 = 0.76954: B6 = 0.01617: E1 = 84.71: E2 = 0.6
        LC1 = 8.7: LC2 = 21#: LC3 = 64.2
   End If
End Select

If (IsNull(boleht) Or boleht = 0) Then 'Use Ek's height equation for Lake States when boleht is not available
   '--set limits to site index
   If (sitree < 20) Then
        sitree = 20
      ElseIf (sitree > 120) Then
        sitree = 120
      Else
        sitree = sitree
   End If
   '--Set limits to condition BA
   If (balive < 50#) Then
        balive = 50#
      ElseIf (balive > 350#) Then
```

```
            balive = 350#
         Else
            balive = balive
      End If
      TDOB = 4#
      boleht = 4.5 + B1 * (1# - (Exp(-B2 * dia))) ^ B3 * sitree ^ B4 * (1.00001 - TDOB / dia) ^ B5 * balive ^ B6
   End If
   TDOB = 4#

‘  Cubic Foot Volume Equations
   S1 = (2.0355 * (10 ^ -3)) * dia
   S2 = (-3.0018 * (10 ^ -3)) * TDOB
   S3 = (6.2381 * (10 ^ -5)) * dia ^ 2
   S4 = (2.5705 * (10 ^ -5)) * dia ^ 2 * boleht
   S5 = (-7.009 * (10 ^ -6)) * boleht ^ 2
   S6 = (3.6708 * (10 ^ -5)) * boleht * TDOB ^ 2
   S7 = (8.14 * (10 ^ -10)) * dia ^ 2 * boleht ^ 3
   S8 = (-1.9 * (10 ^ -9)) * dia ^ 2 * boleht ^ 2 * TDOB

   NRS_GRSVOL = (3.0086 * 10 ^ -3 + S1 + S2 + S3 + S4 + S5 + S6 + S7 + S8) * 79#
   NRS_GRSVOL = NRS_GRSVOL * (E1 + E2 * dia) / 100

   If (treeclcd = 2) Then
      cull = LC1
   ElseIf (treeclcd = 3) Then
      cull = LC2
   ElseIf (treeclcd = 4) Then
      cull = LC3
   Else
      cull = 100#
   End If
   NRS_NETVOL = NRS_GRSVOL * (1 - cull / 100#)
   If (treeclcd = 2) Then
      NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.9
   ElseIf (treeclcd = 3) Then
      NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.85
   ElseIf (treeclcd = 4) Then
      NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.25
   Else
      cull = 100#
   End If
‘CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS_PS_CS
‘===========================================================================================================================
 ElseIf (VOLEQN = “CS” Or VOLEQN = “PS”) Then
   Select Case spcd
    ‘CS_PS_SPGRP 68
   Case 68
      A1 = 112.59: A2 = 0.12504: A3 = -0.00010633: A4 = 2.626: B1 = 0.35933
      DFA1 = -0.3401: DFB1 = 4.2: DFC1 = 47.77: DFA2 = 0.20174: DFB2 = 0.643: DFC2 = 0: DFA3 = 16.3: DFB3 = 16.2: DFC3 = 50.3
      C20 = 0.63: C30 = 3.27: C31 = 0.9: C40 = 24.64
   ‘CS_PS_SPGRP 129
   Case 57, 66, 70, 91, 93, 96, 105, 122, 125, 129, 130, 136, 202
```

A1 = 122.77: A2 = 0.41477: A3 = -0.00002397: A4 = 2.7239: B1 = 0.29204
DFA1 = -0.7145: DFB1 = 18.677: DFC1 = 47.77: DFA2 = 0.10614: DFB2 = 0: DFC2 = 0: DFA3 = 16.9: DFB3 = 48.8: DFC3 = 50.3
C20 = 0.78: C30 = 0.96: C31 = 1.25: C40 = 24.64
‘CS_PS_SPGRP 132
Case 110, 131, 132
A1 = 122.58: A2 = 0.20684: A3 = -0.000057669: A4 = 2.7719: B1 = 0.30131
DFA1 = 0.2113: DFB1 = 18.677: DFC1 = 47.77: DFA2 = 0: DFB2 = 0: DFC2 = 0: DFA3 = 18.4: DFB3 = 48.8: DFC3 = 50.3
C20 = 0.78: C30 = 0.96: C31 = 1.25: C40 = 24.64
‘CS_PS_SPGRP 221
Case 221
A1 = 337.22: A2 = 0.11585: A3 = -0.0000081788: A4 = 3.2004: B1 = 0.30797
DFA1 = 1.4726: DFB1 = 18.677: DFC1 = 47.77: DFA2 = 0: DFB2 = 0: DFC2 = 0: DFA3 = 44.6: DFB3 = 48.8: DFC3 = 50.3
C20 = 0: C30 = 0: C31 = 0: C40 = 0
‘CS_PS_SPGRP 261
Case 12, 71, 94, 95, 241, 261
A1 = 454.13: A2 = 0.13672: A3 = -0.000025473: A4 = 2.6247: B1 = 0.28516
DFA1 = 1.4726: DFB1 = 18.677: DFC1 = 47.77: DFA2 = 0: DFB2 = 0: DFC2 = 0: DFA3 = 44.6: DFB3 = 48.8: DFC3 = 50.3
C20 = 0.78: C30 = 0.96: C31 = 1.25: C40 = 24.64
‘CS_PS_SPGRP 313
Case 300, 313, 321, 330, 331, 332, 334, 355, 372, 379, 381, 421, 423, 451, 452, 481, 491, 521, 545, 551, 552, 571, 651, 680, 681, 682, 694, 749, 752, 760, 828, 901, 927, 931, 991, 997
A1 = 94.985: A2 = 0.24089: A3 = -0.000049457: A4 = 2.8454: B1 = 0.28367
DFA1 = 2.436: DFB1 = 4.08: DFC1 = 34.43: DFA2 = 0: DFB2 = 1.407: DFC2 = 0.9639: DFA3 = 29.7: DFB3 = 32.5: DFC3 = 31.2
C20 = 2.61: C30 = 10.73: C31 = 3.69: C40 = 55.48
‘CS_PS_SPGRP 316
Case 316, 317
A1 = 431.19: A2 = 0.019385: A3 = -0.000046628: A4 = 2.6776: B1 = 0.30461
DFA1 = -0.9963: DFB1 = 17.06: DFC1 = 39.42: DFA2 = 0.2168: DFB2 = 0: DFC2 = 0.4871: DFA3 = 34.8: DFB3 = 48.8: DFC3 = 42.1
C20 = 3.54: C30 = 9.91: C31 = 5.05: C40 = 35.86
‘CS_PS_SPGRP 318
Case 314, 318
A1 = 118.8: A2 = 0.21064: A3 = -0.000071839: A4 = 2.7238: B1 = 0.30171
DFA1 = 1.2702: DFB1 = 11.177: DFC1 = 32.19: DFA2 = 0.045562: DFB2 = 0.2786: DFC2 = 0.5293: DFA3 = 38.8: DFB3 = 33.6: DFC3 = 38.2
C20 = 0.46: C30 = 6.31: C31 = 7.08: C40 = 35.86
‘CS_PS_SPGRP 375
Case 373, 375, 501, 502, 600, 601, 611, 691, 693, 762
A1 = 94.985: A2 = 0.24089: A3 = -0.000049457: A4 = 2.8454: B1 = 0.28367
DFA1 = 2.436: DFB1 = 4.08: DFC1 = 34.43: DFA2 = 0: DFB2 = 1.407: DFC2 = 0.9639: DFA3 = 29.7: DFB3 = 32.5: DFC3 = 31.2
C20 = 0.46: C30 = 6.31: C31 = 7.08: C40 = 35.86
‘CS_PS_SPGRP 402
Case 401, 402, 403, 408
A1 = 60.548: A2 = 0.29655: A3 = -0.000065367: A4 = 2.8739: B1 = 0.29118
DFA1 = 1.637: DFB1 = 19.46: DFC1 = 44.51: DFA2 = 0: DFB2 = 0: DFC2 = 0: DFA3 = 30.4: DFB3 = 25.7: DFC3 = 50.3
C20 = 1.06: C30 = 8.87: C31 = 3.52: C40 = 38.17
‘CS_PS_SPGRP 407
Case 400, 404, 405, 407, 409
A1 = 84.154: A2 = 0.2452: A3 = -0.000064831: A4 = 2.8221: B1 = 0.28686
DFA1 = 0.2967: DFB1 = 19.46: DFC1 = 44.51: DFA2 = 0.08324: DFB2 = 0: DFC2 = 0: DFA3 = 29.6: DFB3 = 25.7: DFC3 = 50.3
C20 = 1.67: C30 = 8.87: C31 = 3.52: C40 = 38.17
‘CS_PS_SPGRP 531
Case 371, 531, 951, 952
A1 = 194.75: A2 = 0.17455: A3 = -0.000045078: A4 = 2.732: B1 = 0.35571
DFA1 = 0.506: DFB1 = 10.437: DFC1 = 38.44: DFA2 = 0.1287: DFB2 = 0.4591: DFC2 = 0: DFA3 = 33.2: DFB3 = 34: DFC3 = 38.4

C20 = 2.05: C30 = 6.31: C31 = 7.08: C40 = 35.86
‘CS_PS_SPGRP 544
Case 541, 543, 544, 546
A1 = 73.722: A2 = 0.22835: A3 = -0.000080785: A4 = 2.7999: B1 = 0.31065
DFA1 = 1.69: DFB1 = 21.78: DFC1 = 39.42: DFA2 = 0: DFB2 = 0: DFC2 = 0.4871: DFA3 = 34.7: DFB3 = 35.2: DFC3 = 42.1
C20 = 2.16: C30 = 6.75: C31 = 9.33: C40 = 52.85
‘CS_PS_SPGRP 602
Case 602
A1 = 137.32: A2 = 0.13993: A3 = -0.000074308: A4 = 2.6999: B1 = 0.30397
DFA1 = 2.698: DFB1 = 11.59: DFC1 = 49.99: DFA2 = 0: DFB2 = 0.974: DFC2 = 0: DFA3 = 33.3: DFB3 = 24.4: DFC3 = 41.5
C20 = 1.04: C30 = 5.08: C31 = 2.16: C40 = 31.15
‘CS_PS_SPGRP 621
Case 621
A1 = 232.88: A2 = 0.20935: A3 = -0.000033792: A4 = 2.7596: B1 = 0.31615
DFA1 = 0.901: DFB1 = 21.469: DFC1 = 49.99: DFA2 = 0: DFB2 = 0.1798: DFC2 = 0: DFA3 = 44.6: DFB3 = 45.8: DFC3 = 41.5
C20 = 0: C30 = 0: C31 = 0: C40 = 0
‘CS_PS_SPGRP 701
Case 315, 319, 341, 345, 356, 357, 367, 391, 471, 500, 591, 641, 660, 664, 701, 761, 763, 765, 766, 919, 920, 921, 923, 925, 935, 996, 999
A1 = 94.985: A2 = 0.24089: A3 = -0.000049457: A4 = 2.8454: B1 = 0.28367
DFA1 = 2.436: DFB1 = 4.08: DFC1 = 34.43: DFA2 = 0: DFB2 = 1.407: DFC2 = 0.9639: DFA3 = 29.7: DFB3 = 32.5: DFC3 = 31.2
C20 = 0.46: C30 = 5.5: C31 = 7.08: C40 = 46.68
‘CS_PS_SPGRP 731
Case 731
A1 = 326.3: A2 = 0.19774: A3 = -0.000032404: A4 = 2.6696: B1 = 0.30304
DFA1 = -0.6859: DFB1 = 21.469: DFC1 = 49.99: DFA2 = 0.09987: DFB2 = 0.1798: DFC2 = 0: DFA3 = 33.7: DFB3 = 45.8: DFC3 = 41.5
C20 = 1.72: C30 = 6.77: C31 = 7.08: C40 = 35.86
‘CS_PS_SPGRP 742
Case 740, 742, 745
A1 = 479.95: A2 = 0.11037: A3 = -0.000030495: A4 = 2.6521: B1 = 0.3494
DFA1 = 1.318: DFB1 = 21.469: DFC1 = 49.99: DFA2 = 0: DFB2 = 0.1798: DFC2 = 0: DFA3 = 44.1: DFB3 = 45.8: DFC3 = 41.5
C20 = 1.65: C30 = 10.52: C31 = 5.8: C40 = 28.31
‘CS_PS_SPGRP 746
Case 741, 743, 744, 746
A1 = 61.217: A2 = 0.28402: A3 = -0.00011838: A4 = 2.631: B1 = 0.31359
DFA1 = 1.318: DFB1 = 21.469: DFC1 = 49.99: DFA2 = 0: DFB2 = 0.1798: DFC2 = 0: DFA3 = 44.1: DFB3 = 45.8: DFC3 = 41.5
C20 = 0.46: C30 = 6.31: C31 = 7.08: C40 = 35.86
‘CS_PS_SPGRP 802
Case 800, 802, 804, 823, 825, 826, 998
A1 = 138.51: A2 = 0.17688: A3 = -0.00007041: A4 = 2.6666: B1 = 0.33464
DFA1 = 0.7264: DFB1 = 14.66: DFC1 = 44.51: DFA2 = 0.00897: DFB2 = 0: DFC2 = 0: DFA3 = 39.5: DFB3 = 44.4: DFC3 = 50.3
C20 = 1.18: C30 = 3.81: C31 = 2.34: C40 = 38.17
‘CS_PS_SPGRP 830
Case 806, 809, 812, 817, 824, 830, 831, 837
A1 = 151.65: A2 = 0.25967: A3 = -0.000044082: A4 = 2.672: B1 = 0.33531
DFA1 = 0.2623: DFB1 = 21.06: DFC1 = 44.51: DFA2 = 0.09571: DFB2 = 0: DFC2 = 0: DFA3 = 41.2: DFB3 = 48.8: DFC3 = 50.3
C20 = 2.08: C30 = 6.26: C31 = 3.52: C40 = 38.17
‘CS_PS_SPGRP 833
Case 813, 833, 834
A1 = 167.98: A2 = 0.28275: A3 = -0.000046166: A4 = 2.5895: B1 = 0.35216
DFA1 = 0.4104: DFB1 = 21.06: DFC1 = 44.51: DFA2 = 0.05894: DFB2 = 0: DFC2 = 0: DFA3 = 38.5: DFB3 = 48.8: DFC3 = 50.3
C20 = 2.21: C30 = 7.43: C31 = 3.52: C40 = 38.17
‘CS_PS_SPGRP 835

```
    Case 822, 832, 835
       A1 = 146.07: A2 = 0.24217: A3 = -0.000052693: A4 = 2.6322: B1 = 0.32485
       DFA1 = 0.4356: DFB1 = 14.66: DFC1 = 44.51: DFA2 = 0.071435: DFB2 = 0: DFC2 = 0: DFA3 = 27.6: DFB3 = 44.4: DFC3 = 50.3
       C20 = 0.82: C30 = 4.29: C31 = 2.34: C40 = 38.17
    'CS_PS_SPGRP 922
    Case 922, 929
       A1 = 39.018: A2 = 0.38544: A3 = -0.000087759: A4 = 2.7685: B1 = 0.25003
       DFA1 = 1.318: DFB1 = 21.469: DFC1 = 49.99: DFA2 = 0: DFB2 = 0.1798: DFC2 = 0: DFA3 = 44.1: DFB3 = 45.8: DFC3 = 41.5
       C20 = 2.3: C30 = 6.77: C31 = 7.08: C40 = 35.86
    'CS_PS_SPGRP 972
    Case 460, 461, 462, 463, 970, 971, 972, 974, 975, 977
       A1 = 191.45: A2 = 0.16087: A3 = -0.000042091: A4 = 2.7469: B1 = 0.31607
       DFA1 = 1.2259: DFB1 = 18.565: DFC1 = 39.42: DFA2 = 0.00443: DFB2 = 0.3632: DFC2 = 0.4871: DFA3 = 33.1: DFB3 = 52.9: DFC3 = 42.1
       C20 = 0.9: C30 = 2.12: C31 = 1.2: C40 = 35.86
    Case Else
       If spcd < 300 Then ' use coefficients from LSspgrp 017 Other softwoods
             A1 = 122.77: A2 = 0.41477: A3 = -0.00002397: A4 = 2.7239
          Else         ' use coefficients from LSspgrp 049 Other hardwoods
             A1 = 94.985: A2 = 0.24089: A3 = -0.000049457: A4 = 2.8454
       End If
    End Select

If (VOLEQN = "PS" And spcd = 122) Then 'We use Rocky Mtn equation for Ponderosa Pine in Plain States
    D2H = dia * dia * ht
    If (D2H <= 6700) Then
      NRS_GRSVOL = 0.002297 * D2H - 1.032297
    Else
      NRS_GRSVOL = 0.002407 * D2H - 2.257724
    End If
    If (NRS_GRSVOL <= 0 And dia >= 1) Then
      NRS_GRSVOL = 0.1
    End If
  Else
      NRS_GRSVOL = A1 * sitree ^ A2 * (1 - Exp(A3 * dia ^ A4))
End If
If VOLEQN = "CS" Then
If treeclcd = 2 Then
    If (dia < DFA3) Then
       cull = DFA1 + DFA2 * dia
    Else
       cull = DFA1 + DFA2 * DFA3
    End If
   ElseIf treeclcd = 3 Then
   If (dia < DFB3) Then
       cull = DFB1 + DFB2 * dia
    Else
       cull = DFB1 + DFB2 * DFB3
   End If
   ElseIf treeclcd = 4 Then
   If (dia < DFC3) Then
       cull = DFC1 + DFC2 * dia
    Else
```

```
        cull = DFC1 + DFC2 * DFC3
    End If
End If
ElseIf VOLEQN = “PS” Then
    If treeclcd = 2 Then
            cull = C20
        ElseIf treeclcd = 3 Then
            cull = C30
        Else
            cull = C40
    End If
End If
‘=================================================================================================================================

NRS_NETVOL = NRS_GRSVOL * (1 - cull / 100#)
    If (treeclcd = 2) Then
        NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.9
    ElseIf (treeclcd = 3) Then
        NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.85
    ElseIf (treeclcd = 4) Then
        NRS_CUFTSND = NRS_NETVOL + (NRS_GRSVOL - NRS_NETVOL) * 0.25
    Else
        NRS_CUFTSND = 0
    End If
 End If

   If (VOLTYPE = “GROSS”) Then
        NRS_VOLUME = NRS_GRSVOL
        ElseIf (VOLTYPE = “NET”) Then
        NRS_VOLUME = NRS_NETVOL
        ElseIf (VOLTYPE = “SOUND”) Then
        NRS_VOLUME = NRS_CUFTSND
        Else
        NRS_VOLUME = 0
  End If
End Function
```

Appendix E

State FIPS Codes for NRS-FIA States

STATECD	STATENM
9	Connecticut
10	Delaware
17	Illinois
18	Indiana
19	Iowa
20	Kansas
23	Maine
24	Maryland
25	Massachusetts
26	Michigan
27	Minnesota
29	Missouri
31	Nebraska
33	New Hampshire
34	New Jersey
36	New York
38	North Dakota
39	Ohio
42	Pennsylvania
44	Rhode Island
46	South Dakota
50	Vermont
54	West Virginia
55	Wisconsin

Appendix F

FIA Species Codes with Common and Scientific Names

SPCD	COMMON_NAME	GENUS	SPECIES	VARIETY
10	fir spp.	*Abies*	*spp.*	
11	Pacific silver fir	*Abies*	*amabilis*	
12	balsam fir	*Abies*	*balsamea*	
14	Santa Lucia or bristlecone fir	*Abies*	*bracteata*	
15	white fir	*Abies*	*concolor*	
16	Fraser fir	*Abies*	*fraseri*	
17	grand fir	*Abies*	*grandis*	
18	corkbark fir	*Abies*	*lasiocarpa*	*arizonica*
19	subalpine fir	*Abies*	*lasiocarpa*	
20	California red fir	*Abies*	*magnifica*	
21	Shasta red fir	*Abies*	*shastensis*	
22	noble fir	*Abies*	*procera*	
40	white-cedar spp.	*Chamaecyparis*	*spp.*	
41	Port-Orford-cedar	*Chamaecyparis*	*lawsoniana*	
42	Alaska yellow-cedar	*Chamaecyparis*	*nootkatensis*	
43	Atlantic white-cedar	*Chamaecyparis*	*thyoides*	
50	cypress	*Cupressus*	*spp.*	
51	Arizona cypress	*Cupressus*	*arizonica*	
52	Baker or Modoc cypress	*Cupressus*	*bakeri*	
53	Tecate cypress	*Cupressus*	*forbesii*	
54	Monterey cypress	*Cupressus*	*macrocarpa*	
55	Sargent's cypress	*Cupressus*	*sargentii*	
56	MacNab's cypress	*Cupressus*	*macnabiana*	
57	redcedar/juniper spp.	*Juniperus*	*spp.*	
58	Pinchot juniper	*Juniperus*	*pinchotii*	
59	redberry juniper	*Juniperus*	*coahuilensis*	
60	Drooping juniper	*Juniperus*	*flaccida*	
61	Ashe juniper	*Juniperus*	*ashei*	
62	California juniper	*Juniperus*	*californica*	
63	alligator juniper	*Juniperus*	*deppeana*	
64	western juniper	*Juniperus*	*occidentalis*	
65	Utah juniper	*Juniperus*	*osteosperma*	
66	Rocky Mountain juniper	*Juniperus*	*scopulorum*	
67	southern redcedar	*Juniperus*	*virginiana*	*silicicola*
68	eastern redcedar	*Juniperus*	*virginiana*	
69	oneseed juniper	*Juniperus*	*monosperma*	
70	larch spp.	*Larix*	*spp.*	
71	tamarack (native)	*Larix*	*laricina*	
72	subalpine larch	*Larix*	*lyallii*	
73	western larch	*Larix*	*occidentalis*	

SPCD	COMMON_NAME	GENUS	SPECIES	VARIETY
81	incense-cedar	*Calocedrus*	*decurrens*	
90	spruce spp.	*Picea*	*spp.*	
91	Norway spruce	*Picea*	*abies*	
92	Brewer spruce	*Picea*	*breweriana*	
93	Engelmann spruce	*Picea*	*engelmannii*	
94	white spruce	*Picea*	*glauca*	
95	black spruce	*Picea*	*mariana*	
96	blue spruce	*Picea*	*pungens*	
97	red spruce	*Picea*	*rubens*	
98	Sitka spruce	*Picea*	*sitchensis*	
100	pine spp.	*Pinus*	*spp.*	
101	whitebark pine	*Pinus*	*albicaulis*	
102	Rocky Mountain bristlecone pine	*Pinus*	*aristata*	
103	knobcone pine	*Pinus*	*attenuata*	
104	foxtail pine	*Pinus*	*balfouriana*	
105	jack pine	*Pinus*	*banksiana*	
106	common or two-needle pinyon	*Pinus*	*edulis*	
107	sand pine	*Pinus*	*clausa*	
108	lodgepole pine	*Pinus*	*contorta*	
109	Coulter pine	*Pinus*	*coulteri*	
110	shortleaf pine	*Pinus*	*echinata*	
111	slash pine	*Pinus*	*elliottii*	
112	Apache pine	*Pinus*	*engelmannii*	
113	limber pine	*Pinus*	*flexilis*	
114	southwestern white pine	*Pinus*	*strobiformis*	
115	spruce pine	*Pinus*	*glabra*	
116	Jeffrey pine	*Pinus*	*jeffreyi*	
117	sugar pine	*Pinus*	*lambertiana*	
118	Chihuahua pine	*Pinus*	*leiophylla*	
119	western white pine	*Pinus*	*monticola*	
120	bishop pine	*Pinus*	*muricata*	
121	longleaf pine	*Pinus*	*palustris*	
122	ponderosa pine	*Pinus*	*ponderosa*	
123	Table Mountain pine	*Pinus*	*pungens*	
124	Monterey pine	*Pinus*	*radiata*	
125	red pine	*Pinus*	*resinosa*	
126	pitch pine	*Pinus*	*rigida*	
127	gray or California foothill pine	*Pinus*	*sabiniana*	
128	pond pine	*Pinus*	*serotina*	
129	eastern white pine	*Pinus*	*strobus*	
130	Scotch pine	*Pinus*	*sylvestris*	
131	loblolly pine	*Pinus*	*taeda*	
132	Virginia pine	*Pinus*	*virginiana*	
133	singleleaf pinyon	*Pinus*	*monophylla*	

SPCD	COMMON_NAME	GENUS	SPECIES	VARIETY
134	border pinyon	*Pinus*	*discolor*	
135	Arizona pine	*Pinus*	*arizonica*	
136	Austrian pine	*Pinus*	*nigra*	
137	Washoe pine	*Pinus*	*washoensis*	
138	four-leaf or Parry pinyon pine	*Pinus*	*quadrifolia*	
139	Torrey pine	*Pinus*	*torreyana*	
140	Mexican pinyon pine	*Pinus*	*cembroides*	
141	Papershell pinyon pine	*Pinus*	*remota*	
142	Great Basin bristlecone pine	*Pinus*	*longaeva*	
143	Arizona pinyon pine	*Pinus*	*monophylla*	*fallax*
144	Honduras pine	*Pinus*	*elliottii*	*elliottii*
200	Douglas-fir spp.	*Pseudotsuga*	*spp.*	
201	bigcone Douglas-fir	*Pseudotsuga*	*macrocarpa*	
202	Douglas-fir	*Pseudotsuga*	*menziesii*	
211	redwood	*Sequoia*	*sempervirens*	
212	giant sequoia	*Sequoiadendron*	*giganteum*	
220	baldcypress spp.	*Taxodium*	*spp.*	
221	baldcypress	*Taxodium*	*distichum*	
222	pondcypress	*Taxodium*	*ascendens*	
223	Montezuma baldcypress	*Taxodium*	*mucronatum*	
230	yew spp.	*Taxus*	*spp.*	
231	Pacific yew	*Taxus*	*brevifolia*	
232	Florida yew	*Taxus*	*floridana*	
240	thuja spp.	*Thuja*	*spp.*	
241	northern white-cedar	*Thuja*	*occidentalis*	
242	western redcedar	*Thuja*	*plicata*	
250	torreya (nutmeg) spp.	*Torreya*	*spp.*	
251	California torreya (nutmeg)	*Torreya*	*californica*	
252	Florida torreya (nutmeg)	*Torreya*	*taxifolia*	
260	hemlock spp.	*Tsuga*	*spp.*	
261	eastern hemlock	*Tsuga*	*canadensis*	
262	Carolina hemlock	*Tsuga*	*caroliniana*	
263	western hemlock	*Tsuga*	*heterophylla*	
264	mountain hemlock	*Tsuga*	*mertensiana*	
299	Unknown dead conifer	*Tree*	*evergreen*	
300	acacia spp.	*Acacia*	*spp.*	
303	sweet acacia	*Acacia*	*farnesiana*	
304	catclaw acacia	*Acacia*	*greggii*	
310	maple spp.	*Acer*	*spp.*	
311	Florida maple	*Acer*	*barbatum*	
312	bigleaf maple	*Acer*	*macrophyllum*	
313	boxelder	*Acer*	*negundo*	
314	black maple	*Acer*	*nigrum*	
315	striped maple	*Acer*	*pensylvanicum*	

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316	red maple	*Acer*	*rubrum*	
317	silver maple	*Acer*	*saccharinum*	
318	sugar maple	*Acer*	*saccharum*	
319	mountain maple	*Acer*	*spicatum*	
320	Norway maple	*Acer*	*platanoides*	
321	Rocky Mountain maple	*Acer*	*glabrum*	
322	bigtooth maple	*Acer*	*grandidentatum*	
323	chalk maple	*Acer*	*leucoderme*	
330	buckeye, horsechestnut spp.	*Aesculus*	*spp.*	
331	Ohio buckeye	*Aesculus*	*glabra*	
332	yellow buckeye	*Aesculus*	*flava*	
333	California buckeye	*Aesculus*	*californica*	
334	Texas buckeye	*Aesculus*	*glabra*	*arguta*
336	red buckeye	*Aesculus*	*pavia*	
337	painted buckeye	*Aesculus*	*sylvatica*	
341	ailanthus	*Ailanthus*	*altissima*	
345	mimosa, silktree	*Albizia*	*julibrissin*	
350	alder spp.	*Alnus*	*spp.*	
351	red alder	*Alnus*	*rubra*	
352	white alder	*Alnus*	*rhombifolia*	
353	Arizona alder	*Alnus*	*oblongifolia*	
355	European alder	*Alnus*	*glutinosa*	
356	serviceberry spp.	*Amelanchier*	*spp.*	
357	common serviceberry	*Amelanchier*	*arborea*	
358	roundleaf serviceberry	*Amelanchier*	*sanguinea*	
360	madrone spp.	*Arbutus*	*spp.*	
361	Pacific madrone	*Arbutus*	*menziesii*	
362	Arizona madrone	*Arbutus*	*arizonica*	
363	Texas madrone	*Arbutus*	*xalapensis*	
367	pawpaw	*Asimina*	*triloba*	
370	birch spp.	*Betula*	*spp.*	
371	yellow birch	*Betula*	*alleghaniensis*	
372	sweet birch	*Betula*	*lenta*	
373	river birch	*Betula*	*nigra*	
374	water birch	*Betula*	*occidentalis*	
375	paper birch	*Betula*	*papyrifera*	
377	Virginia roundleaf birch	*Betula*	*uber*	
378	northwestern paper birch	*Betula*	*x utahensis*	
379	gray birch	*Betula*	*populifolia*	
381	chittamwood, gum bumelia	*Sideroxylon*	*lanuginosum*	
391	American hornbeam, musclewood	*Carpinus*	*caroliniana*	
400	hickory spp.	*Carya*	*spp.*	
401	water hickory	*Carya*	*aquatica*	
402	bitternut hickory	*Carya*	*cordiformis*	

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403	pignut hickory	*Carya*	*glabra*	
404	pecan	*Carya*	*illinoinensis*	
405	shellbark hickory	*Carya*	*laciniosa*	
406	nutmeg hickory	*Carya*	*myristiciformis*	
407	shagbark hickory	*Carya*	*ovata*	
408	black hickory	*Carya*	*texana*	
409	mockernut hickory	*Carya*	*alba*	
410	sand hickory	*Carya*	*pallida*	
411	scrub hickory	*Carya*	*floridana*	
412	red hickory	*Carya*	*ovalis*	
413	southern shagbark hickory	*Carya*	*carolinae-septentrionalis*	
420	chestnut spp.	*Castanea*	*spp.*	
421	American chestnut	*Castanea*	*dentata*	
422	Allegheny chinkapin	*Castanea*	*pumila*	
423	Ozark chinkapin	*Castanea*	*pumila*	*ozarkensis*
424	Chinese chestnut	*Castanea*	*mollissima*	
431	giant chinkapin, golden chinkapin	*Chrysolepis*	*chrysophylla*	*chrysophylla*
450	catalpa spp.	*Catalpa*	*spp.*	
451	southern catalpa	*Catalpa*	*bignonioides*	
452	northern catalpa	*Catalpa*	*speciosa*	
460	hackberry spp.	*Celtis*	*spp.*	
461	sugarberry	*Celtis*	*laevigata*	
462	hackberry	*Celtis*	*occidentalis*	
463	netleaf hackberry	*Celtis*	*laevigata*	*reticulata*
471	eastern redbud	*Cercis*	*canadensis*	
475	curlleaf mountain-mahogany	*Cercocarpus*	*ledifolius*	
481	yellowwood	*Cladrastis*	*kentukea*	
490	dogwood spp.	*Cornus*	*spp.*	
491	flowering dogwood	*Cornus*	*florida*	
492	Pacific dogwood	*Cornus*	*nuttallii*	
500	hawthorn spp.	*Crataegus*	*spp.*	
501	cockspur hawthorn	*Crataegus*	*crus-galli*	
502	downy hawthorn	*Crataegus*	*mollis*	
503	Brainerd's hawthorn	*Crataegus*	*brainerdii*	
504	pear hawthorn	*Crataegus*	*calpodendron*	
505	fireberry hawthorn	*Crataegus*	*chrysocarpa*	
506	broadleaf hawthorn	*Crataegus*	*dilatata*	
507	fanleaf hawthorn	*Crataegus*	*flabellata*	
508	oneseed hawthorn	*Crataegus*	*monogyna*	
509	scarlet hawthorn	*Crataegus*	*pedicellata*	
510	eucalyptus spp.	*Eucalyptus*	*spp.*	
511	Tasmanian bluegum	*Eucalyptus*	*globulus*	
512	river redgum	*Eucalyptus*	*camaldulensis*	
513	grand eucalyptus	*Eucalyptus*	*grandis*	

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514	swampmahogany	*Eucalyptus*	*robusta*	
520	persimmon spp.	*Diospyros*	*spp.*	
521	common persimmon	*Diospyros*	*virginiana*	
522	Texas persimmon	*Diospyros*	*texana*	
523	Anacua knockaway	*Ehretia*	*anacua*	
531	American beech	*Fagus*	*grandifolia*	
540	ash spp.	*Fraxinus*	*spp.*	
541	white ash	*Fraxinus*	*americana*	
542	Oregon ash	*Fraxinus*	*latifolia*	
543	black ash	*Fraxinus*	*nigra*	
544	green ash	*Fraxinus*	*pennsylvanica*	
545	pumpkin ash	*Fraxinus*	*profunda*	
546	blue ash	*Fraxinus*	*quadrangulata*	
547	velvet ash	*Fraxinus*	*velutina*	
548	Carolina ash	*Fraxinus*	*caroliniana*	
549	Texas ash	*Fraxinus*	*texensis*	
550	honeylocust spp.	*Gleditsia*	*spp.*	
551	waterlocust	*Gleditsia*	*aquatica*	
552	honeylocust	*Gleditsia*	*triacanthos*	
555	loblolly-bay	*Gordonia*	*lasianthus*	
561	ginkgo, maidenhair tree	*Ginkgo*	*biloba*	
571	Kentucky coffeetree	*Gymnocladus*	*dioicus*	
580	silverbell spp.	*Halesia*	*spp.*	
581	Carolina silverbell	*Halesia*	*carolina*	
582	two-wing silverbell	*Halesia*	*diptera*	
583	little silverbell	*Halesia*	*parviflora*	
591	American holly	*Ilex*	*opaca*	
600	walnut spp.	*Juglans*	*spp.*	
601	butternut	*Juglans*	*cinerea*	
602	black walnut	*Juglans*	*nigra*	
603	northern California black walnut	*Juglans*	*hindsii*	
604	southern California black walnut	*Juglans*	*californica*	
605	Texas walnut	*Juglans*	*microcarpa*	
606	Arizona walnut	*Juglans*	*major*	
611	sweetgum	*Liquidambar*	*styraciflua*	
621	yellow-poplar	*Liriodendron*	*tulipifera*	
631	tanoak	*Lithocarpus*	*densiflorus*	
641	Osage-orange	*Maclura*	*pomifera*	
650	magnolia spp.	*Magnolia*	*spp.*	
651	cucumbertree	*Magnolia*	*acuminata*	
652	southern magnolia	*Magnolia*	*grandiflora*	
653	sweetbay	*Magnolia*	*virginiana*	
654	bigleaf magnolia	*Magnolia*	*macrophylla*	
655	mountain or Fraser magnolia	*Magnolia*	*fraseri*	

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657	pyramid magnolia	*Magnolia*	*pyramidata*	
658	umbrella magnolia	*Magnolia*	*tripetala*	
660	apple spp.	*Malus*	*spp.*	
661	Oregon crab apple	*Malus*	*fusca*	
662	southern crab apple	*Malus*	*angustifolia*	
663	sweet crab apple	*Malus*	*coronaria*	
664	prairie crab apple	*Malus*	*ioensis*	
680	mulberry spp.	*Morus*	*spp.*	
681	white mulberry	*Morus*	*alba*	
682	red mulberry	*Morus*	*rubra*	
683	Texas mulberry	*Morus*	*microphylla*	
684	black mulberry	*Morus*	*nigra*	
690	tupelo spp.	*Nyssa*	*spp.*	
691	water tupelo	*Nyssa*	*aquatica*	
692	Ogeechee tupelo	*Nyssa*	*ogeche*	
693	blackgum	*Nyssa*	*sylvatica*	
694	swamp tupelo	*Nyssa*	*biflora*	
701	eastern hophornbeam	*Ostrya*	*virginiana*	
711	sourwood	*Oxydendrum*	*arboreum*	
712	paulownia, empress-tree	*Paulownia*	*tomentosa*	
720	bay spp.	*Persea*	*spp.*	
721	redbay	*Persea*	*borbonia*	
722	water-elm, planertree	*Planera*	*aquatica*	
729	sycamore spp.	*Platanus*	*spp.*	
730	California sycamore	*Platanus*	*racemosa*	
731	American sycamore	*Platanus*	*occidentalis*	
732	Arizona sycamore	*Platanus*	*wrightii*	
740	cottonwood and poplar spp.	*Populus*	*spp.*	
741	balsam poplar	*Populus*	*balsamifera*	
742	eastern cottonwood	*Populus*	*deltoides*	
743	bigtooth aspen	*Populus*	*grandidentata*	
744	swamp cottonwood	*Populus*	*heterophylla*	
745	plains cottonwood	*Populus*	*deltoides*	
746	quaking aspen	*Populus*	*tremuloides*	
747	black cottonwood	*Populus*	*balsamifera*	
748	Fremont cottonwood	*Populus*	*fremontii*	
749	narrowleaf cottonwood	*Populus*	*angustifolia*	
752	silver poplar	*Populus*	*alba*	
753	Lombardy poplar	*Populus*	*nigra*	
755	mesquite spp.	*Prosopis*	*spp.*	
756	honey mesquite	*Prosopis*	*glandulosa*	
757	velvet mesquite	*Prosopis*	*velutina*	
758	screwbean mesquite	*Prosopis*	*pubescens*	
760	cherry and plum spp.	*Prunus*	*spp.*	

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761	pin cherry	*Prunus*	*pensylvanica*	
762	black cherry	*Prunus*	*serotina*	
763	chokecherry	*Prunus*	*virginiana*	
764	peach	*Prunus*	*persica*	
765	Canada plum	*Prunus*	*nigra*	
766	American plum	*Prunus*	*americana*	
768	bitter cherry	*Prunus*	*emarginata*	
769	Allegheny plum	*Prunus*	*alleghaniensis*	
770	Chickasaw plum	*Prunus*	*angustifolia*	
771	sweet cherry, domesticated	*Prunus*	*avium*	
772	sour cherry, domesticated	*Prunus*	*cerasus*	
773	European plum, domesticated	*Prunus*	*domestica*	
774	Mahaleb cherry, domesticated	*Prunus*	*mahaleb*	
800	oak spp	*Quercus*	*spp.*	
801	California live oak	*Quercus*	*agrifolia*	
802	white oak	*Quercus*	*alba*	
803	Arizona white oak	*Quercus*	*arizonica*	
804	swamp white oak	*Quercus*	*bicolor*	
805	canyon live oak	*Quercus*	*chrysolepis*	
806	scarlet oak	*Quercus*	*coccinea*	
807	blue oak	*Quercus*	*douglasii*	
808	Durand oak	*Quercus*	*sinuata*	*sinuata*
809	northern pin oak	*Quercus*	*ellipsoidalis*	
810	Emory oak	*Quercus*	*emoryi*	
811	Engelmann oak	*Quercus*	*engelmannii*	
812	southern red oak	*Quercus*	*falcata*	
813	cherrybark oak	*Quercus*	*pagoda*	
814	Gambel oak	*Quercus*	*gambelii*	
815	Oregon white oak	*Quercus*	*garryana*	
816	scrub oak	*Quercus*	*ilicifolia*	
817	shingle oak	*Quercus*	*imbricaria*	
818	California black oak	*Quercus*	*kelloggii*	
819	turkey oak	*Quercus*	*laevis*	
820	laurel oak	*Quercus*	*laurifolia*	
821	California white oak	*Quercus*	*lobata*	
822	overcup oak	*Quercus*	*lyrata*	
823	bur oak	*Quercus*	*macrocarpa*	
824	blackjack oak	*Quercus*	*marilandica*	
825	swamp chestnut oak	*Quercus*	*michauxii*	
826	chinkapin oak	*Quercus*	*muehlenbergii*	
827	water oak	*Quercus*	*nigra*	
828	Texas red oak	*Quercus*	*texana*	
829	Mexican blue oak	*Quercus*	*oblongifolia*	
830	pin oak	*Quercus*	*palustris*	

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831	willow oak	*Quercus*	*phellos*	
832	chestnut oak	*Quercus*	*prinus*	
833	northern red oak	*Quercus*	*rubra*	
834	Shumard oak	*Quercus*	*shumardii*	
835	post oak	*Quercus*	*stellata*	
836	Delta post oak	*Quercus*	*similis*	
837	black oak	*Quercus*	*velutina*	
838	live oak	*Quercus*	*virginiana*	
839	interior live oak	*Quercus*	*wislizeni*	
840	dwarf post oak	*Quercus*	*margarettiae*	
841	dwarf live oak	*Quercus*	*minima*	
842	bluejack oak	*Quercus*	*incana*	
843	silverleaf oak	*Quercus*	*hypoleucoides*	
844	Oglethorpe oak	*Quercus*	*oglethorpensis*	
845	dwarf chinkapin oak	*Quercus*	*prinoides*	
846	gray oak	*Quercus*	*grisea*	
847	netleaf oak	*Quercus*	*rugosa*	
851	Chisos oak	*Quercus*	*graciliformis*	
852	sea torchwood	*Amyris*	*elemifera*	
853	pond-apple	*Annona*	*glabra*	
854	gumbo limbo	*Bursera*	*simaruba*	
855	sheoak spp.	*Casuarina*	*spp.*	
856	gray sheoak	*Casuarina*	*glauca*	
857	belah	*Casuarina*	*lepidophloia*	
858	camphortree	*Cinnamomum*	*camphora*	
859	Florida fiddlewood	*Citharexylum*	*fruticosum*	
860	citrus spp.	*Citrus*	*spp.*	
863	tietongue, pigeon-plum	*Coccoloba*	*diversifolia*	
864	soldierwood	*Colubrina*	*elliptica*	
865	largeleaf geigertree	*Cordia*	*sebestena*	
866	carrotwood	*Cupaniopsis*	*anacardioides*	
867	Bluewood	*Condalia*	*hookeri*	
868	Blackbead ebony	*Ebenopsis*	*ebano*	
869	Great leucaene	*Leucaena*	*pulverulenta*	
870	Texas sophora	*Sophora*	*affinis*	
873	red stopper	*Eugenia*	*rhombea*	
874	butterbough, inkwood	*Exothea*	*paniculata*	
876	Florida strangler fig	*Ficus*	*aurea*	
877	wild banyantree, shortleaf fig	*Ficus*	*citrifolia*	
882	beeftree, longleaf blolly	*Guapira*	*discolor*	
883	manchineel	*Hippomane*	*mancinella*	
884	false tamarind	*Lysiloma*	*latisiliquum*	
885	mango	*Mangifera*	*indica*	
886	Florida poisontree	*Metopium*	*toxiferum*	

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887	fishpoison tree	*Piscidia*	*piscipula*	
888	octopus tree, schefflera	*Schefflera*	*actinophylla*	
890	false mastic	*Sideroxylon*	*foetidissimum*	
891	white bully, willow bustic	*Sideroxylon*	*salicifolium*	
895	paradisetree	*Simarouba*	*glauca*	
896	Java plum	*Syzygium*	*cumini*	
897	tamarind	*Tamarindus*	*indica*	
901	black locust	*Robinia*	*pseudoacacia*	
902	New Mexico locust	*Robinia*	*neomexicana*	
906	Everglades palm, paurotis-palm	*Acoelorraphe*	*wrightii*	
907	Florida silver palm	*Coccothrinax*	*argentata*	
908	coconut palm	*Cocos*	*nucifera*	
909	royal palm spp.	*Roystonea*	*spp.*	
911	Mexican palmetto	*Sabal*	*mexicana*	
912	cabbage palmetto	*Sabal*	*palmetto*	
913	key thatch palm	*Thrinax*	*morrisii*	
914	Florida thatch palm	*Thrinax*	*radiata*	
915	other palms	*Family Arecaceae*	*not listed above*	
919	western soapberry	*Sapindus*	*saponaria*	*drummondii*
920	willow spp.	*Salix*	*spp.*	
921	peachleaf willow	*Salix*	*amygdaloides*	
922	black willow	*Salix*	*nigra*	
923	Bebb willow	*Salix*	*bebbiana*	
924	Bonpland willow	*Salix*	*bonplandiana*	
925	coastal plain willow	*Salix*	*caroliniana*	
926	balsam willow	*Salix*	*pyrifolia*	
927	white willow	*Salix*	*alba*	
928	Scouler’s willow	*Salix*	*scouleriana*	
929	weeping willow	*Salix*	*sepulcralis*	
931	sassafras	*Sassafras*	*albidum*	
934	mountain-ash spp.	*Sorbus*	*spp.*	
935	American mountain-ash	*Sorbus*	*americana*	
936	European mountain-ash	*Sorbus*	*aucuparia*	
937	northern mountain-ash	*Sorbus*	*decora*	
940	West Indian mahogany	*Swietenia*	*mahagoni*	
950	basswood spp.	*Tilia*	*spp.*	
951	American basswood	*Tilia*	*americana*	
952	white basswood	*Tilia*	*americana*	*heterophylla*
953	Carolina basswood	*Tilia*	*americana*	*caroliniana*
970	elm spp.	*Ulmus*	*spp.*	
971	winged elm	*Ulmus*	*alata*	
972	American elm	*Ulmus*	*americana*	
973	cedar elm	*Ulmus*	*crassifolia*	
974	Siberian elm	*Ulmus*	*pumila*	

SPCD	COMMON_NAME	GENUS	SPECIES	VARIETY
975	slippery elm	*Ulmus*	*rubra*	
976	September elm	*Ulmus*	*serotina*	
977	rock elm	*Ulmus*	*thomasii*	
981	California-laurel	*Umbellularia*	*californica*	
982	Joshua tree	*Yucca*	*brevifolia*	
986	black-mangrove	*Avicennia*	*germinans*	
987	buttonwood-mangrove	*Conocarpus*	*erectus*	
988	white-mangrove	*Laguncularia*	*racemosa*	
989	American mangrove	*Rhizophora*	*mangle*	
990	desert ironwood	*Olneya*	*tesota*	
991	saltcedar	*Tamarix*	*spp.*	
992	melaleuca	*Melaleuca*	*quinquenervia*	
993	chinaberry	*Melia*	*azedarach*	
994	Chinese tallowtree	*Triadica*	*sebifera*	
995	tungoil tree	*Vernicia*	*fordii*	
996	smoketree	*Cotinus*	*obovatus*	
997	Russian-olive	*Elaeagnus*	*angustifolia*	
998	Unknown dead hardwood	*Tree*	*broadleaf*	
999	Other or unknown live tree	*Tree*	*unknown*	
5091	Washington hawthorn	*Crataegus*	*phaenopyrum*	
5092	fleshy hawthorn	*Crataegus*	*succulenta*	
5093	dwarf hawthorn	*Crataegus*	*uniflora*	
5491	Berlandier ash	*Fraxinus*	*berlandieriana*	
7211	avocado	*Persea*	*americana*	
8511	Graves oak	*Quercus*	*gravesii*	
8512	Mexican white oak	*Quercus*	*polymorpha*	
8513	Buckley oak	*Quercus*	*buckleyi*	
8514	Lacey oak	*Quercus*	*laceyi*	
8651	Anacahuita Texas Olive	*Cordia*	*boissieri*	

Appendix G

SQL Scripts for Generating Sound Volume Estimates for Four NRS States

Script label	SQL scripts for generating all live-tree sound volume statewide
VOLCFSND sound volume (thousand cuft)	SELECT POP_EVAL_GRP.EVAL_GRP_DESCR, Sum(EXPVOL * **VOLCFSND*** TPA_UNADJ * IIf(IsNull(dia), adj_expvol_subp, IIf(dia < 5, adj_expvol_micr, IIf(IsNull(MACRO_BREAKPOINT_DIA), adj_expvol_subp, IIf(dia < MACRO_BREAKPOINT_DIA, adj_expvol_subp, adj_expvol_macr)))))/1000 AS 'All live sound volume on forestland (thousand cuft)' FROM POP_EVAL_GRP INNER JOIN((PLOTSNAP INNER JOIN COND ON PLOTSNAP.CN = COND.PLT_CN) INNER JOIN TREE ON (COND.CONDID = TREE.CONDID) AND (COND.PLT_CN = TREE.PLT_CN)) ON POP_EVAL_GRP.CN = PLOTSNAP.EVAL_GRP_CN WHERE (((COND.COND_STATUS_CD) = 1) AND ((TREE.STATUSCD) = 1)) AND (TREE.DIA>=5) AND POP_EVAL_GRP.EVAL_GRP IN (272007,192007,312007,342006) GROUP BY POP_EVAL_GRP.EVAL_GRP_DESCR;
NRS_VOLUME sound volume (thousand cuft)	SELECT POP_EVAL_GRP.EVAL_GRP_DESCR, Sum(EXPVOL * **NRS_VOLUME(tree.statecd, tree.spcd, tree.dia, NZ(tree.boleht,0), tree.cull, tree.cullcf, tree.treeclcd, cond.balive, tree.sitree, tree.ht,"SOUND")*** TPA_UNADJ * IIf(IsNull(dia), adj_expvol_subp, IIf(dia < 5, adj_expvol_micr, IIf(IsNull(MACRO_BREAKPOINT_DIA), adj_expvol_subp, IIf(dia < MACRO_BREAKPOINT_DIA, adj_expvol_subp, adj_expvol_macr)))))/1000 AS 'All live sound volume on forestland (thousand cuft)' FROM POP_EVAL_GRP INNER JOIN((PLOTSNAP INNER JOIN COND ON PLOTSNAP.CN = COND.PLT_CN) INNER JOIN TREE ON (COND.CONDID = TREE.CONDID) AND (COND.PLT_CN = TREE.PLT_CN)) ON POP_EVAL_GRP.CN = PLOTSNAP.EVAL_GRP_CN WHERE (((COND.COND_STATUS_CD) = 1) AND ((TREE.STATUSCD) = 1)) AND (TREE.DIA>=5) AND POP_EVAL_GRP.EVAL_GRP IN (272007,192007,312007,342006) GROUP BY POP_EVAL_GRP.EVAL_GRP_DESCR;

Miles, Patrick D.; Andrew D. Hill. 2010. **Volume equations for the Northern Research Station's Forest Inventory and Analysis Program as of 2010.** Gen. Tech. Rep. NRS-74. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 50 p.

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program collects sample plot data on all forest ownerships across the United States. This report documents the methodology used to estimate live-tree gross, net, and sound volume for the 24 States inventoried by the Northern Research Station's (NRS) FIA unit. Sound volume is of particular interest because it is used in live-tree biomass and carbon estimates. NRS currently uses four volume equations for each of four geographic regions.

KEY WORDS: wood volume, mensuration, sound volume, biomass

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