Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Southern (SN) Variant Overview of the Forest Vegetation Simulator

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Longleaf pine shelterwood, Desoto NF
(Greg Janney, FS-R8)

Southern (SN) Variant Overview of the Forest Vegetation Simulator

Authors and Contributors:

The FVS staff has maintained model documentation for this variant in the form of a variant overview since its release in 2001. The original authors were Dennis Donnelly and Barry Lilly. In 2008, the previous document was replaced with this updated variant overview. Gary Dixon, Christopher Dixon, Robert Havis, Chad Keyser, Stephanie Rebain, Erin Smith-Mateja, and Don Vandendriesche were involved with this update. Chad Keyser cross-checked information contained in this variant overview with the FVS source code.

FVS Staff. 2008 (revised April 25, 2024). Southern (SN) Variant Overview – Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 83p.

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Quick Guide to Default Settings

Parameter or Attribute	**Default Setting**
Number of Projection Cycles	1 (10 if using FVS GUI)
Projection Cycle Length	5 years
Location Code (National Forest)	80106 – NF in Alabama – Talledega Ranger District
Ecological Classification Code	231Dd (Quartzite and Talladega Slate Ridge)
Slope	5 percent
Aspect	0 (no meaningful aspect)
Elevation (Default location)	7 (700 feet)
Latitude (Default location)	32.37
Longitude (Default location)	86.30
Site Species	WO
Site Index	70 (total age; 50 years)
Maximum Stand Density Index	Forest Cover Type specific
Maximum Basal Area	Forest Cover Type specific
Volume Equations	National Volume Estimator Library
Volume Specifications:	
Pulpwood Volume	Minimum DBH / Top Diameter Outside Bark
Softwoods Default	4 / 4
SR	6 / 4
LP	6 / 4
Hardwoods - Default	4 / 4
LB	6 / 4
WN	6 / 4
SU	6 / 4
MB	6 / 4
WT	6 / 4
TS	6 / 4
WO	6 / 4
Stump Height	0.5 feet
Sawtimber Volume	Minimum DBH / Top Diameter Outside Bark
Softwoods Default	10 / 7
JU on Ozark & St. Francis NFs	9 / 7
Hardwoods - Default	12 / 9
Stump Height	1.0 foot
Sampling Design:	
Large Trees (variable radius plot)	40 BAF
Small Trees (fixed radius plot)	1/300th Acre

Parameter or Attribute	**Default Setting**
Breakpoint DBH	5.0 inches

1.0 Introduction

The Forest Vegetation Simulator (FVS) is an individual tree, distance independent growth and yield model with linkable modules called extensions, which simulate various insect and pathogen impacts, fire effects, fuel loading, snag dynamics, and development of understory tree vegetation. FVS can simulate a wide variety of forest types, stand structures, and pure or mixed species stands.

New “variants” of the FVS model are created by imbedding new tree growth, mortality, and volume equations for a particular geographic area into the FVS framework. Geographic variants of FVS have been developed for most of the forested lands in the United States.

The Southeast (SE) variant was developed in 1996 using relationships found in the Southeast TWIGS model and applied to Alabama, Georgia, and South Carolina. There was need for a variant that covered more of the forested area in the southeast United States.

Using data from Forest Inventory and Analysis (FIA), the Southern (SN) variant was developed using completely new growth equations and expanded to cover all southern states including the area previously covered by the Southeast TWIGS variant. Development of the SN variant of FVS began in 1998 and was released for production use in 2001. Development of the variant began as a cooperative effort of the Southern Research Station, Southern Regional Office, and the Forest Management Service Center using the FIA data from all 13 states of the Southern Region, Forest Service Research data, and data from the Bureau of Indian Affairs. All model relationships were developed by FMSC staff.

To fully understand how to use this variant, users should also consult the following publication:

- Essential FVS: A User’s Guide to the Forest Vegetation Simulator (Dixon 2002)

This publication may be downloaded from the Forest Management Service Center (FMSC), Forest Service website. Other FVS publications may be needed if one is using an extension that simulates the effects of fire, insects, or diseases.

2.0 Geographic Range

The SN variant was fit to data from the states within the USDA Forest Service Southern Region. Data used in initial model development came from Forest Inventory and Analysis (FIA) data from all 13 states of the Southern Region, Forest Service research data, and data from the Bureau of Indian Affairs. Distribution of data samples for species fit from this data are shown in table 2.0.1.

Table 2.0.1 The distribution of original growth sample trees by species for the SN variant.

Species	Total Number of Observations	Species	Total Number of Observations	Species	Total Number of Observations
redcedar	4132	common persimmon	1219	black cherry	2944
spruce	1141	American beech	4953	white oak	27487
sand pine	820	ash	5463	scarlet oak	6009
shortleaf pine	26008	white ash	1989	southern red oak	13442
slash pine	18736	black ash	3958	cherrybark oak, swamp red oak	4239
spruce pine	884	green ash	3958	turkey oak	2764
longleaf pine	9190	honeylocust	588	laurel oak	8105
table mountain pine	9860	loblolly-bay	1483	overcup oak	2960
pitch pine	735	silverbell	89	blackjack oak	3605
pond pine	2590	American holly	3417	swamp chestnut oak	1504
eastern white pine	2602	butternut	941	chinkapin oak	831
loblolly pine	92313	black walnut	941	water oak	24356
Virginia pine	9860	sweetgum	38847	chestnut oak	12188
baldcypress	6428	yellow-poplar	19207	northern red oak	8401
pondcypress	5578	magnolia spp.	6729	Shumard oak	505
hemlock	1141	cucumbertree	376	post oak	14841
Florida maple	455	southern magnolia	938	black oak	10119
boxelder	1426	sweetbay	6729	live oak	2916
red maple	28402	bigleaf magnolia	938	black locust	1990

Species	Total Number of	Species	Total Number of	Species	Total Number of
silver maple	28402	apple spp.	539	willow	2134
sugar maple	2763	mulberry spp.	539	sassafras	1577
buckeye, horsechestnut	277	water tupelo	6104	basswood	763
birch spp.	2107	blackgum	10328	elm	3230
sweet birch	2107	swamp tupelo	17098	winged elm	2294
American hornbeam	3513	eastern hophornbeam,	840	American elm	2024
hickory spp.	24404	sourwood	5689	slippery elm	791
catalpa	972	redbay	1953	softwoods, misc.	4132
hackberry spp.	4485	sycamore	1892	hardwoods, misc.	840
eastern redbud	482	cottonwood	972	unknown or not listed	639
flowering dogwood	7775	bigtooth aspen	972		

The SN variant covers forest areas in all of the southeastern states including Florida, Georgia, Alabama, Mississippi, Louisiana, the Carolinas, Virginia, Kentucky, Tennessee, Arkansas, and parts of Texas and Oklahoma. The suggested geographic range of use for the SN variant is shown in figure 2.0.1. In addition, the SN variant may be used to simulate the forest types within the Central States (CS) variant range in southern Missouri and southern Illinois.

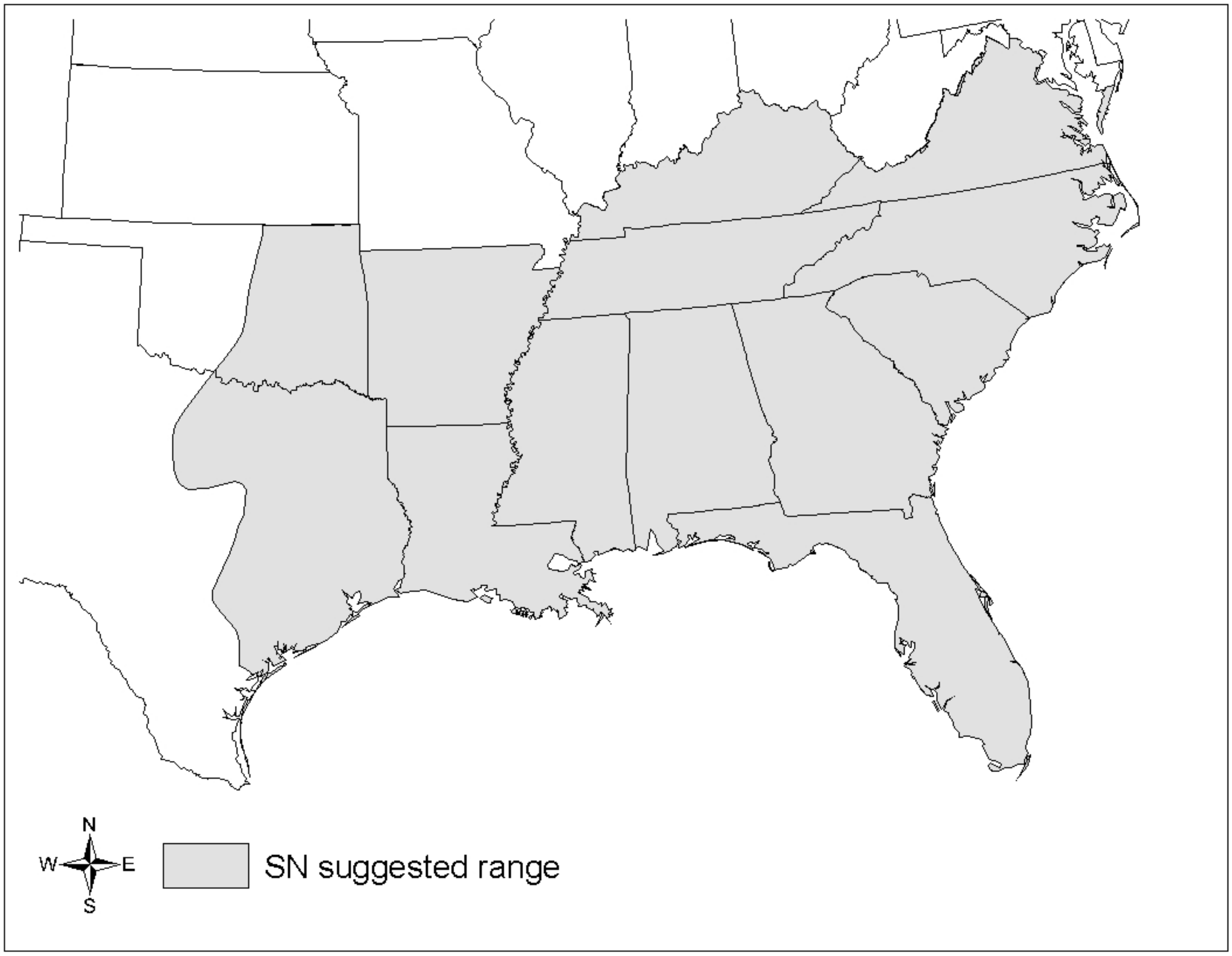

Figure 2.0.1 Suggested geographic range of use for the SN variant.

3.0 Control Variables

FVS users need to specify certain variables used by the SN variant to control a simulation. These are entered in parameter fields on various FVS keywords available in the FVS interface or they are read from an FVS input database using the Database Extension.

3.1 Location Codes

Most location codes in the SN variant use a 4- or 5-digit code. The first digit of the code represents the Forest Service Region Number, the second and third digits represent the Forest Number, and the fourth and fifth digits represent the District Number. In some cases, a location code beginning with a "7" or "8" is used to indicate an administrative boundary that doesn't use a Forest Service Region number (for example, other federal agencies, state agencies, or other lands).

If the location code is missing or incorrect in the SN variant, a default forest code of 80106 (National Forests in Alabama, Talledega Ranger District) will be used. Location codes recognized in the SN variant, and their associated default latitude, longitude, and elevation are shown in tables 3.1.1 and 3.1.2.

Table 3.1.1 Location codes used in the SN variant.

USFS National Forest	District	Location Code	Latitude	Longitude	Elevation
National Forests in Alabama	Bankhead	80101	32.37	86.30	7 (700 ft)
	Conecuh	80103			
	Oakmulgee	80104			
	Shoal Creek	80105			
	Talledega	80106			
	Tuskegee	80107			
Daniel Boone	Morehead	80211	37.99	84.18	12 (1200 ft)
	Stanton	80212			
	Berea	80213			
	London	80214			
	Somerset	80215			
	Stearns	80216			
	Redbird	80217			
Chattahoochee-Oconee	Armuchee	80301	34.34	83.82	17 (1700 ft)
	Toccoa	80302			
	Brasstown	80304			
	Tallulah	80305			
	Chattooga	80306			
	Cohutta	80307			
	Oconee	80308			

USFS National Forest	District	Location Code	Latitude	Longitude	Elevation
Cherokee	Hiwassee	80401	35.16	84.88	22 (2200 ft)
	Nolichucky	80402			
	Ocoee	80403			
	Tellico	80404			
	Unaka	80405			
	Watuga	80406			
National Forests in Florida	Apalachicola	80501	30.44	84.28	1 (100 ft)
	Lake George	80502			
	Osceola	80504			
	Seminole	80505			
	Wakulla	80506			
Kisatchie	Catahoula	80601	31.32	92.43	2 (200 ft)
	Calcasieu	80602			
	Kisatchie	80603			
	Winn	80604			
	Caney	80605			
National Forests in Mississippi	Bienville	80701	33.31	89.17	3 (300 ft)
	Desoto	80702			
	Homochitto	80704			
	Chickasawhay	80705			
	Delta	80706			
	Holly Springs	80707			
	Tombigbee	80717			
George Washington/Jefferson NFs	Deerfield	80801	37.27	79.94	21 (2100 ft)
	Dry River	80802			
	James River	80803			
	Lee	80804			
	Pedlar	80805			
	Warm Springs	80806			
	Blacksburg	80811			
	Clinch	80812			
	Glenwood	80813			
	Mt. Rogers	80814			
	New Castle	80815			
	Wythe	80816			
Ouachita	Choctaw	80901	34.50	93.06	9 (900 ft)
	Caddo	80902			
	Cold Springs	80903			
	Fourche	80904			

USFS National Forest	District	Location Code	Latitude	Longitude	Elevation
	Jessieville	80905			
	Kiamichi	80906			
	Mena	80907			
	Oden	80908			
	Poteau	80909			
	Womble	80910			
	Winona	80911			
	Tiak	80912			
Ozark & St. Francis NFs	Sylamore	81001	35.28	93.13	13 (1300 ft)
	Buffalo	81002			
	Bayou	81003			
	Pleasant Hill	81004			
	Boston Mountain	81005			
	Magazine	81006			
	St. Francis	81007			
National Forests in North Carolina	Cheoah	81102	35.60	82.55	25 (2500 ft)
	Croatan	81103			
	Grandfather	81105			
	Appalachian (old)	81104			
	Highlands	81106			
	Pisgah	81107			
	Appalachian	81108			
	Tusquitee	81109			
	Uwharrie	81110			
	Wayah	81111			
Francis Marion & Sumter NFs	Enoree	81201	34.00	81.04	4 (400 ft)
	Andrew Pickens	81202			
	Long cane	81203			
	Francis Marion	81205			
National Forests in Texas	Angelina	81301	31.34	94.73	3 (300 ft)
	Davy Crockett	81303			
	Sam Houston	81304			
	Sabine	81307			
	Caddo/LBJ	81308			
Mark Twain	All	905	37.95	91.77	10 (1000 ft)
Shawnee	All	908	37.74	88.54	4 (400 ft)
Savannah River Admin (mapped to 81203)	All	836	34.00	81.04	4 (400 ft)
Savannah River Proclaimed	All	824	34.00	81.04	4 (400 ft)

USFS National Forest	District	Location Code	Latitude	Longitude	Elevation
(mapped to 81203)					
Land Between the Lakes Admin (mapped to 80216)	All	860	37.99	84.18	12 (1200 ft)
Land Between the Lakes Admin (mapped to 80216)	All	835	37.99	84.18	12 (1200 ft)
Dept. of Defense, Fort Bragg Military Reservation (mapped to 81110)[1]	All	701	35.60	82.55	25 (2500 ft)

Table 3.1.2 Bureau of Indian Affairs reservation codes used in the SN variant.

Location Code	Location
7201	Alabama-Coushatta Reservation (mapped to 813)
7207	Kiowa-Comanche-Apache- Fort Sill Apache Otsa (mapped to 809)
7210	Kaw Otsa (mapped to 810)
7211	Otoe-Missouria Otsa (mapped to 810)
7212	Pawnee Otsa (mapped to 810)
7213	Ponca Otsa (mapped to 810)
7215	Citizen Potawatomi Nation-Absentee Shawnee Otsa (mapped to 809)
7216	Iowa Otsa (mapped to 809)
7218	Sac And Fox Otsa (mapped to 809)
7601	Chickasaw Otsa (mapped to 80906)
7602	Quapaw Otsa (mapped to 81005)
7603	Eastern Shawnee Otsa (mapped to 81005)
7604	Seneca-Cayuga Otsa (mapped to 81005)
7605	Wyandotte Otsa (mapped to 81005)
7606	Miami Otsa (mapped to 81005)
7607	Peoria Otsa (mapped to 81005)
7608	Modoc Otsa (mapped to 81005)
7609	Osage Reservation (mapped to 81005)
7610	Creek Otsa (mapped to 80901)
7611	Cherokee Otsa (mapped to 81005)
7612	Choctaw Otsa (mapped to 80906)
7613	Seminole Otsa (mapped to 80901)
8205	Miccosukee Reservation (mapped to 80505)
8207	Poarch Creek Reservation (mapped to 80103)
8210	Catawba Reservation (mapped to 81201)

[1] For some species, a Dept. of Defense, Fort Bragg Military reservation code will use equations from Shaw and others (2006).

Location Code	Location
8212	Tunica-Biloxi Reservation (mapped to 80601)
8213	Coushatta Reservation (mapped to 80602)
8219	Eastern Cherokee Reservation (mapped to 81111)
8220	Seminole Fl Trust Land (mapped to 80505)
8221	Mississippi Choctaw Reservation (mapped to 80701)

3.2 Species Codes

The SN variant recognizes 87 species, plus three other composite species categories. You may use FVS species codes, Forest Inventory and Analysis (FIA) species codes, or USDA Natural Resources Conservation Service PLANTS symbols to represent these species in FVS input data. Any valid eastern species code identifying species not recognized by the variant will be mapped to a similar species in the variant. The species mapping crosswalk is available on the FVS website variant documentation webpage. Any non-valid species code will default to the "other" category.

Either the FVS sequence number or species code must be used to specify a species in FVS keywords and Event Monitor functions. FIA codes or PLANTS symbols are only recognized during data input and may not be used in FVS keywords. Table 3.2.1 shows the complete list of species codes recognized by the SN variant.

Table 3.2.1 Species codes used in the SN variant.

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
1	FR	010	ABIES	*Abies*	fir
2	JU	057	JUNIP	*Juniperus*	juniper
3	PI	090	PICEA	*Picea*	spruce
4	PU	107	PICL	*Pinus clausa*	sand pine
5	SP	110	PIEC2	*Pinus echinata*	shortleaf pine
6	SA	111	PIEL	*Pinus elliottii*	slash pine
7	SR	115	PIGL2	*Pinus glabra*	spruce pine
8	LL	121	PIPA2	*Pinus palustris*	longleaf pine
9	TM	123	PIPU5	*Pinus pungens*	Table Mountain pine
10	PP	126	PIRI	*Pinus rigida*	pitch pine
11	PD	128	PISE	*Pinus serotina*	pond pine
12	WP	129	PIST	*Pinus strobus*	eastern white pine
13	LP	131	PITA	*Pinus taeda*	loblolly pine
14	VP	132	PIVI2	*Pinus viginiana*	Virginia pine
15	BY	221	TADI2	*Taxodium distichum*	bald cypress
16	PC	222	TAAS	*Taxodium ascendens*	pond cypress
17	HM	260	TSUGA	*Tsuga*	hemlock
18	FM	311	ACBA3	*Acer barbatum*	southern sugar maple
19	BE	313	ACNE2	*Acer negundo*	boxelder

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
20	RM	316	ACRU	*Acer rubrum*	red maple
21	SV	317	ACSA2	*Acer saccharinum*	silver maple
22	SM	318	ACSA3	*Acer saccharum*	sugar maple
23	BU	330	AESCU	*Aesculus*	buckeye
24	BB	370	BETUL	*Betula*	birch
25	SB	372	BELE	*Betula lenta*	sweet birch
26	AH	391	CACA18	*Carpinus caroliniana*	American hornbeam
27	HI	400	CARYA	*Carya*	hybrid hickory
28	CA	450	CATAL	*Catalpa*	catalpa
29	HB	460	CELTI	*Celtis*	hackberry
30	RD	471	CECA4	*Cercis canadensis*	eastern redbud
31	DW	491	COFL2	*Cornus florida*	flowering dogwood
32	PS	521	DIVI5	*Diospyros virginiana*	common persimmon
33	AB	531	FAGR	*Fagus grandifolia*	American beech
34	AS	540	FRAXI	*Fraxinus*	ash
35	WA	541	FRAM2	*Fraxinus americana*	white ash
36	BA	543	FRNI	*Fraxinus nigra*	black ash
37	GA	544	FRPE	*Fraxinus pennsylvanica*	green ash
38	HL	552	GLTR	*Gleditsia triacanthos*	honeylocust
39	LB	555	GOLA	*Gordonia lasianthus*	loblolly bay
40	HA	580	HALES	*Halesia*	silverbell
41	HY	591	ILOP	*Ilex opaca*	American holly
42	BN	601	JUCI	*Juglans cinerea*	butternut
43	WN	602	JUNI	*Juglans nigra*	black walnut
44	SU	611	LIST2	*Liquidamber styraciflua*	sweetgum
45	YP	621	LITU	*Liriodendron tulipifera*	tuliptree
46	MG	650	MAGNO	*Magnolia*	magnolia
47	CT	651	MAAC	*Magnolia acuminata*	cucumber tree
48	MS	652	MAGR4	*Magnolia grandiflora*	southern magnolia
49	MV	653	MAVI2	*Magnolia virginiana*	sweetbay
50	ML	654	MAMA2	*Magnolia macrophylla*	bigleaf magnolia
51	AP	660	MALUS	*Malus*	apple
52	MB	680	MORUS	*Morus*	mulberry
53	WT	691	NYAQ2	*Nyssa aquatica*	water tupelo
54	BG	693	NYSY	*Nyssa sylvatica*	blackgum
55	TS	694	NYBI	*Nyssa biflora*	swamp tupelo
56	HH	701	OSVI	*Ostrya virginiana*	hophornbeam
57	SD	711	OXAR	*Oxydendrum arboreum*	sourwood
58	RA	721	PEBO	*Persea borbonia*	redbay
59	SY	731	PLOC	*Platanus occidentalis*	American sycamore

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
60	CW	740	POPUL	*Populus*	cottonwood
61	BT	743	POGR4	*Populus grandidentata*	bigtooth aspen
62	BC	762	PRSE2	*Prunus serotina*	black cherry
63	WO	802	QUAL	*Quercus alba*	white oak
64	SO	806	QUCO2	*Quercus coccinea*	scarlet oak
65	SK	812	QUFA	*Quercus falcata*	southern red oak
66	CB	813	QUPA5	*Quercus pagoda*	cherrybark oak
67	TO	819	QULA2	*Quercus laevis*	turkey oak
68	LK	820	QULA3	*Quercus laurifolia*	laurel oak
69	OV	822	QULY	*Quercus lyrata*	overcup oak
70	BJ	824	QUMA3	*Quercus marilandica*	blackjack oak
71	SN	825	QUMI	*Quercus michauxii*	swamp chestnut oak
72	CK	826	QUMU	*Quercus muehlenbergii*	chinkapin oak
73	WK	827	QUNI	*Quercus nigra*	water oak
74	CO	832	QUPR2	*Quercus prinus*	chestnut oak
75	RO	833	QURU	*Quercus rubra*	northern red oak
76	QS	834	QUSH	*Quercus shumardii*	Shumard's oak
77	PO	835	QUST	*Quercus stellata*	post oak
78	BO	837	QUVE	*Quercus velutina*	black oak
79	LO	838	QUVI	*Quercus virginiana*	live oak
80	BK	901	ROPS	*Robinia pseudoacacia*	black locust
81	WI	920	SALIX	*Salix*	willow
82	SS	931	SAAL5	*Sassafras albidum*	sassafras
83	BD	950	TILIA	*Tilia*	basswood
84	EL	970	ULMUS	*Ulmus*	elm
85	WE	971	ULAL	*Ulmus alata*	winged elm
86	AE	972	ULAM	*Ulmus americana*	American elm
87	RL	975	ULRU	*Ulmus rubra*	slippery elm
88	OS	299	2TN		other softwood[2]
89	OH	998	2TB		other hardwood[2]
90	OT	999	2TREE		other[2]

[1]Set based on the USDA Forest Service NRM TAXA lists and the USDA Plants database.
[2]Other categories use FIA codes and NRM TAXA codes that best match the other category.

3.3 Habitat Type, Plant Association, and Ecological Unit Codes

The SN variant uses subregions within the ecoregion classification system as means to identify major geographic regions within the southern US (Cleland and others 2007; Keys and others 1995, McNab and Keyser 2011). Users enter subregion at the subsection level via an Ecological Unit Code (EUC). EUC affect species site index transformation, large tree diameter growth and the initialization of live surface fuels. Site index conversions are split via mountain and other province EUC. EUC are aggregated into ecoregion categories, delineated for the most part at the province level, for use in the large tree diameter growth model and for initializing live surface fuels.

A complete list of acceptable EUC and the mapping of EUC into ecoregion categories are shown in Appendix A. Digital spatial data for the EUC are available on the USDA Forest Service's FSGeodata Clearinghouse webpage as "Ecomap Subsections" at https://data.fs.usda.gov/geodata/edw/datasets.php?dsetParent=EcomapSubSections_2007 (USDA Forest Service 2017).

If no EUC or an incorrect EUC is entered in the input data, then the default EUC code of 231Dd (Quartzite and Talladega Slate Ridge) is used. Users may enter the EUC or the EUC FVS sequence number on the STDINFO keyword, when entering stand information from a database, or when using the SETSITE keyword without the PARMS option. If using the PARMS option with the SETSITE keyword, users must use the FVS sequence number for the EUC. Note that the EUC is set to '232BQ' for the Fort Bragg Military Reservation.

3.4 Site Index

Site index is used in the growth equations for the SN variant. Users should always use the site index curves from Carmean and others (1989) to estimate site index, as identified in table 3.4.1. If site index is available, a single site index for the whole stand can be entered, a site index for each individual species in the stand can be entered, or a combination of these can be entered. While a site index may be entered for any species, only those species identified in table 3.4.1 may be assigned as a valid site species. These species were identified as valid site index species by the Southern states Forest Inventory and Analysis Units at the time of model development. If site species is set to a non-valid species or site index is missing, the site species is set to white oak with a default site index set to 70.

Site indices for species not assigned a site index are converted from the site species site index using transformation equations outlined in Doolittle (1958) for the Southern Appalachian species and USDA Forest Service site index equivalency tables (USDA Forest Service 1992) for the Southern Piedmont and Mountains species. Species are grouped according to similar growth rates into nine site index groups. Determining each species site index is a four-step process. First, the relative site index of the site species is determined using the minimum and maximum site index values identified in table 3.4.1 and equation {3.4.1}. Second, a site index transformation index is computed using equation {3.4.2} for the site species; coefficients are located in table 3.4.2. Third, the relative site index for each of the site index groups is computed using equation {3.4.3}. Fourth, species site indices are computed using the relative site index for their assigned site index group using equation {3.4.4}. All non-valid site species are assigned a site index based on the relative site index of white oak (site group 9).

{3.4.1} $RISP = (SIsite - SImin) / (SImax - SImin)$

{3.4.2} $MGSPIX = A + B * (RSISP * (SIGmax - SIGmin) + SIGmin)$

{3.4.3} $MGRSI = ((C + D * MGSPIX) - SIGmin) / (SIGmax - SIGmin)$

{3.4.4} *SISP = MGRSI * (SImax – SImin) + SImin*

where:

RSISP	is relative site index of site species
SIsite	is site index of site species
SImin	is site index minimum of species
SImax	is site index maximum of species
MGSPIX	is site index transformation index for the site species group
SIGmin	is site index minimum of site species group
SIGmax	is site index maximum of site species group
A and B	are coefficients of the transformation index shown in table 3.4.2
MGRSI	is relative site index of each site index group
C and D	are coefficients of the site index group shown in table 3.4.2
SISP	is species site index
MGRSI	is relative site index assigned in table 3.4.2

Table 3.4.1 Site index equations and minimum and maximum site index ranges for the SN variant.

Species Code	NC-128: Height Growth Equation (FIA species code/page number)	SI_{min}	SI_{max}
FR[1]	012/70	15	100
JU[1]	068/73	15	70
PI[1]	097/88	15	80
PU[1]	107/92	35	100
SP[1]	110/93	35	105
SA[1]	111/99	35	105
SR[1]	097/88	45	90
LL[1]	121/107	45	125
TM	068/73	35	70
PP[1]	132/139	25	95
PD[1]	128/117	35	105
WP[1]	129/119	40	135
LP[1]	131/125	40	125
VP[1]	132/139	35	95
BY[1]	611/36	30	120
PC[1]	611/36	30	120
HM[1]	261/142	35	90
FM	317/19	35	70
BE	316/16	35	70
RM[1]	316/16	35	85
SV	317/19	30	105
SM[1]	318/18	35	100

Species Code	NC-128: Height Growth Equation (FIA species code/page number)	SI_{min}	SI_{max}
BU	318/18	25	90
BB[1]	371/21	35	85
SB[1]	371/21	35	70
AH	068/73	15	40
HI	400/25	25	85
CA	543/29	30	90
HB	068/73	15	90
RD	068/73	15	40
DW	068/73	15	45
PS	068/73	15	70
AB[1]	531/26	35	85
AS[1]	544/30	35	105
WA[1]	541/28	35	95
BA	543/29	35	85
GA	544/30	35	105
HL	901/65	25	120
LB	043/72	15	50
HA	068/73	15	65
HY	531/26	35	70
BN	602/31	35	85
WN	602/31	35	85
SU[1]	611/36	30	125
YP[1]	621/39 (Mountain)	30	135
YP[1]	621/38 (Piedmont)	30	135
MG	694/42	35	125
CT[1]	802/52	25	115
MS	694/42	35	125
MV	694/42	15	75
ML	694/42	35	125
AP	068/73	15	40
MB	068/73	15	55
WT	691/41	30	105
BG	694/42	35	105
TS	694/42	35	95
HH	068/73	15	40
SD	068/73	15	70
RA	068/73	15	60
SY[1]	621/39	30	120
CW[1]	742/45	40	125

Species Code	NC-128: Height Growth Equation (FIA species code/page number)	SI_{min}	SI_{max}
BT[1]	743/47	30	90
BC[1]	762/50	35	105
WO[1]	Upland Oak/52	25	115
SO[1]	Upland Oak/52	25	115
SK[1]	Upland Oak/52	25	115
CB[1]	813/58	30	125
TO	068/73	25	65
LK	068/73	25	65
OV[1]	828/60	35	95
BJ	068/73	25	65
SN[1]	827/59	35	95
CK	802/52	35	75
WK[1]	827/59	30	115
CO[1]	Upland Oak/52	25	115
RO[1]	Upland Oak/52	25	115
QS[1]	813/58	15	125
PO	068/73	25	85
BO[1]	Upland Oak/52	25	115
LO	827/59	30	65
BK	901/65	25	95
WI	901/65	15	110
SS	068/73	15	80
BD[1]	951/66	35	90
EL	972/68	35	90
WE	972/68	35	90
AE	972/68	35	90
RL[1]	972/68	35	90
OS	068/73	15	55
OH	068/73	15	55
OT	068/73	15	55

[1] Denotes valid site index site species.

Table 3.4.2 Site index groups, species mapping and coefficients for site index transformations for the SN variant.

Site Index Group	Site Index Species	Mapped Species	Site*	A	B	C	D
1	SP	SP,SA,PD,HM	M	-7.1837	0.1633	44	6.13
			O	-10.000	0.2000	50	5.00
2	SO	SO,WA,CT,RO,BO	M	-8.6809	0.1702	51	5.88

			O	-12.000	0.2000	60	5.00
			S	-16.000	0.2667	60	3.75
3	YP	BY,PC,SU,SY,QS,YP	All	-4.0000	0.1000	40	10.00
4	WP	LL,WP,LP	All	-9.4118	0.1569	60	6.38
5	VP	JU,FR,PI,SR,PU,VP	All	-9.3913	0.1739	54	5.75
6	SK	AS,BT,SK,RL	All	-10.000	0.2000	50	5.00
7	CO	CO	All	-8.6809	0.1702	51	5.88
8	PP	PP	All	-7.1839	0.1633	44	6.13
9	WO	RM,SM,BB,SB,AB,CW,BC, WO,CB,OV,SN,WK,BD	M	-8.7442	0.1860	47	5.38
			O	-10.000	0.2000	50	5.00

*M = Mountain, O = Other, S = species 78(BO)

3.5 Maximum Density

Maximum stand density index (SDI) and maximum basal area (BA) are important variables in determining density related mortality and crown ratio change. Maximum basal area is a stand level metric that can be set using the BAMAX or SETSITE keywords. If not set by the user, a default value is calculated from maximum stand SDI each projection cycle. Maximum stand density index can be set for each species using the SDIMAX or SETSITE keywords. If not set by the user, a default value is assigned as discussed below.

The default maximum SDI is set by species or a user specified basal area maximum. If a user specified basal area maximum is present, the maximum SDI for all species is computed using equation {3.5.1}; otherwise, species SDI maximums are assigned from the SDI maximums shown in table 3.5.1. Maximum stand density index at the stand level is a weighted average, by basal area, of the individual species SDI maximums.

Stand SDI is calculated using the Zeide calculation method (Dixon 2002).

{3.5.1} $SDIMAX_i = BAMAX / (0.5454154 * SDIU)$

where:

$SDIMAX_i$ is species-specific SDI maximum
BAMAX is the user-specified stand basal area maximum
SDIU is the proportion of theoretical maximum density at which the stand reaches actual maximum density (default 0.85, changed with the SDIMAX keyword)

Table 3.5.1 Stand density index maximums by species in the SN variant.

Species Code	SDI Maximums*	Mapped to	Species Code	SDI Maximums*	Mapped to
FR	655	balsam fir	MG	492	sweetbay
JU	354	eastern redcedar	CT	415	
PI	412	white spruce	MS	492	sweetbay
PU	499	Virginia pine	MV	492	
SP	490		ML	492	sweetbay

Species Code	SDI Maximums*	Mapped to
SA	385	
SR	490	shortleaf pine
LL	332	
TM	398	pitch pine
PP	398	
PD	310	
WP	529	
LP	480	
VP	499	
BY	692	
PC	623	
HM	518	eastern hemlock
FM	371	sugar maple
BE	344	
RM	421	
SV	590	
SM	371	
BU	371	sugar maple
BB	400	river birch
SB	350	
AH	375	
HI	276	pignut hickory
CA	492	sassafras
HB	420	hackberry
RD	422	
DW	257	
PS	147	
AB	364	
AS	414	green ash
WA	408	
BA	423	
GA	414	
HL	338	
LB	492	sweetbay
HA	430	blackgum
HY	155	
BN	283	black walnut

Species Code	SDI Maximums*	Mapped to
AP	422	eastern redbud
MB	277	red mulberry
WT	726	
BG	430	
TS	704	
HH	304	
SD	164	
RA	492	sweetbay
SY	499	
CW	648	eastern cottonwood
BT	520	
BC	384	
WO	361	
SO	315	
SK	342	
CB	405	
TO	326	blackjack oak
LK	387	
OV	384	
BJ	326	
SN	417	chestnut oak
CK	336	
WK	365	
CO	417	
RO	414	
QS	342	southern red oak
PO	311	
BO	370	
LO	410	
BK	343	
WI	447	black willow
SS	492	
BD	526	American basswood
EL	282	American elm
WE	263	
AE	282	
RL	227	

Species Code	SDI Maximums*	Mapped to
WN	283	
SU	430	
YP	478	

Species Code	SDI Maximums*	Mapped to
OS	354	eastern redcedar
OH	492	sassafras
OT	421	red maple

*Source of SDI maximums is an unpublished analysis of FIA data by John Shaw.

4.0 Growth Relationships

This chapter describes the functional relationships used to fill in missing tree data and calculate incremental growth. In FVS, trees are grown in either the small tree sub-model or the large tree sub-model depending on the diameter.

4.1 Height-Diameter Relationships

Height-diameter relationships in FVS are primarily used to estimate tree heights missing in the input data, and occasionally to estimate diameter growth on trees smaller than a given threshold diameter. In the SN variant, the model will dub in heights by one of two methods. By default, the SN variant will use the Curtis-Arney functional form as shown in equation {4.1.1} (Curtis 1967, Arney 1985). FVS can switch to a logistic height-diameter equation {4.1.2} (Wykoff, et.al 1982) that may be calibrated to the input data; however, the default in the SN variant is to use equation {4.1.1}.

FVS will not automatically use equation {4.1.2} even if you have enough height values in the input data. To override this default, the user must use the NOHTDREG keyword and change field 2 to a 1. Coefficients for the height-diameter equations are given in table 4.1.1. Tree records eligible for calibrating the height-diameter curve must have diameters greater than 3 inches.

{4.1.1} Curtis-Arney equation

$DBH \geq 3.0”: HT = 4.5 + P_2 * \exp(-P_3 * DBH ^{P_4})$
$DBH < 3.0”: HT = ((4.5 + P_2 * \exp(-P_3 * 3.0^{P_4}) – 4.51) * (DBH – D_{bw}) / (3 – D_{bw})) + 4.51$

{4.1.2}Wykoff functional form

$HT = 4.5 + \exp(B_1 + B_2 / (DBH + 1.0))$

where:

HT	is tree height
DBH	is tree diameter at breast height
D_{bw}	is bud width diameter at 4.51 feet shown in table 4.1.1
B_1 - B_2	are species-specific coefficients shown in table 4.1.1
P_2 - P_4	are species-specific coefficients shown in table 4.1.2

Table 4.1.1 Coefficients (P2 - P4), (B1 - B2), and Dbw for the height-diameter relationship equations {4.1.1}, {4.1.2}, and {4.1.3} in the SN variant.

Species Code	Curtis-Arney Coefficients				Wykoff Coefficients	
	P_2	P_3	P_4	D_{bw}	Default B_1	B_2
FR	2163.946776	6.26880851	-0.2161439	0.1	4.5084	-6.0116
JU	212.7932729	3.47154903	-0.3258523	0.3	4.0374	-4.2964

Species Code	Curtis-Arney Coefficients				Wykoff Coefficients	
	P_2	P_3	P_4	D_{bw}	Default B_1	B_2
PI	2163.946776	6.26880851	-0.2161439	0.2	4.5084	-6.0116
PU	3919.995225	6.87312726	-0.19063343	0.5	4.2899	-4.1019
SP	444.0921666	4.11876312	-0.30617043	0.5	4.6271	-6.4095
SP*	444.0921666	4.11876312	-0.30617043	0.5	4.705	-7.904
SA	1087.101439	5.10450596	-0.24284896	0.5	4.6561	-6.2258
SA*	110.3	7.0670	-1.0420	0.5	4.787	-8.015
SR	333.3145742	4.13108244	-0.37092539	0.5	4.7258	-6.7703
LL	98.56082813	3.89930709	-0.86730393	0.5	4.5991	-5.9111
LL*	114.6	4.1840	-0.6940	0.5	4.562	-7.314
TM	691.5411919	4.19801014	-0.1856823	0.5	4.2139	-4.5419
PP	208.7773185	3.72806565	-0.410875	0.5	4.3898	-5.7183
PD	142.7468108	3.97260802	-0.5870983	0.5	4.5457	-6.8000
PD*	623.9	4.7396	-0.2763	0.5	4.806	-9.573
WP	2108.844224	5.65948135	-0.18563136	0.4	4.6090	-6.1896
LP	243.860648	4.28460566	-0.47130185	0.5	4.6897	-6.8801
LP*	184.3	4.2660	-0.5496	0.5	4.79	-8.5
VP	926.1802712	4.46209203	-0.20053974	0.5	4.4718	-5.0078
BY	119.5749091	4.13535453	-0.79625456	0.2	4.6171	-6.2684
PC	162.6505825	3.20796415	-0.47880203	0.2	4.4603	-5.0577
HM	266.4562239	3.99313675	-0.38600287	0.1	4.5084	-6.0116
FM	603.6736175	3.9896005	-0.21651785	0.2	4.3164	-4.0582
BE	287.9445676	3.27674704	-0.26617485	0.2	4.2378	-4.1080
RM	268.5564351	3.11432843	-0.29411156	0.2	4.3379	-3.8214
SV	80.51179925	26.98331005	-2.02202808	0.2	4.5991	-6.6706
SM	209.8555358	2.95281334	-0.36787496	0.2	4.4834	-4.5431
BU	630.9504602	4.51086779	-0.26826208	0.3	4.5697	-5.7172
BB	170.5253403	2.68833651	-0.40080716	0.1	4.4388	-4.0872
SB	68.92234069	43.33832185	-2.44448482	0.1	4.4522	-4.5758
AH	628.0209077	3.88103963	-0.15387585	0.2	3.8550	-2.6623
HI	337.6684758	3.62726466	-0.32083172	0.3	4.5128	-4.9918
CA	190.9797059	3.69278884	-0.52730469	0.3	4.9396	-8.1838
HB	484.7529797	3.93933286	-0.25998833	0.1	4.4207	-5.1435
RD	103.1767713	2.21695491	-0.3596216	0.2	3.7512	-2.5539
DW	863.0501053	4.38560239	-0.14812185	0.1	3.7301	-2.7758
PS	488.9349192	4.06503751	-0.27180547	0.2	4.4091	-4.8464

Species Code	Curtis-Arney Coefficients				Wykoff Coefficients	
	P_2	P_3	P_4	D_{bw}	Default B_1	B_2
AB	526.1392688	3.89232121	-0.22587084	0.1	4.4772	-4.7206
AS	251.4042514	3.26919806	-0.35905996	0.2	4.4819	-4.5314
WA	91.35276617	6.99605268	-1.22937669	0.2	4.5959	-6.4497
BA	178.9307637	4.92861465	-0.63777014	0.2	4.6155	-6.2945
GA	404.9692122	3.39019741	-0.255096	0.2	4.6155	-6.2945
HL	778.9356784	4.20756452	-0.18734197	0.1	4.3734	-5.3135
LB	265.7422693	3.59041788	-0.35232417	0.2	4.4009	-5.0560
HA	2620.585492	5.84993689	-0.18030935	0.2	4.4931	-4.6501
HY	1467.643523	5.33438509	-0.17395792	0.1	4.0151	-4.3314
BN	285.8797853	3.52138815	-0.3193688	0.3	4.5018	-5.6123
WN	93.71042027	3.6575094	-0.88246833	0.4	4.5018	-5.6123
SU	290.90548	3.6239536	-0.3720123	0.2	4.5920	-5.1719
YP	625.7696614	3.87320571	-0.23349496	0.2	4.6892	-4.9605
MG	585.6609078	3.41972033	-0.17661706	0.2	4.4004	-4.7519
CT	660.1996521	3.92077102	-0.21124354	0.2	4.6067	-5.2030
MS	139.3315132	2.89981329	-0.48514023	0.2	4.4004	-4.7519
MV	184.1931837	2.84569124	-0.36952511	0.2	4.3609	-4.1423
ML	366.4744742	2.8733336	-0.1819814	0.2	4.4004	-4.7519
AP	574.0200612	3.86373895	-0.16318776	0.2	3.9678	-3.2510
MB	750.1823388	4.14262749	-0.15940723	0.2	3.9613	-3.1993
WT	163.9728054	2.76819717	-0.44098009	0.2	4.4330	-4.5383
BG	319.9788466	3.67313408	-0.30651323	0.2	4.3802	-4.7903
TS	252.3566527	3.24398683	-0.33343129	0.2	4.4334	-4.5709
HH	109.7324294	2.25025802	-0.41297463	0.2	4.0322	-3.0833
SD	690.4917743	4.15983216	-0.18613455	0.2	4.1352	-3.7450
RA	257.0532628	3.4047448	-0.30291274	0.2	4.0965	-3.9250
SY	644.3567687	3.92045786	-0.21444786	0.1	4.6355	-5.2776
CW	190.9797059	3.69278884	-0.52730469	0.1	4.9396	-8.1838
BT	66.6488871	135.4825559	-2.88622709	0.2	4.9396	-8.1838
BC	364.0247807	3.55987361	-0.27263121	0.1	4.3286	-4.0922
WO	170.1330787	3.27815866	-0.48744214	0.2	4.5463	-5.2287
SO	196.0564703	3.0067167	-0.38499624	0.2	4.5225	-4.9401
SK	150.4300023	3.13270999	-0.49925872	0.1	4.5142	-5.2205
CB	182.6306309	3.12897883	-0.46391125	0.1	4.7342	-6.2674
TO	2137.575644	5.80907868	-0.15590506	0.2	3.9365	-4.4599

Species Code	Curtis-Arney Coefficients				Wykoff Coefficients	
	P_2	P_3	P_4	D_{bw}	Default B_1	B_2
LK	208.2300233	3.13834277	-0.37158262	0.1	4.4375	-4.6654
OV	184.0856396	3.49535241	-0.46211544	0.2	4.5710	-6.0922
BJ	157.4828626	3.38919504	-0.39151499	0.2	3.9191	-4.3503
SN	281.3413276	3.51695826	-0.3336282	0.2	4.6135	-5.7613
CK	72.7907469	3.67065539	-1.09878979	0.1	4.3420	-5.1193
WK	470.0617193	3.78892643	-0.25123824	0.1	4.5577	-4.9595
CO	94.54465221	3.42034111	-0.818759	0.2	4.4618	-4.8786
RO	700.0636452	4.10607389	-0.21392785	0.2	4.5202	-4.8896
QS	215.0009406	3.14204012	-0.39067352	0.1	4.6106	-5.4380
PO	765.2907525	4.22375114	-0.18974706	0.1	4.2496	-4.8061
BO	224.716279	3.11648501	-0.35982064	0.2	4.4747	-4.8698
LO	153.9588254	3.11348786	-0.38947124	0.2	4.2959	-5.3332
BK	880.2844971	4.59642097	-0.21824277	0.1	4.4299	-4.9920
WI	408.2772475	3.81808285	-0.27210505	0.1	4.4911	-5.7928
SS	755.1038099	4.39496421	-0.21778831	0.1	4.3383	-4.5018
BD	293.5715132	3.52261899	-0.35122247	0.1	4.582	-5.0903
EL	1005.80672	4.6473994	-0.20336143	0.1	4.3744	-4.5257
WE	1001.672885	4.57310438	-0.18898217	0.1	4.5992	-7.7428
AE	418.5941897	3.17038578	-0.18964025	0.1	4.6008	-7.2732
RL	1337.547184	4.48953501	-0.14749529	0.1	4.6238	-7.4847
OS	212.7932729	3.47154903	-0.3258523	0.3	4.3898	-5.7183
OH	109.7324294	2.25025802	-0.41297463	0.2	3.9392	-3.4279
OT	31021.35552	8.3958757	-0.10372075	0.2	3.9089	-3.0149

* Coefficients for Fort Bragg Military Reservation

4.2 Bark Ratio Relationships

Bark ratio estimates are used to convert between diameter outside bark and diameter inside bark in various parts of the model. The equation is shown in equation {4.2.1} and coefficients (b_1 and b_2) for this equation by species are shown in table 4.2.1. Coefficients for the SN variant are based on Clark (1991).

{4.2.1} $DIB = b_1 + b_2 * (DOB)$ $BRATIO = DIB / DOB$

where:

BRATIO is species-specific bark ratio (bounded to $0.80 \leq BRATIO \leq 0.99$)
DIB is tree diameter inside bark at breast height

DOB	is tree diameter outside bark at breast height
b_1, b_2	are species-specific coefficients shown in table 4.2.1

Table 4.2.1 Bark ratio coefficients by species for the SN variant.

Species Code	b_1	b_2	Species Code	b_1	b_2
FR	0.05119	0.89372	MG	-0.21140	0.94461
JU	-0.27012	0.97546	CT	-0.21140	0.94461
PI	-0.17289	0.91572	MS	-0.21140	0.94461
PU	-0.39956	0.95183	MV	-0.17978	0.92381
SP	-0.44121	0.93045	ML	-0.21140	0.94461
SA	-0.55073	0.91887	AP	-0.33014	0.94215
SR	-0.13301	0.93755	MB	-0.33014	0.94215
LL	-0.45903	0.92746	WT	-0.38140	0.97327
TM	0.05119	0.89372	BG	0.19899	0.88941
PP	-0.58808	0.91852	TS	-0.15231	0.93442
PD	-0.51271	0.90245	HH	-0.42001	0.94264
WP	-0.31608	0.92054	SD	-0.25063	0.94349
LP	-0.48140	0.91413	RA	-0.33014	0.94215
VP	-0.31137	0.95011	SY	-0.09192	0.96411
BY	-0.27012	0.97546	CW	-0.25063	0.94349
PC	-0.94204	0.96735	BT	-0.25063	0.94349
HM	-0.04931	0.92272	BC	-0.12958	0.94152
FM	-0.09800	0.94646	WO	-0.24096	0.93789
BE	-0.09800	0.94646	SO	-0.40860	0.94613
RM	-0.09800	0.94646	SK	-0.42141	0.93008
SV	-0.09800	0.94646	CB	-0.21801	0.93540
SM	-0.09800	0.94646	TO	-0.61021	0.95803
BU	-0.35332	0.95955	LK	-0.04612	0.93127
BB	0.21790	0.92290	OV	-0.37973	0.94380
SB	0.21790	0.92290	BJ	-0.61021	0.95803
AH	-0.13040	0.97071	SN	-0.49699	0.94832
HI	-0.60912	0.94347	CK	-0.34225	0.93494
CA	-0.33014	0.94215	WK	-0.30330	0.95826
HB	-0.18338	0.95768	CO	-0.43197	0.92120
RD	-0.33014	0.94215	RO	-0.52266	0.95215
DW	-0.33014	0.94215	QS	-0.61021	0.95803
PS	-0.42001	0.94264	PO	-0.26493	0.91899
AB	-0.13040	0.97071	BO	-0.70754	0.94821
AS	-0.34316	0.93964	LO	-0.70754	0.94821
WA	-0.48735	0.93847	BK	-0.37166	0.89193
BA	-0.25063	0.94349	WI	-0.25063	0.94349
GA	-0.34316	0.93964	SS	-0.25063	0.94349

Species Code	b_1	b_2
HL	-0.42001	0.94264
LB	-0.33014	0.94215
HA	-0.33014	0.94215
HY	-0.33014	0.94215
BN	-0.42001	0.94264
WN	-0.42001	0.94264
SU	-0.39271	0.95997
YP	-0.22976	0.92408

Species Code	b_1	b_2
BD	-0.35979	0.95322
EL	-0.42027	0.96305
WE	-0.42027	0.96305
AE	-0.42027	0.96305
RL	-0.42027	0.96305
OS	-0.38344	0.91915
OH	-0.33014	0.94215
OT	-0.25063	0.94349

4.3 Crown Ratio Relationships

Crown ratio equations are used for three purposes in FVS: (1) to estimate tree crown ratios missing from the input data for both live and dead trees; (2) to estimate change in crown ratio from cycle to cycle for live trees; and (3) to estimate initial crown ratios for regenerating trees established during a simulation.

4.3.1 Crown Ratio Dubbing

In the SN variant, crown ratio missing on dead trees in the input data is dubbed using equation set {4.3.1.1}.

{4.3.1.1} $DBH \leq 24$: $X = 0.70-0.40/24.0*DBH$
$DBH > 24$: $X = 0.30$

{4.3.1.2} $CR = 1 / (1 + \exp(X + N(0,SD)))$

where:

CR is crown ratio expressed as a proportion (bounded to $0.05 \leq CR \leq 0.95$)
DBH is tree diameter at breast height
N(0,SD) is a random increment from a normal distribution with a mean of 0 and a standard deviation of SD

A Weibull-based crown model developed by Dixon (1985) as described in Dixon (2002) is used to predict crown ratio for all live trees. To estimate crown ratio using this methodology, the average stand crown ratio is estimated from stand density index using one of following five equations {4.3.1.3} – {4.3.1.7}. Weibull parameters are then estimated from the average stand crown ratio using equations in equation set {4.3.1.8}. Individual tree crown ratio is then set from the Weibull distribution, equation {4.3.1.9} based on a tree's relative position in the diameter distribution and multiplied by a scale factor, shown in equation {4.3.1.10}, which accounts for stand density. Crowns estimated from the Weibull distribution are bounded to be between the 5 and 95 percentile points of the specified Weibull distribution. Equation reference and coefficients for each species are shown in table 4.3.1.1.

{4.3.1.3} $ACR = \exp[d_0 + (d_1 * \ln(RELSDI)) + (d_2 * RELSDI))]$

{4.3.1.4} $ACR = \exp[d_0 + (d_1 * \ln(RELSDI)]$

{4.3.1.5} $ACR = d_0 + (d_2 * RELSDI)$

{4.3.1.6} $ACR = d_0 + (d_1 * \log_{10}(RELSDI))$

{4.3.1.7} $ACR = RELSDI / ((d_0 * RELSDI) + d_1)$

{4.3.1.8} Weibull parameters A, B, and C are estimated from average crown ratio

$A = a_0$
$B = b_0 + b_1 * ACR$, bounded to be greater than 3.0
$C = c$, bounded to be greater than 2.0

{4.3.1.9} $Y = A + B(-\ln(1-X))^{(1/C)}$

{4.3.1.10} $SCALE = 1 – 0.00167 * (CCF – 100)$

where:

ACR is the predicted average crown ratio for the species
RELSDI is the relative site density index ((Stand *SDI* / Maximum *SDI*) * 10) and is bounded between 1.0 and 12.0
A, *B*, *C* are parameters of the Weibull crown ratio distribution
Y is a tree's crown ratio expressed as a percent of total height
X is a trees rank in the diameter distribution (1 = smallest; ITRN = largest) divided by the total number of trees (ITRN) multiplied by *SCALE*, bounded between [0.05,0.95]
SCALE is a density dependent scaling factor (bounded to $0.3 \le SCALE \le 1.0$)
CCF is the stand crown competition factor
a_0, b_0, b_1, c_0, c_1, d_0, and d_1 are species-specific coefficients shown in table 4.3.1

Table 4.3.1 Coefficients for crown ratio change equations {4.3.1} – {4.3.6} in the SN variant.

Species Code	*ACR* Equation	d_0	d_1	d_2	a	b_0	b_1	c
FR	4.3.1.5	63.51		-0.09	4.0659	-6.8708	1.0510	4.1741
JU	4.3.1.5	67.64		-2.25	2.4435	-32.4837	1.6503	2.6518
PI	4.3.1.5	63.51		-0.09	4.0659	-6.8708	1.0510	4.1741
PU	4.3.1.6	54.0462	-18.2118		4.3780	-5.0254	0.9620	2.4758
SP	4.3.1.6	47.7297	-16.352		4.6721	-3.9456	1.0509	3.0228
SA	4.3.1.6	42.8255	-15.0135		3.8940	-4.7342	0.9786	2.9082
SR	4.3.1.4	4.17	-0.23		5.0000	-10.1125	1.0734	3.3218
LL	4.3.1.6	42.84	-5.62		3.9771	14.3941	0.5189	3.7531
TM	4.3.1.6	45.8231	-13.8999		3.9190	1.2933	0.7986	2.9202
PP	4.3.1.3	4.3546	-0.5034	0.0163	3.9190	1.2933	0.7986	2.9202
PD	4.3.1.3	3.8904	-0.3565	0.0478	4.3300	-34.2606	1.7823	3.0554
WP	4.3.1.5	51.8		-0.8	4.6496	-11.4277	1.1343	2.9405
LP	4.3.1.3	3.8284	-0.2234	0.0172	4.9701	-14.6680	1.3196	2.8517
VP	4.3.1.3	4.1136	-0.331	0.007	5.0000	-10.2832	1.1019	2.4693
BY	4.3.1.6	48.2413	-10.1014		5.0000	-9.8322	1.1062	2.8512

Species Code	*ACR* Equation	d_0	d_1	d_2	a	b_0	b_1	c
PC	4.3.1.6	36.0855	-5.4737		4.9986	-9.6939	1.0740	2.3667
HM	4.3.1.5	63.51		-0.09	4.0659	-6.8708	1.0510	4.1741
FM	4.3.1.6	53.1867	-9.4122		5.0000	-18.6340	1.2622	3.6407
BE	4.3.1.6	61.9643	-22.3363		5.0000	-18.6340	1.2622	3.6407
RM	4.3.1.6	46.1653	-6.088		4.7322	-24.2740	1.4587	2.9951
SV	4.3.1.5	42.98		0.55	5.0000	-18.6340	1.2622	3.6407
SM	4.3.1.5	48.2		-0.01	4.6903	-19.5613	1.2928	3.3715
BU	4.3.1.5	42.13		-0.1	5.0000	-18.6340	1.2622	3.6407
BB	4.3.1.3	3.7275	-0.1124	0.0282	4.1939	1.2500	0.8795	3.1500
SB	4.3.1.3	3.8785	-0.1749	0.0171	4.1939	1.2500	0.8795	3.1500
AH	4.3.1.3	3.9904	-0.1496	0.0171	4.5640	0.9693	0.9093	3.0540
HI	4.3.1.3	3.9939	-0.2117	0.0238	5.0000	-29.1096	1.5626	3.5310
CA	4.3.1.6	48.03	-13.21		4.8371	-14.3180	1.2060	3.7345
HB	4.3.1.6	50.8266	-14.5261		4.5671	-49.1736	2.1311	2.9883
RD	4.3.1.6	44.5839	-14.0874		5.0000	15.0407	0.6546	3.0344
DW	4.3.1.6	51.8467	-14.1876		4.7093	-9.6999	1.1020	2.7391
PS	4.3.1.3	3.8415	-0.2879	0.0297	4.7093	-9.6999	1.1020	2.7391
AB	4.3.1.6	59.09	-4.99		4.6965	-14.3809	1.2016	3.5571
AS	4.3.1.5	38.26		-0.77	4.0098	-12.7054	1.2224	2.7400
WA	4.3.1.3	3.7881	-0.0634	-0.0055	4.8776	-11.6617	1.1668	3.8475
BA	4.3.1.5	35.49			4.0098	-12.7054	1.2224	2.7400
GA	4.3.1.5	35.49			4.5987	-16.9647	1.3925	3.3601
HL	4.3.1.4	3.82	-0.1		4.9245	-13.3135	1.2765	2.8455
LB	4.3.1.5	37.83		-0.15	4.1992	-16.8789	1.2949	2.7697
HA	4.3.1.3	4.4653	-0.834	0.107	4.7093	-9.6999	1.1020	2.7391
HY	4.3.1.5	52.05		-0.11	4.6965	-14.3809	1.2016	3.5571
BN	4.3.1.4	3.91	-0.12		4.2967	-17.7977	1.3186	3.0386
WN	4.3.1.4	3.91	-0.12		4.2967	-17.7977	1.3186	3.0386
SU	4.3.1.3	3.8153	-0.0964	0.0055	4.6350	-39.7348	1.9132	3.0574
YP	4.3.1.4	3.87	-0.07		4.9948	-11.1090	1.1089	3.8822
MG	4.3.1.5	44.71		0.4	5.0000	9.2520	0.7899	3.2166
CT	4.3.1.5	42.15		-0.11	4.9829	-5.2479	0.9552	3.8219
MS	4.3.1.5	44.71		0.4	5.0000	9.2520	0.7899	3.2166
MV	4.3.1.5	36.5		-0.23	4.2299	-32.4970	1.7316	2.7902
ML	4.3.1.5	44.71		0.4	5.0000	9.2520	0.7899	3.2166
AP	4.3.1.5	55.48		-2.38	4.2932	-7.1512	1.0504	2.7738
MB	4.3.1.5	42.32		-1.08	4.8677	-22.5591	1.4240	2.8686
WT	4.3.1.5	36.02		-0.3	5.0000	-15.1643	1.2524	3.1645
BG	4.3.1.5	41.01		-0.21	4.6134	-42.6970	1.9983	3.0081
TS	4.3.1.5	41.379		-0.8012	4.8257	-7.1092	1.0128	2.7232

Species Code	*ACR* Equation	d_0	d_1	d_2	a	b_0	b_1	c
HH	4.3.1.6	52.7207	-11.484		5.0000	15.0407	0.6546	3.0344
SD	4.3.1.5	38.71		-0.1	4.8677	-22.5591	1.4240	2.8686
RA	4.3.1.5	38.03		-0.09	3.5122	22.2798	0.3081	2.7868
SY	4.3.1.5	3.9839	-0.0462	-0.0248	4.5640	-30.7592	1.6192	3.2836
CW	4.3.1.6	48.03	-13.21		4.8371	-14.3180	1.2060	3.7345
BT	4.3.1.6	48.03	-13.21		4.8371	-14.3180	1.2060	3.7345
BC	4.3.1.5	45.06		-0.96	4.2932	-7.1512	1.0504	2.7738
WO	4.3.1.4	4.05	-0.12		5.0000	-16.0927	1.2319	3.5016
SO	4.3.1.6	51.7	-9.65		5.0000	-4.6551	0.9593	3.8340
SK	4.3.1.4	3.92	-0.09		5.0000	-26.7842	1.6030	3.5160
CB	4.3.1.3	3.9112	-0.1697	0.0147	5.0000	-4.2993	1.0761	3.5922
TO	4.3.1.4	3.95	-0.02		4.1406	13.6950	0.6895	3.0427
LK	4.3.1.6	54.36	-11.3181		4.6329	-1.2977	0.9438	3.2263
OV	4.3.1.6	57.82	-18.45		5.0000	11.2401	0.7081	3.5258
BJ	4.3.1.6	56.42	-14.13		4.1406	13.6950	0.6895	3.0427
SN	4.3.1.3	3.9344	-0.0845	0.0043	4.4764	-18.7445	1.3539	3.8384
CK	4.3.1.3	4.1233	-0.1279	-0.0142	5.0000	-7.5332	1.0257	3.1662
WK	4.3.1.3	3.9116	-0.2657	0.0509	5.0000	-50.1177	2.1127	3.5148
CO	4.3.1.6	54.53	-14.7		5.0000	-9.7922	1.0728	3.6340
RO	4.3.1.4	3.9	-0.07		5.0000	-12.4107	1.1363	3.6430
QS	4.3.1.5	46.72		-0.85	5.0000	5.0414	0.8032	3.6764
PO	4.3.1.6	44.34	-5.23		4.7585	-83.4596	3.0817	3.4788
BO	4.3.1.4	4.17	-0.18		5.0000	-6.5883	1.0266	3.5587
LO	4.3.1.5	49.27		-0.72	5.0000	11.2401	0.7081	3.5258
BK	4.3.1.6	49.022	-22.5732		3.5643	-10.5101	1.2176	2.2033
WI	4.3.1.5	44.5295		-1.0053	4.8547	-17.1135	1.3108	3.2431
SS	4.3.1.5	38.85		-0.99	4.9082	-11.2413	1.1519	2.4971
BD	4.3.1.7	0.0283	-0.012		4.2656	-26.6773	1.5580	4.4024
EL	4.3.1.4	3.68	-0.02		5.0000	1.1421	0.9141	3.0621
WE	4.3.1.6	43.64	-10.03		4.9367	7.6678	0.9105	3.0303
AE	4.3.1.3	3.7366	-0.0896	0.0151	5.0000	1.1421	0.9141	3.0621
RL	4.3.1.3	3.8487	-0.2005	0.0276	4.7375	-21.8810	1.5340	3.3558
OS	4.3.1.5	67.64		-2.25	2.4435	-32.4837	1.6503	2.6518
OH	4.3.1.3	3.78	-0.02	-0.02	4.1374	17.2956	0.4987	2.2670
OT	4.3.1.4	3.93	-0.15		4.9041	-2.5097	0.9225	2.7628

4.3.2 Crown Ratio Change

Crown ratio change is estimated after growth, mortality and regeneration are estimated during a projection cycle. Crown ratio change is the difference between the crown ratio at the beginning of the cycle and the predicted crown ratio at the end of the cycle. Crown ratio predicted at the end of the projection cycle is estimated for live tree records using the Weibull distribution, equations {4.3.1.3}-{4.3.1.10}, for all species. Crown change is checked to make sure it doesn't exceed the change possible if all height growth produces new crown. Crown change is further bounded to 1% per year for the length of the cycle to avoid drastic changes in crown ratio. Equations {4.3.1.1} and {4.3.1.2} are not used when estimating crown ratio change.

4.3.3 Crown Ratio for Newly Established Trees

Crown ratios for newly established trees during regeneration are estimated using equation {4.3.3.1}. A random component is added in equation {4.3.3.1} to ensure that not all newly established trees are assigned exactly the same crown ratio.

{4.3.3.1} $CR = 0.89722 - 0.0000461 * PCCF + RAN$

where:

CR	is crown ratio expressed as a proportion (bounded to $0.2 \leq CR \leq 0.9$)
PCCF	is crown competition factor on the inventory point where the tree is established
RAN	is a small random component

4.4 Crown Width Relationships

The SN variant calculates the maximum crown width for each individual tree based on individual tree and stand attributes. Crown width for each tree is reported in the tree list output table and used to calculate percent canopy cover (*PCC*) and crown competition factor (CCF) within the model. When available, forest-grown maximum crown width equations are used to compute *PCC* and open-grown maximum crown width equations are used to compute *CCF*.

The SN variant computes tree crown width using equations {4.4.1} through {4.4.5}. Species equation assignment and coefficients are shown in tables 4.4.1 and 4.4.2 for forest- and open-grown equations, respectively. Equations are numbered via the FIA species code and equation number, i.e. the forest grown equation from Bechtold (2003) assigned to fir has the number: 01201.

{4.4.1} Bechtold (2003); Equation 01

$DBH \geq 5.0$: $FCW = a_1 + (a_2 * DBH) + (a_3 * DBH^2) + (a_4 * CR) + (a_5 * HI)$
$DBH < 5.0$: $FCW = [a_1 + (a_2 * 5.0) + (a_3 * 5.0^2) + (a_4 * CR) + (a_5 * HI)] * (DBH / 5.0)$

{4.4.2} Bragg (2001); Equation 02

$DBH \geq 5.0$: $FCW = a_1 + (a_2 * DBH^{a_3})$
$DBH < 5.0$: $FCW = [a_1 + (a_2 * 5.0^{a_3})] * (DBH / 5.0)$

{4.4.3} Ek (1974); Equation 03

$DBH \geq 3.0$: $OCW = a_1 + (a_2 * DBH^{a_3})$
$DBH < 3.0$: $OCW = [a_1 + (a_2 * 3.0^{a_3})] * (DBH / 3.0)$

{4.4.4} Krajicek and others (1961); Equation 04

$DBH \geq 3.0$: $OCW = a_1 + (a_2 * DBH)$

$DBH < 3.0$: $OCW = [a_1 + (a_2 * 3.0)] * (DBH / 3.0)$

{4.4.5} Smith and others (1992); Equation 05

$DBH \geq 3.0$: $OCW = a_1 + (a_2 * DBH * 2.54) + (a_3 * (DBH * 2.54)^{\wedge} 2) * 3.28084$
$DBH < 3.0$: $OCW = [a_1 + (a_2 * 3.0 * 2.54) + (a_3 * (3.0 * 2.54)^{\wedge} 2) * 3.28084] * (DBH / 3.0)$

where:

FCW	is crown width of forest grown trees (used in *PCC* calculations)
OCW	is crown width of open-grown trees (used in *CCF* calculations))
DBH	is tree diameter at breast height, if bounded
CR	is crown ratio expressed as a percent
HI	is the Hopkins Index $HI = (ELEVATION - 887) / 100) * 1.0 + (LATITUDE – 39.54) * 4.0 + (-82.52 - LONGITUDE) * 1.25$
$a_1 - a_5$	are the coefficients shown in tables 4.4.1 and 4.4.2

Table 4.4.1. Crown width equation assignment and coefficients for forest-grown trees in the SN variant.

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
FR	01201	0.6564	0.8403		0.0792		*FCW* ≤ 34
JU	06801	1.2359	1.2962		0.0545		*FCW* ≤ 33
PI	09401	0.3789	0.8658		0.0878		*FCW* ≤ 30
PU	13201	-0.1211	1.2319		0.1212		*FCW* ≤ 34
SP	11001	-2.2564	1.3004		0.1031	-0.0562	*FCW* ≤ 34
SA	11101	-6.9659	2.1192	-0.0333	0.0587	-0.0959	*DBH* ≤ 30
SR	11001	-2.2564	1.3004		0.1031	-0.0562	*FCW* ≤ 34
LL	12101	-12.2105	1.3376		0.1237	-0.2759	*FCW* ≤ 50
TM	12601	-0.9442	1.4531		0.0543	-0.1144	*FCW* ≤ 34
PP	12601	-0.9442	1.4531		0.0543	-0.1144	*FCW* ≤ 34
PD	12801	-8.7711	3.7252	-0.1063			*DBH* ≤ 18
WP	12901	0.3914	0.9923		0.1080		*FCW* ≤ 45
LP	13101	-0.8277	1.3946		0.0768		*FCW* ≤ 55
VP	13201	-0.1211	1.2319		0.1212		*FCW* ≤ 34
BY	22101	-1.0183	0.8856		0.1162		*FCW* ≤ 37
PC	22101	-1.0183	0.8856		0.1162		*FCW* ≤ 37
HM	26101	6.1924	1.4491	-0.0178		-0.0341	*DBH* ≤ 40
FM	31801	4.9399	1.0727		0.1096	-0.0493	*FCW* ≤ 54
BE	31301	6.4741	1.0778		0.0719	-0.0637	*FCW* ≤ 57
RM	31601	2.7563	1.4212	0.0143	0.0993		*DBH* ≤ 50
SV	31701	3.3576	1.1312		0.1011	-0.1730	*FCW* ≤ 45
SM	31801	4.9399	1.0727		0.1096	-0.0493	*FCW* ≤ 54
BU	40701	4.5453	1.3721		0.0430		*FCW* ≤ 54

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
BB	37301	11.6634	1.0028				*FCW* ≤ 68
SB	37201	4.6725	1.2968		0.0787		*FCW* ≤ 54
AH	39101	0.9219	1.6303		0.1150	-0.1113	*FCW* ≤ 42
HI	40701	4.5453	1.3721		0.0430		*FCW* ≤ 54
CA	93101	4.6311	1.0108		0.0564		*FCW* ≤ 29
HB	46201	7.1043	1.3041		0.0456		*FCW* ≤ 51
RD	49101	2.9646	1.9917		0.0707		*FCW* ≤ 36
DW	49101	2.9646	1.9917		0.0707		*FCW* ≤ 36
PS	52101	3.5393	1.3939		0.0625		*FCW* ≤ 36
AB	53101	3.9361	1.1500		0.1237	-0.0691	*FCW* ≤ 80
AS	54401	2.9672	1.3066		0.0585		*FCW* ≤ 61
WA	54101	1.7625	1.3413		0.0957		*FCW* ≤ 62
BA	54301	5.2824	1.1184				*FCW* ≤ 34
GA	54401	2.9672	1.3066		0.0585		*FCW* ≤ 61
HL	55201	4.1971	1.5567		0.0880		*FCW* ≤ 46
LB	65301	8.2119	0.9708				*FCW* ≤ 41
HA	49101	2.9646	1.9917		0.0707		*FCW* ≤ 36
HY	59101	4.5803	1.0747		0.0661		*FCW* ≤ 31
BN	60201	3.6031	1.1472		0.1224		*FCW* ≤ 37
WN	60201	3.6031	1.1472		0.1224		*FCW* ≤ 37
SU	61101	1.8853	1.1625		0.0656		*FCW* ≤ 50
YP	62101	3.3543	1.1627		0.0857		*FCW* ≤ 61
MG	65301	8.2119	0.9708				*FCW* ≤ 41
CT	65101	4.1711	1.6275				*FCW* ≤ 39
MS	65301	8.2119	0.9708				*FCW* ≤ 41
MV	65301	8.2119	0.9708				*FCW* ≤ 41
ML	65301	8.2119	0.9708				*FCW* ≤ 41
AP	76102	4.102718	1.396006	1.077474			*FCW* ≤ 52
MB	68201	13.3255	1.0735				*FCW* ≤ 46
WT	69101	5.3409	0.7499		0.1047		*FCW* ≤ 37
BG	69301	5.5037	1.0567		0.0880	0.0610	*FCW* ≤ 50
TS	69401	1.3564	1.0991		0.1243		*FCW* ≤ 41
HH	70101	7.8084	0.8129		0.0941	-0.0817	*FCW* ≤ 39
SD	71101	7.9750	0.8303		0.0423	-0.0706	*FCW* ≤ 36
RA	72101	4.2756	1.0773		0.1526	0.1650	*FCW* ≤ 25
SY	73101	-1.3973	1.3756		0.1835		*FCW* ≤ 66
CW	74201	3.4375	1.4092				*FCW* ≤ 80
BT	74301	0.6847	1.1050		0.1420	-0.0265	*FCW* ≤ 43
BC	76201	3.0237	1.1119		0.1112	-0.0493	*FCW* ≤ 52
WO	80201	3.2375	1.5234		0.0455	-0.0324	*FCW* ≤ 69

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
SO	80601	0.5656	1.6766		0.0739		*FCW* ≤ 66
SK	81201	2.1517	1.6064		0.0609		*FCW* ≤ 56
CB	81201	2.1517	1.6064		0.0609		*FCW* ≤ 56
TO	81901	5.8858	1.4935				*FCW* ≤ 29
LK	82001	6.3149	1.6455				*FCW* ≤ 54
OV	82301	1.7827	1.6549		0.0343		*FCW* ≤ 61
BJ	82401	0.5443	1.4882		0.0565		*FCW* ≤ 37
SN	83201	2.1480	1.6928	-0.0176	0.0569		*DBH* ≤ 50
CK	82601	0.5189	1.4134		0.1365	-0.0806	*FCW* ≤ 45
WK	82701	1.6349	1.5443		0.0637	-0.0764	*FCW* ≤ 57
CO	83201	2.1480	1.6928	-0.0176	0.0569		*DBH* ≤ 50
RO	83301	2.8908	1.4077		0.0643		*FCW* ≤ 82
QS	81201	2.1517	1.6064		0.0609		*FCW* ≤ 56
PO	83501	1.6125	1.6669		0.0536		*FCW* ≤ 45
BO	83701	2.8974	1.3697		0.0671		*FCW* ≤ 52
LO	83801	5.6694	1.6402				*FCW* ≤ 66
BK	90101	3.0012	0.8165		0.1395		*FCW* ≤ 48
WI	97201	1.7296	2.0732		0.0590	-0.0869	*FCW* ≤ 50
SS	93101	4.6311	1.0108		0.0564		*FCW* ≤ 29
BD	95101	1.6871	1.2110		0.1194	-0.0264	*FCW* ≤ 61
EL	97201	1.7296	2.0732		0.0590	-0.0869	*FCW* ≤ 50
WE	97101	4.3649	1.6612		0.0643		*FCW* ≤ 40
AE	97201	1.7296	2.0732		0.0590	-0.0869	*FCW* ≤ 50
RL	97501	9.0023	1.3933			-0.0785	*FCW* ≤ 49
OS	06801	1.2359	1.2962		0.0545		*FCW* ≤ 33
OH	93101	4.6311	1.0108		0.0564		*FCW* ≤ 29
OT	31601	2.7563	1.4212	0.0143	0.0993		*DBH* ≤ 50

Table 4.4.2 Crown width equation assignment and coefficients for open-grown trees for the SN variant.

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
FR	01203	0.3270	5.1160	0.5035			*OCW* ≤ 34
JU	06801	1.2359	1.2962		0.0545		*OCW* ≤ 33
PI	09403	3.5940	1.9630	0.8820			*OCW* ≤ 37
PU	13201	-0.1211	1.2319		0.1212		*OCW* ≤ 34
SP	11005	0.5830	0.2450	0.0009			*OCW* ≤ 45
SA	11101	-6.9659	2.1192	-0.0333	0.0587	-0.0959	*DBH* ≤ 30
SR	11005	0.5830	0.2450	0.0009			*OCW* ≤ 45
LL	12105	0.113	0.259				*OCW* ≤ 50
TM	12601	-0.9442	1.4531		0.0543	-0.1144	*OCW* ≤ 34

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
PP	12601	-0.9442	1.4531		0.0543	-0.1144	*OCW* ≤ 34
PD	12801	-8.7711	3.7252	-0.1063			*DBH* ≤ 18
WP	12903	1.6200	3.1970	0.7981			*OCW* ≤ 58
LP	13105	0.7380	0.2450	0.000809			*OCW* ≤ 66
VP	13201	-0.1211	1.2319		0.1212		*OCW* ≤ 34
BY	22101	-1.0183	0.8856		0.1162		*OCW* ≤ 37
PC	22101	-1.0183	0.8856		0.1162		*OCW* ≤ 37
HM	26101	6.1924	1.4491	-0.0178		-0.0341	*DBH* ≤ 40
FM	31803	0.8680	4.1500	0.7514			*OCW* ≤ 54
BE	31301	6.4741	1.0778		0.0719	-0.0637	*OCW* ≤ 57
RM	31603	0.00	4.7760	0.7656			*OCW* ≤ 55
SV	31701	3.3576	1.1312		0.1011	-0.1730	*OCW* ≤ 45
SM	31803	0.8680	4.1500	0.7514			*OCW* ≤ 54
BU	40703	2.3600	3.5480	0.7986			*OCW* ≤ 54
BB	37301	11.6634	1.0028				*OCW* ≤ 68
SB	37201	4.6725	1.2968		0.0787		*OCW* ≤ 54
AH	39101	0.9219	1.6303		0.1150	-0.1113	*OCW* ≤ 42
HI	40703	2.3600	3.5480	0.7986			*OCW* ≤ 54
CA	93101	4.6311	1.0108		0.0564		*OCW* ≤ 29
HB	46201	7.1043	1.3041		0.0456		*OCW* ≤ 51
RD	49101	2.9646	1.9917		0.0707		*OCW* ≤ 36
DW	49101	2.9646	1.9917		0.0707		*OCW* ≤ 36
PS	52101	3.5393	1.3939		0.0625		*OCW* ≤ 36
AB	53101	3.9361	1.1500		0.1237	-0.0691	*OCW* ≤ 80
AS	54403	0.0000	4.7550	0.7381			*OCW* ≤ 61
WA	54101	1.7625	1.3413		0.0957		*OCW* ≤ 62
BA	54301	5.2824	1.1184				*OCW* ≤ 34
GA	54403	0.0000	4.7550	0.7381			*OCW* ≤ 61
HL	55201	4.1971	1.5567		0.0880		*OCW* ≤ 46
LB	65301	8.2119	0.9708				*OCW* ≤ 41
HA	49101	2.9646	1.9917		0.0707		*OCW* ≤ 36
HY	59101	4.5803	1.0747		0.0661		*OCW* ≤ 31
BN	60201	3.6031	1.1472		0.1224		*OCW* ≤ 37
WN	60201	3.6031	1.1472		0.1224		*OCW* ≤ 37
SU	61101	1.8853	1.1625		0.0656	-0.0300	*OCW* ≤ 50
YP	62101	3.3543	1.1627		0.0857		*OCW* ≤ 61
MG	65301	8.2119	0.9708				*OCW* ≤ 41
CT	65101	4.1711	1.6275				*OCW* ≤ 39
MS	65301	8.2119	0.9708				*OCW* ≤ 41
MV	65301	8.2119	0.9708				*OCW* ≤ 41

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
ML	65301	8.2119	0.9708				*OCW* ≤ 41
AP	76102	4.102718	1.396006	1.077474			*OCW* ≤ 52
MB	68201	13.3255	1.0735				*OCW* ≤ 46
WT	69101	5.3409	0.7499		0.1047		*OCW* ≤ 37
BG	69301	5.5037	1.0567		0.0880	0.0610	*OCW* ≤ 50
TS	69401	1.3564	1.0991		0.1243		*OCW* ≤ 41
HH	70101	7.8084	0.8129		0.0941	-0.0817	*OCW* ≤ 39
SD	71101	7.9750	0.8303		0.0423	-0.0706	*OCW* ≤ 36
RA	72101	4.2756	1.0773		0.1526	0.1650	*OCW* ≤ 25
SY	73101	-1.3973	1.3756		0.1835		*OCW* ≤ 66
CW	74203	2.934	2.538	0.8617			*OCW* ≤ 80
BT	74301	0.6847	1.1050		0.1420	-0.0265	*OCW* ≤ 43
BC	76203	0.621	7.059	0.5441			*OCW* ≤ 52
WO	80204	1.8000	1.8830				*OCW* ≤ 69
SO	80601	0.5656	1.6766		0.0739		*OCW* ≤ 66
SK	81201	2.1517	1.6064		0.0609		*OCW* ≤ 56
CB	81201	2.1517	1.6064		0.0609		*OCW* ≤ 56
TO	81901	5.8858	1.4935				*OCW* ≤ 29
LK	82001	6.3149	1.6455				*OCW* ≤ 54
OV	82303	0.942	3.539	0.7952			*OCW* ≤ 78
BJ	82401	0.5443	1.4882		0.0565		*OCW* ≤ 37
SN	83201	2.1480	1.6928	-0.0176	0.0569		*DBH* ≤ 50
CK	82601	0.5189	1.4134		0.1365	-0.0806	*OCW* ≤ 45
WK	82701	1.6349	1.5443		0.0637	-0.0764	*OCW* ≤ 57
CO	83201	2.1480	1.6928	-0.0176	0.0569		*DBH* ≤ 50
RO	83303	2.8500	3.7820	0.7968			*OCW* ≤ 82
QS	81201	2.1517	1.6064		0.0609		*OCW* ≤ 56
PO	83501	1.6125	1.6669		0.0536		*OCW* ≤ 45
BO	83704	4.5100	1.6700				*OCW* ≤ 52
LO	83801	5.6694	1.6402				*OCW* ≤ 66
BK	90101	3.0012	0.8165		0.1395		*OCW* ≤ 48
WI	97203	2.8290	3.4560	0.8575			*OCW* ≤ 72
SS	93101	4.6311	1.0108		0.0564		*OCW* ≤ 29
BD	95101	1.6871	1.2110		0.1194	-0.0264	*OCW* ≤ 61
EL	97203	2.8290	3.4560	0.8575			*OCW* ≤ 72
WE	97101	4.3649	1.6612		0.0643		*OCW* ≤ 40
AE	97203	2.8290	3.4560	0.8575			*OCW* ≤ 72
RL	97501	9.0023	1.3933			-0.0785	*OCW* ≤ 49
OS	06801	1.2359	1.2962		0.0545		*OCW* ≤ 33
OH	93101	4.6311	1.0108		0.0564		*OCW* ≤ 29

Species Code	Equation Number	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
OT	31603	0.00	4.7760	0.7656			$OCW \leq 55$

[1] Maximum crown widths and DBH have been assigned to prevent poor behavior beyond the source data. In addition, *CR* has been set to 90% for species using equation 01, Bechtold (2003).

4.5 Crown Competition Factor

The SN variant uses crown competition factor (*CCF*) as a predictor variable in some growth relationships. Crown competition factor (Krajicek and others 1961) is a relative measurement of stand density that is based on tree diameters. Individual tree CCF_t values estimate the percentage of an acre that would be covered by the tree's crown if the tree were open-grown. Stand *CCF* is the summation of individual tree (CCF_t) values. A stand *CCF* value of 100 theoretically indicates that tree crowns will just touch in an unthinned, evenly spaced stand. Crown competition factor for an individual tree is calculated using equation {4.5.1}, and is based on crown width of open-grown trees.

{4.5.1} All species

$DBH > 0.1”: CCF_t = 0.001803 * OCW_t\text{^}2$
$DBH \leq 0.1”: CCF_t = 0.001$

where:

CCF_t	is crown competition factor for an individual tree
OCW_t	is open-grown crown width for an individual tree
DBH	is tree diameter at breast height

4.6 Small Tree Growth Relationships

Trees are considered “small trees” for FVS modeling purposes when they are smaller than some threshold diameter. This threshold diameter is set to 3.0” for all species in the SN variant.

The small tree model is height growth driven, meaning height growth is estimated first and diameter growth is estimated from height growth. These relationships are discussed in the following sections.

4.6.1 Small Tree Height Growth

The small-tree height growth model predicts periodic potential height growth (POTHTG) from height growth curves using the Chapman-Richards nonlinear functional form for a particular species, see GTR-NC-128 (Carmean and others 1989). A linear function fills in the height growth curves from 0 at age 0 to the lower end of the height growth curve. Height growth is computed by subtracting the current predicted height from the predicted height 5 years in the future, as depicted in equation {4.6.1.1}. Coefficients for each species are located in table 4.6.1.1.

{4.6.1.1} $POTHT = c_1 * SI\text{^}c_2 * [1.0 – \exp(c_3 * AGET)]\text{^}(c_4 * (SI \text{^} c_5))$

where:

POTHT	is predicted tree height, used for current and future height growth.
SI	is species site index
AGET	is tree age
	$AGET = 1./c_3*(\ln(1-(HT/c_1/SI\text{^}c_2)\text{^}(1./c_4/SI\text{^}c_5)))$
HT	tree height in feet
$c_1 - c_5$	are species-specific coefficients

Table 4.6.1.1 Height growth curve coefficients from GTR-NC-128 (Carmean and others 1989) for the SN variant.

Species Code	NC-128 Height Growth Equation (FIA code / page number)	c_1	c_2	c_3	c_4	c_5
FR	012/70	2.077	0.9303	-0.0285	2.8937	-0.1414
JU	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
PI	097/88	1.3307	1.0442	-0.0496	3.5829	0.0945
PU	107/92	1.266	1.0034	-0.0365	1.5515	-0.0221
SP	110/93	1.4232	0.9989	-0.0285	1.2156	0.0088
SA	111/99	1.1557	1.0031	-0.0408	0.9807	0.0314
SR	097/88	1.3307	1.0442	-0.0496	3.5829	0.0945
LL	107/92	1.421	0.9947	-0.0269	1.1344	-0.0109
TM	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
PP	132/139	1.1204	0.9984	-0.0597	2.4448	-0.0284
PD	128/117	1.1266	1.0051	-0.0367	0.678	0.0404
WP	129/119	3.2425	0.798	-0.0435	52.0549	-0.7064
LP	131/125	1.1421	1.0042	-0.0374	0.7632	0.0358
VP	132/139	1.1204	0.9984	-0.0597	2.4448	-0.0284
BY	611/36	1.0902	1.0298	-0.0354	0.7011	0.1178
PC	611/36	1.0902	1.0298	-0.0354	0.7011	0.1178
HM	261/142	2.1493	0.9979	-0.0175	1.4086	-0.0008
FM	317/19	1.0645	0.9918	-0.0812	1.5754	-0.0272
BE	316/16	2.9435	0.9132	-0.0141	1.658	-0.1095
RM	316/16	2.9435	0.9132	-0.0141	1.658	-0.1095
SV	317/19	1.0645	0.9918	-0.0812	1.5754	-0.0272
SM	318/18	6.1308	0.6904	-0.0195	10.1563	-0.5330
BU	318/18	6.1308	0.6904	-0.0195	10.1563	-0.5330
BB	371/21	6.0522	0.6768	-0.0217	15.4232	-0.6354
SB	371/21	6.0522	0.6768	-0.0217	15.4232	-0.6354
AH	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
HI	400/25	1.8326	1.0015	-0.0207	1.408	-0.0005
CA	543/29	4.2286	0.7857	-0.0178	4.6219	-0.3591

Species Code	NC-128 Height Growth Equation (FIA code / page number)	c_1	c_2	c_3	c_4	c_5
HB	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
RD	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
DW	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
PS	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
AB	531/26	29.73	0.3631	-0.0127	16.7616	-0.6804
AS	544/30	1.6505	0.9096	-0.0644	125.7045	-0.8908
WA	541/28	4.1492	0.7531	-0.0269	14.5384	-0.5811
BA	543/29	4.2286	0.7857	-0.0178	4.6219	-0.3591
GA	544/30	1.6505	0.9096	-0.0644	125.7045	-0.8908
HL	901/65	0.968	1.0301	-0.0468	0.1639	0.4127
LB	043/72	1.5341	1.0013	-0.0208	0.9986	-0.0012
HA	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
HY	531/26	29.73	0.3631	-0.0127	16.7616	-0.6804
BN	602/31	1.2898	0.9982	-0.0289	0.8546	0.0171
WN	602/31	1.2898	0.9982	-0.0289	0.8546	0.0171
SU	611/36	1.0902	1.0298	-0.0354	0.7011	0.1178
YP	621/39 (Mountain)	1.2673	1.0	-0.0331	1.1149	0.0001
YP	621/38 (Piedmont)	1.1798	1.0	-0.0339	0.8117	-0.0001
MG	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
CT	802/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
MS	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
MV	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
ML	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
AP	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
MB	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
WT	691/41	1.2721	0.9995	-0.0256	0.7447	-0.0019
BG	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
TS	694/42	1.3213	0.9995	-0.0254	0.8549	-0.0016
HH	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
SD	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
RA	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
SY	621/39	1.2673	1.0	-0.0331	1.1149	0.0001
CW	742/45	1.2834	0.9571	-0.068	100.0	-0.9223
BT	743/47	5.2188	0.6855	-0.0301	50.0071	-0.8695
BC	762/50	7.1846	0.6781	-0.0222	13.9186	-0.5268
WO	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
SO	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
SK	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316

Species Code	NC-128 Height Growth Equation (FIA code / page number)	c_1	c_2	c_3	c_4	c_5
CB	813/58	1.0945	0.9938	-0.0755	2.5601	0.0114
TO	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
LK	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
OV	828/60	1.3295	0.9565	-0.0668	16.0085	-0.4157
BJ	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
SN	827/59	1.3466	0.959	-0.0574	8.9538	-0.3454
CK	802/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
WK	827/59	1.3466	0.959	-0.0574	8.9538	-0.3454
CO	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
RO	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
QS	813/58	1.0945	0.9938	-0.0755	2.5601	0.0114
PO	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
BO	Upland Oak/52	1.2866	0.9962	-0.0355	1.4485	-0.0316
LO	827/59	1.3466	0.959	-0.0574	8.9538	-0.3454
BK	901/65	0.968	1.0301	-0.0468	0.1639	0.4127
WI	901/65	0.968	1.0301	-0.0468	0.1639	0.4127
SS	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
BD	951/66	4.7633	0.7576	-0.0194	6.511	-0.4156
EL	972/68	6.4362	0.6827	-0.0194	10.9767	-0.5477
WE	972/68	6.4362	0.6827	-0.0194	10.9767	-0.5477
AE	972/68	6.4362	0.6827	-0.0194	10.9767	-0.5477
RL	972/68	6.4362	0.6827	-0.0194	10.9767	-0.5477
OS	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
OH	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114
OT	068/73	0.9276	1.0591	-0.0424	0.3529	0.3114

For all species, a small random error is then added to the height growth estimate. The estimated height growth is then adjusted to account for cycle length, user defined small-tree height growth adjustments, and adjustments due to small tree height increment calibration from input data.

Height growth estimates from the small-tree model are weighted with the height growth estimates from the large tree model over a range of diameters (X_{min} and X_{max}) in order to smooth the transition between the two models. For example, the closer a tree's *DBH* value is to the minimum diameter (X_{min}), the more the growth estimate will be weighted towards the small-tree growth model. The closer a tree's *DBH* value is to the maximum diameter (X_{max}), the more the growth estimate will be weighted towards the large-tree growth model. If a tree's *DBH* value falls outside of the range given by X_{min} and X_{max}, then the model will use only the small-tree or large-tree growth model in the growth estimate. The weight applied to the growth estimate is calculated using equation {4.6.1.2}, and applied as shown in equation {4.6.1.3}. The range of diameters for each species is shown in table 4.6.1.3.

{4.6.1.2}

$DBH \leq X_{min}$: $XWT = 0$
$X_{min} < DBH < X_{max}$: $XWT = (DBH - X_{min}) / (X_{max} - X_{min})$
$DBH \geq X_{max}$: $XWT = 1$

{4.6.1.3} Estimated growth = $[(1 - XWT) * STGE] + [XWT * LTGE]$

where:

XWT	is the weight applied to the growth estimates
DBH	is tree diameter at breast height
X_{max}	is the maximum *DBH* is the diameter range, set to 1.0”
X_{min}	is the minimum *DBH* in the diameter range, set to 3.0”
STGE	is the growth estimate obtained using the small-tree growth model
LTGE	is the growth estimate obtained using the large-tree growth model

4.6.2 Small Tree Diameter Growth

As stated previously, for trees being projected with the small tree equations, height growth is predicted first, and then diameter growth. So both height at the beginning of the cycle and height at the end of the cycle are known when predicting diameter growth. Small tree diameter growth for trees over 4.5 feet tall is calculated as the difference of predicted diameter at the start of the projection period and the predicted diameter at the end of the projection period, adjusted for bark ratio. These two predicted diameters are estimated using the species-specific height-diameter relationships discussed in section 4.1. By definition, diameter growth is zero for trees less than 4.5 feet tall.

4.7 Large Tree Growth Relationships

Trees are considered “large trees” for FVS modeling purposes when they are equal to, or larger than, some threshold diameter. This threshold diameter is set to 3.0” for all species in the SN variant.

The large-tree model is driven by diameter growth meaning diameter growth is estimated first, and then height growth is estimated from diameter growth and other variables. These relationships are discussed in the following sections.

4.7.1 Large Tree Diameter Growth

The large tree diameter growth model used in most FVS variants is described in section 7.2.1 in Dixon (2002). For most variants, instead of predicting diameter increment directly, the natural log of the periodic change in squared inside-bark diameter (ln(*DDS*)) is predicted (Dixon 2002; Wykoff 1990; Stage 1973; and Cole and Stage 1972). For variants predicting diameter increment directly, diameter increment is converted to the *DDS* scale to keep the FVS system consistent across all variants.

The SN variant predicts 5-year diameter growth using equation {4.7.1.1}. Coefficients for this equation are shown in tables 4.7.1.1 through 4.7.1.7.

{4.7.1.1} $\ln(DDS) = b_1 + (b_2 * \ln(DBH)) + (b_3 * DBH^2) + (b_4 * \ln(CR)) + (b_5 * RELHT) + (b_6 * SI) + (b_7 * BA) + (b_8 * PBAL) + (b_9 * SLOPE) + (b_{10} * \cos(ASP) * SLOPE) + (b_{11} * \sin(ASP) * SLOPE) + FORTYPE + ECOUNIT + PLANT$

where:

DDS	is the predicted 5-year periodic change in squared inside-bark diameter
DBH	is tree diameter at breast height
CR	is crown ratio expressed as a percent
HREL	is relative height of subject tree to the Top Height of the stand
SI	is site index of the species
BA	is the stand basal area per acre
PBAL	is the plot basal area in larger trees
SLOPE	is the stand slope, scaled to a range of 0-1
ASPECT	is the stand aspect in radians
FORTYPE	is a current forest type group dependent coefficient shown in tables 4.7.1.3 and 4.7.1.4
ECOUNIT	is an ecological unit group dependent coefficient shown in tables 4.7.1.5 and 4.7.1.6
PLANT	is a managed pine stand coefficient shown in table 4.7.1.7
b_1- b_{11}	are species-specific coefficients shown in tables 4.7.1.1 and 4.7.1.2

Large-tree 5-year diameter growth for longleaf pine and loblolly pine on the Fort Bragg Military Reservation is predicted from equation set {4.7.1.2} (Shaw and others 2006). While not shown here, this diameter growth estimate is eventually converted to the *DDS* scale.

{4.7.1.2} Fort Bragg Military Reservation longleaf and loblolly pine equations

Longleaf pine: $DG = (DBH*BRATIO)*((-0.4553 * (0.09737 - EXP(-0.2428 * DBH))) + (0.05574 * CR) – (0.0002965 * BA) – (0.00002481 * PBA) – (0.001192 * (PCT^{-0.9663})) + (0.0010110 * SI) – (0.007711 * HREL))$

Loblolly pine $DG = (DBH*BRATIO)*((-0.3428 * (-0.1741 - EXP(-0.1328 * DBH))) + (0.1145 * CR) – (0.0001682 * BA) – (0.00003978 * PBA) – (0.159400 * (PCT^{-0.1299})) + (0.0006204 * SI) + (0.02474 * HREL))$

where:

DG	is the predicted 5-year diameter growth
DBH	is tree diameter at breast height
BRATIO	is the bark ratio as expressed in Section4.1
CR	is crown ratio expressed as a proportion
BA	is the stand basal area per acre
PBA	is the plot basal area per acre
PCT	is the percentile in the distribution of tree basal area
SI	is site index of the species

HREL is relative height of subject tree to the Top Height of the stand

During data analysis and regression fitting for the large-tree diameter growth model, it became apparent that data for most species were concentrated in small to medium large trees and were lacking in the very large size classes. Since this could lead to overestimation of diameter growth in larger trees, a bounding function was established to decrease the growth rates for very large trees.

The bounding function is applied using the following concepts. For a tree with projected diameter less than or equal to the lower diameter-bounding limit, diameter growth is not modified. For a tree with a projected diameter greater than the lower diameter-bounding limit and less than or equal to the upper diameter-bounding limit, diameter growth is modified using equation {4.7.1.3}. For a tree with a projected diameter greater than the upper diameter-bounding limit, diameter growth is set to 0.048. The lower and upper diameter limits were determined from data used to fit the diameter growth models, hundreds of thousands of FVS simulations and from literature for maximum tree sizes (Harlow and Harrar 1968, Burns and Honkala 1990). The bounding limits for the diameter growth bounding function are located in Table 4.7.1.8. For twenty-three species, the bounding function was determined to produce unrealistic results and essentially turned off by setting the lower diameter limit to 998 inches.

{4.7.1.3} $DGBMOD = \max(1.0 + 0.9 * ((DBH - DBH_{LOW}) / (DBH_{LOW} - DBH_{HI})), 0.048)$

where:

$DGBMOD$ is diameter growth bounding modifier
DBH is the predicted diameter at breast height
DBH_{LOW} is the lower diameter-bounding limit
DBH_{HI} is the upper diameter-bounding limit

Table 4.7.1.1 Coefficients (b_1- b_6) for the non-categorical variables of the diameter increment model by species for the SN variant.

Species Code	Model Coefficients					
	b_1	b_2	b_3	b_4	b_5	b_6
FR	-2.267851	1.442529	-0.000548	0.568468	-0.403762	-0.001151
JU	-1.864431	1.403065	-0.001237	0.273616	0.177408	-0.000374
PI	-2.267851	1.442529	-0.000548	0.568468	-0.403762	-0.001151
PU	-3.791466	1.796179	-0.005109	0.902185	0.000000	-0.002009
SP	-0.008942	1.238170	-0.001170	0.053076	0.040334	0.004723
SA	-1.641698	1.461093	-0.002530	0.265872	0.069104	0.006851
SR	-2.431165	1.691731	-0.000945	0.588558	-0.326169	0.000109
LL	-1.331052	1.098112	-0.001834	0.184512	0.388018	0.008774
TM	-2.600803	1.525435	-0.003519	0.615731	0.059646	0.001033
PP	-3.639059	1.397394	-0.001670	0.739443	-0.193198	0.008731
PD	-2.353114	1.425614	-0.001694	0.455833	-0.198222	0.007876
WP	-3.497764	1.339503	-0.000961	0.759060	0.605201	0.004214

Species Code	Model Coefficients					
	b_1	b_2	b_3	b_4	b_5	b_6
LP	0.222214	1.163040	-0.000863	0.028483	0.006935	0.005018
VP	-2.600803	1.525435	-0.003519	0.615731	0.059646	0.001033
BY	-1.735969	1.505649	-0.000054	0.132441	-0.119572	0.003996
PC	-4.224977	1.831739	-0.000595	0.446234	-0.125847	0.005975
HM	-2.267851	1.442529	-0.000548	0.568468	-0.403762	-0.001151
FM	-1.685778	1.454506	-0.000818	0.242436	-0.140837	0.004360
BE	-0.871047	1.217898	-0.000105	0.240101	0.071213	-0.000022
RM	-2.260482	1.449834	-0.000931	0.361311	0.282436	0.003444
SV	-2.260482	1.449834	-0.000931	0.361311	0.282436	0.003444
SM	-2.313444	1.350084	-0.000816	0.394806	0.631803	-0.000542
BU	-1.876225	1.197048	-0.000778	0.183857	0.547747	0.010254
BB	-1.092055	1.024946	-0.000653	0.206770	0.489441	0.002354
SB	-1.092055	1.024946	-0.000653	0.206770	0.489441	0.002354
AH	-1.281144	1.335625	0.000000	0.111128	-0.244632	0.005347
HI	-2.728289	1.548449	-0.000761	0.203837	0.570012	0.004399
CA	-1.068980	1.164191	0.000000	0.084279	0.501307	0.009700
HB	-0.833167	1.190567	0.000000	0.193368	0.508738	-0.000056
RD	-1.062539	1.174050	0.000000	0.239942	0.411945	-0.005893
DW	-2.540719	1.293125	-0.000856	0.368481	-0.611245	0.004257
PS	-2.524455	1.479865	-0.001512	0.289171	0.243575	0.003369
AB	-1.251887	1.349337	-0.000447	0.193148	0.279322	-0.000287
AS	-2.954457	1.461691	0.000000	0.377819	0.185353	0.007104
WA	-1.315283	1.216264	-0.000080	0.087907	0.487191	0.003424
BA	-0.897707	1.243091	0.000000	0.090158	0.496594	-0.000465
GA	-0.897707	1.243091	0.000000	0.090158	0.496594	-0.000465
HL	-0.314922	0.927191	0.000000	0.103234	0.538379	0.003038
LB	-2.514589	1.459672	-0.001317	0.654209	0.106808	-0.003582
HA	-2.352258	1.746852	0.000000	0.291502	-1.771604	0.003239
HY	-1.981934	1.456263	-0.002061	0.215249	-0.414064	0.004240
BN	-2.354190	1.050171	-0.000154	0.425328	0.616257	0.001348
WN	-2.354190	1.050171	-0.000154	0.425328	0.616257	0.001348
SU	-1.324147	1.395884	-0.000490	0.145539	0.256765	0.001993
YP	-2.513351	1.495351	-0.000756	0.530123	0.161718	0.000746
MG	-2.516823	1.454173	-0.000925	0.252335	0.243666	0.007223
CT	-1.239592	1.063360	-0.000092	0.243097	0.533202	-0.003084
MS	-1.477929	1.126474	-0.000267	0.134257	0.539000	0.005884

Species Code	Model Coefficients					
	b_1	b_2	b_3	b_4	b_5	b_6
MV	-2.516823	1.454173	-0.000925	0.252335	0.243666	0.007223
ML	-1.477929	1.126474	-0.000267	0.134257	0.539000	0.005884
AP	-1.746231	1.234133	-0.000017	0.285511	0.180572	0.002596
MB	-1.746231	1.234133	-0.000017	0.285511	0.180572	0.002596
WT	-2.721782	1.599221	-0.000162	0.351271	0.133939	0.001783
BG	-1.508549	1.306362	-0.000576	0.112403	0.121169	0.003356
TS	-2.555720	1.303035	0.000000	0.319301	-0.109064	0.006498
HH	-1.431973	1.452294	-0.001475	0.061077	-0.208915	0.004856
SD	-3.180040	1.355790	-0.000784	0.532236	0.077021	0.005170
RA	-2.096616	1.254708	0.000000	0.344067	0.176829	0.002656
SY	-1.012995	1.272885	-0.000238	0.234530	0.332494	0.000406
CW	-1.068980	1.164191	0.000000	0.084279	0.501307	0.009700
BT	-1.068980	1.164191	0.000000	0.084279	0.501307	0.009700
BC	-2.610023	1.220310	-0.000234	0.520739	0.181418	0.003897
WO	-1.608339	1.468589	-0.000778	0.139456	0.358369	0.004530
SO	-2.284302	1.569893	-0.000632	0.272422	0.206868	0.005065
SK	-0.783581	1.432483	-0.000412	0.044460	0.241383	0.003012
CB	-0.295485	1.239946	-0.000163	0.020622	0.431515	0.003830
TO	-2.698130	1.622081	-0.001703	0.354924	-0.033854	0.000682
LK	-1.561284	1.335456	-0.000412	0.246163	0.381808	0.004714
OV	-0.947174	1.376350	-0.000482	0.099697	0.427943	0.001280
BJ	-1.948938	1.611438	-0.000844	0.135696	0.056739	0.002740
SN	-1.321662	1.640507	-0.000285	0.038193	0.086499	0.005844
CK	-2.223515	0.937359	0.000212	0.286311	0.733279	0.008621
WK	-0.845477	1.488444	-0.000286	0.053292	0.130856	0.005330
CO	-2.900655	1.347350	-0.000533	0.300133	0.597032	0.008415
RO	-2.732646	1.499450	-0.000729	0.344764	0.466082	0.004632
QS	-0.328678	1.282494	-0.000351	0.071625	0.455600	-0.001173
PO	-1.430321	1.293728	-0.000452	0.047937	0.514612	0.005466
BO	-2.345845	1.450330	-0.000674	0.251441	0.527504	0.005921
LO	-3.640660	1.448503	-0.000210	0.549199	0.073672	0.009377
BK	-1.307911	0.963269	0.000000	0.268621	0.396699	0.003713
WI	-1.109398	1.187096	0.000000	0.202056	0.093966	0.006303
SS	-1.745126	1.313340	-0.000179	0.201048	0.542693	0.004206
BD	-1.848106	1.424209	-0.001488	0.289244	0.253525	0.003499
EL	-2.356235	1.479429	-0.000517	0.425367	-0.083383	0.002767

Species Code	Model Coefficients					
	b_1	b_2	b_3	b_4	b_5	b_6
WE	-0.790138	0.949707	0.000000	0.100266	0.348136	0.004360
AE	-0.510736	1.164789	0.000000	0.127893	0.516517	0.000450
RL	-0.229212	1.060275	0.000000	0.116801	0.430393	-0.001806
OS	-1.864431	1.403065	-0.001237	0.273616	0.177408	-0.000374
OH	-1.431973	1.452294	-0.001475	0.061077	-0.208915	0.004856
OT	-1.645961	1.447657	-0.002158	0.241038	0.719652	-0.003250

Table 4.7.1.2 Coefficients (b_7-b_{11}) for the non-categorical variables of the diameter increment model by species for the SN variant.

Species Code	Model Coefficients				
	b_7	b_8	b_9	b_{10}	b_{11}
FR	-0.000824	-0.002503	-0.241408	0.066508	0.086959
JU	-0.003620	-0.001890	-0.231988	0.077542	-0.025792
PI	-0.000824	-0.002503	-0.241408	0.066508	0.086959
PU	-0.005287	-0.003203	0.501409	-1.788107	-1.231519
SP	-0.004394	-0.003271	-0.704687	0.127667	0.028391
SA	-0.002939	-0.004873	-0.018479	-0.193157	-0.251016
SR	-0.001847	-0.001394	-0.324278	0.526867	0.009866
LL	-0.002182	-0.002898	0.225213	0.086883	0.107445
TM	-0.002304	-0.002716	-0.217771	0.018819	-0.052142
PP	-0.002257	-0.002188	-0.317178	0.083538	0.150686
PD	-0.003001	-0.004510	0.685018	-2.907934	1.683401
WP	-0.000865	-0.004065	-0.372738	-0.085193	-0.035582
LP	-0.003408	-0.004184	-0.759347	0.185360	-0.072842
VP	-0.002304	-0.002716	-0.217771	0.018819	-0.052142
BY	-0.000502	-0.000768	-0.560585	-0.428140	-0.739509
PC	-0.000191	-0.000600	2.356739	-8.639114	5.615465
HM	-0.000824	-0.002503	-0.241408	0.066508	0.086959
FM	-0.003268	-0.001923	-0.339807	-0.204878	-0.147110
BE	-0.001242	-0.000826	-0.613177	0.315909	-0.237088
RM	-0.002133	-0.001383	-0.097604	-0.069753	0.094162
SV	-0.002133	-0.001383	-0.097604	-0.069753	0.094162
SM	-0.001413	-0.001527	-0.032482	-0.009543	0.005581
BU	-0.004219	-0.000586	-0.178079	0.187157	-0.108544
BB	-0.002005	-0.001848	-0.192793	-0.112449	0.113349
SB	-0.002005	-0.001848	-0.192793	-0.112449	0.113349
AH	-0.003852	-0.000644	-0.224489	0.031993	-0.160702

Species Code	Model Coefficients				
	b_7	b_8	b_9	b_{10}	b_{11}
HI	-0.003339	-0.001029	-0.245761	0.055798	0.080648
CA	-0.001041	-0.001349	0.075733	-0.601088	-0.757088
HB	-0.001846	-0.001776	-0.179044	0.039673	-0.071628
RD	-0.001141	-0.002822	-0.391784	0.039121	-0.038350
DW	-0.003144	-0.001235	-0.282662	-0.084011	0.104748
PS	-0.001319	-0.002784	-0.327799	-0.200696	-0.145939
AB	-0.002547	-0.001176	-0.380400	0.160386	-0.088382
AS	-0.002027	-0.000779	-0.619659	0.020132	-0.020785
WA	-0.000807	-0.001262	0.018297	-0.001091	-0.021565
BA	-0.000001	-0.001450	-0.158064	-0.138225	-0.081197
GA	-0.000001	-0.001450	-0.158064	-0.138225	-0.081197
HL	-0.001181	-0.002489	-0.107755	0.958763	0.823135
LB	-0.000311	-0.002192	-3.469125	-10.149549	1.404412
HA	0.000000	-0.000770	0.335703	-0.657751	0.585839
HY	-0.003096	-0.000394	-0.303627	0.210525	-0.159362
BN	-0.000564	-0.000588	0.133415	-0.209729	0.014948
WN	-0.000564	-0.000588	0.133415	-0.209729	0.014948
SU	-0.002978	-0.001940	-0.502977	0.141477	0.003549
YP	-0.001839	-0.002217	-0.321777	-0.001645	0.064815
MG	-0.001259	-0.001111	-0.025555	0.149606	0.032438
CT	0.000680	-0.001643	-0.308453	-0.071496	0.265688
MS	-0.002740	-0.000886	0.405735	-0.063579	0.017095
MV	-0.001259	-0.001111	-0.025555	0.149606	0.032438
ML	-0.002740	-0.000886	0.405735	-0.063579	0.017095
AP	-0.001709	-0.000099	-0.872861	-0.078948	-0.023609
MB	-0.001709	-0.000099	-0.872861	-0.078948	-0.023609
WT	-0.000370	-0.000262	-0.023349	2.073647	-2.213173
BG	-0.002482	-0.001013	-0.296628	-0.131968	-0.031596
TS	-0.001087	-0.001185	-0.130105	-0.053688	0.149549
HH	-0.003145	0.000000	-0.422675	-0.236535	0.201149
SD	-0.002389	-0.000797	-0.292680	0.050523	-0.008687
RA	-0.002625	-0.000811	-1.762191	1.202555	0.383865
SY	-0.000252	-0.001608	-0.092471	0.494599	-0.367667
CW	-0.001041	-0.001349	0.075733	-0.601088	-0.757088
BT	-0.001041	-0.001349	0.075733	-0.601088	-0.757088
BC	-0.002494	-0.001904	-0.071719	-0.028196	-0.180664

Species Code	Model Coefficients				
	b_7	b_8	b_9	b_{10}	b_{11}
WO	-0.002807	-0.002269	-0.223273	0.008526	-0.032889
SO	-0.001157	-0.001315	-0.204324	-0.004871	0.048758
SK	-0.003263	-0.001913	-0.312121	0.051221	0.109366
CB	-0.002257	-0.001826	-0.105862	0.191286	-0.324254
TO	-0.002773	-0.002901	-1.084846	-0.196932	0.514630
LK	-0.001526	-0.002253	-0.704548	0.421803	0.296509
OV	-0.001416	-0.002636	-0.666854	-0.977891	-0.311322
BJ	-0.003558	-0.001825	-0.071837	-0.147407	0.241882
SN	-0.004171	-0.001962	-1.251051	-0.342161	0.077775
CK	-0.000299	-0.001711	-0.065269	-0.008808	0.471906
WK	-0.003479	-0.001641	-0.151128	0.073469	-0.165679
CO	-0.001112	-0.001536	-0.133852	-0.056050	0.003947
RO	-0.000908	-0.001131	-0.174932	-0.042528	0.110336
QS	-0.000482	-0.002125	-0.692617	0.176391	0.069174
PO	-0.003306	-0.001375	-0.408878	0.009165	0.054469
BO	-0.002235	-0.000862	-0.307814	-0.033568	0.054762
LO	-0.003217	-0.000779	-0.099727	-0.174200	-0.102828
BK	-0.001858	-0.001674	-0.335364	-0.084806	0.127896
WI	0.000000	-0.001075	-0.135482	-0.083002	0.059529
SS	-0.002593	-0.000345	-0.013340	-0.021681	-0.069965
BD	-0.001236	-0.002875	-0.580068	0.235707	-0.055862
EL	-0.003132	-0.001352	-1.000956	-0.064524	-0.146557
WE	-0.002975	-0.001030	-0.439374	0.272172	0.248287
AE	-0.003114	-0.001524	-0.446461	0.228712	0.069806
RL	-0.001330	-0.002098	0.158824	-0.216082	0.037837
OS	-0.003620	-0.001890	-0.231988	0.077542	-0.025792
OH	-0.003145	0.000000	-0.422675	-0.236535	0.201149
OT	0.000000	-0.002468	-1.080004	0.112883	0.158354

Table 4.7.1.3 *FORTYPE* values by species and forest type groups for the SN variant.

Species Code	Base *FORTYPE*	Forest Type Group Codes						
		FTLOHD	FTNOHD	FTOKPN	FTSFHP	FTUPHD	FTUPOK	FTYLPN
FR	FTUPOK	0.000000	-0.023264	0.294886	-0.271743	-0.004304	0.000000	0.039012
JU	FTUPOK	0.128828	-0.020186	0.054362	0.000000	0.079239	0.000000	0.144288
PI	FTUPOK	0.000000	-0.023264	0.294886	-0.271743	-0.004304	0.000000	0.039012
PU	FTYLPN	1.214007	0.000000	0.751229	0.000000	1.139953	0.239480	0.000000

Species Code	Base *FORTYPE*	Forest Type Group Codes						
		FTLOHD	**FTNOHD**	**FTOKPN**	**FTSFHP**	**FTUPHD**	**FTUPOK**	**FTYLPN**
SP	FTYLPN	0.106418	0.455020	0.017518	0.000000	0.066811	-0.040181	0.000000
SA	FTYLPN	0.325861	0.000000	0.116235	0.000000	0.162020	0.410684	0.000000
SR	FTLOHD	0.000000	0.000000	-0.098950	0.000000	0.072308	-0.055071	-0.236871
LL	FTYLPN	0.048216	0.000000	0.088872	0.000000	0.086720	0.106061	0.000000
TM	FTYLPN	-0.059007	0.325781	0.045370	0.091999	-0.004333	-0.067779	0.000000
PP	FTUPHD	0.000000	-0.110161	-0.010394	0.043707	0.000000	-0.315855	0.116814
PD	FTYLPN	0.187724	0.000000	0.044416	0.000000	0.482241	0.296549	0.000000
WP	FTUPHD	-0.585211	-0.062163	-0.073668	-0.198969	0.000000	0.022013	0.046063
LP	FTYLPN	0.126441	-0.122163	0.050835	0.000000	0.063669	-0.016885	0.000000
VP	FTYLPN	-0.059007	0.325781	0.045370	0.091999	-0.004333	-0.067779	0.000000
BY	FTLOHD	0.000000	-0.050765	-0.201498	0.000000	0.194880	0.081554	-0.324291
PC	FTLOHD	0.000000	0.000000	-0.196837	0.000000	0.000000	0.000000	-0.241760
HM	FTUPOK	0.000000	-0.023264	0.294886	-0.271743	-0.004304	0.000000	0.039012
FM	FTLOHD	0.000000	-0.581137	-0.049388	0.000000	-0.021913	-0.323458	0.304165
BE	FTLOHD	0.000000	0.197314	-0.002307	-0.361488	0.213336	-0.003385	-0.252234
RM	FTLOHD	0.000000	-0.008575	-0.091712	-0.226500	-0.115718	-0.233899	-0.000042
SV	FTLOHD	0.000000	-0.008575	-0.091712	-0.226500	-0.115718	-0.233899	-0.000042
SM	FTUPOK	0.177698	0.081088	-0.007830	0.268289	0.018085	0.000000	-0.969059
BU	FTNOHD	0.276485	0.000000	0.000000	0.000000	-0.158379	-0.066001	0.000000
BB	FTLOHD	0.000000	-0.090106	-0.211483	-0.112850	-0.150287	-0.229603	-0.122245
SB	FTLOHD	0.000000	-0.090106	-0.211483	-0.112850	-0.150287	-0.229603	-0.122245
AH	FTLOHD	0.000000	0.107053	-0.184779	0.000000	-0.144979	-0.125931	-0.023984
HI	FTUPOK	0.307092	0.127121	0.075082	0.163686	0.145813	0.000000	0.091028
CA	FTLOHD	0.000000	0.000000	-0.122639	0.000000	-0.227215	0.428371	-0.127654
HB	FTLOHD	0.000000	-0.020917	-0.227013	0.000000	-0.046600	-0.142184	-0.373160
RD	FTUPHD	-0.131762	-0.159125	0.081533	0.000000	0.000000	-0.091293	0.005318
DW	FTUPOK	0.193678	0.080191	0.227760	-0.207255	0.123444	0.000000	0.395749
PS	FTYLPN	0.140335	0.008246	-0.030083	0.000000	0.064726	-0.063738	0.000000
AB	FTUPOK	0.139891	0.094979	0.112394	0.191476	0.098473	0.000000	0.301892
AS	FTLOHD	0.000000	0.065051	-0.006241	0.243386	0.009788	-0.041769	-0.049053
WA	FTUPOK	0.112081	0.244086	-0.042491	0.000000	0.199271	0.000000	0.256243
BA	FTLOHD	0.000000	0.003456	-0.108803	0.000000	-0.018640	-0.085510	-0.279440
GA	FTLOHD	0.000000	0.003456	-0.108803	0.000000	-0.018640	-0.085510	-0.279440
HL	FTLOHD	0.000000	0.000000	-0.228299	0.000000	-0.170453	-0.178680	-0.343244
LB	FTLOHD	0.000000	0.000000	-0.063217	0.000000	-0.297261	0.000000	0.065035
HA	FTUPOK	0.000000	-0.063207	0.000000	0.000000	-0.111645	0.000000	0.000000

Species Code	Base *FORTYPE*	Forest Type Group Codes						
		FTLOHD	FTNOHD	FTOKPN	FTSFHP	FTUPHD	FTUPOK	FTYLPN
HY	FTLOHD	0.000000	-0.003095	-0.007689	0.000000	-0.082245	-0.187742	-0.008297
BN	FTUPHD	0.163749	-0.176854	-0.164651	-0.557302	0.000000	-0.156488	-0.232630
WN	FTUPHD	0.163749	-0.176854	-0.164651	-0.557302	0.000000	-0.156488	-0.232630
SU	FTLOHD	0.000000	0.057604	-0.090836	0.491153	-0.155894	-0.168272	0.058458
YP	FTUPHD	0.083904	0.057388	-0.055234	-0.499954	0.000000	-0.090655	0.053935
MG	FTLOHD	0.000000	-0.326815	-0.017682	0.000000	-0.029526	-0.096994	-0.031043
CT	FTUPOK	-0.295834	0.049636	-0.353219	0.000000	0.008351	0.000000	-0.627226
MS	FTLOHD	0.000000	-0.153348	0.183663	-0.024673	0.055907	0.109578	0.052422
MV	FTLOHD	0.000000	-0.326815	-0.017682	0.000000	-0.029526	-0.096994	-0.031043
ML	FTLOHD	0.000000	-0.153348	0.183663	-0.024673	0.055907	0.109578	0.052422
AP	FTLOHD	0.000000	-0.357484	0.010020	0.000000	-0.023979	-0.024950	0.272524
MB	FTLOHD	0.000000	-0.357484	0.010020	0.000000	-0.023979	-0.024950	0.272524
WT	FTLOHD	0.000000	0.000000	-0.203627	0.000000	0.066993	0.696768	0.045531
BG	FTUPOK	0.114656	0.063092	0.076702	-0.447981	0.111483	0.000000	0.229180
TS	FTLOHD	0.000000	0.580807	-0.116496	0.000000	-0.110740	-0.195302	0.006188
HH	FTLOHD	0.000000	-0.154634	-0.087145	0.000000	-0.071133	-0.204189	0.120468
SD	FTUPOK	0.076657	0.352409	0.079881	-0.131538	-0.023003	0.000000	0.300435
RA	FTLOHD	0.000000	-1.199357	-0.022774	0.000000	0.060206	0.390875	-0.045807
SY	FTLOHD	0.000000	-0.019656	-0.262507	0.000000	-0.150643	-0.161551	-0.239422
CW	FTLOHD	0.000000	0.000000	-0.122639	0.000000	-0.227215	0.428371	-0.127654
BT	FTLOHD	0.000000	0.000000	-0.122639	0.000000	-0.227215	0.428371	-0.127654
BC	FTUPOK	0.181563	0.303382	0.162524	0.000000	0.146052	0.000000	0.203538
WO	FTUPOK	0.214921	0.196181	0.106951	0.210088	0.100081	0.000000	0.154886
SO	FTUPOK	0.081994	0.174080	0.073767	-0.126888	0.089055	0.000000	0.015718
SK	FTUPOK	0.148989	0.201455	0.055742	0.000000	0.068460	0.000000	0.047989
CB	FTLOHD	0.000000	0.130043	-0.065943	0.000000	-0.066026	-0.114309	-0.023093
TO	FTUPOK	-0.049627	0.000000	0.167384	0.000000	0.099290	0.000000	0.184647
LK	FTLOHD	0.000000	-0.127737	0.029504	0.000000	-0.053091	0.012219	0.030690
OV	FTLOHD	0.000000	-0.924265	-0.183514	0.000000	-0.083244	-0.057771	-0.076588
BJ	FTUPOK	-0.123167	0.000000	0.000279	0.000000	0.170335	0.000000	-0.096186
SN	FTLOHD	0.000000	-0.286340	0.076760	0.000000	0.037457	0.010126	0.088233
CK	FTUPOK	0.086112	0.035396	0.021275	0.000000	0.111528	0.000000	-0.518898
WK	FTLOHD	0.000000	0.044529	-0.042926	0.000000	-0.088049	-0.085910	-0.068603
CO	FTUPOK	0.237228	0.136033	0.030761	-0.238190	0.096751	0.000000	0.053589
RO	FTUPOK	0.103731	0.207951	0.010721	-0.023986	0.138142	0.000000	0.052338
QS	FTUPOK	0.139953	0.207603	0.009285	0.000000	0.132520	0.000000	0.219845

Species Code	Base *FORTYPE*	Forest Type Group Codes						
		FTLOHD	FTNOHD	FTOKPN	FTSFHP	FTUPHD	FTUPOK	FTYLPN
PO	FTUPOK	0.268975	0.482744	0.042786	0.000000	0.090618	0.000000	0.056597
BO	FTUPOK	0.049693	0.272007	0.034224	-0.104624	0.071804	0.000000	-0.044373
LO	FTLOHD	0.000000	0.000000	0.074099	0.000000	0.061718	0.229807	-0.043042
BK	FTUPHD	0.138241	0.117354	-0.097572	0.000000	0.000000	-0.083039	-0.046524
WI	FTLOHD	0.000000	0.000000	0.001536	0.000000	0.019648	0.165022	-0.001371
SS	FTUPHD	-0.058475	0.013995	-0.139506	0.414214	0.000000	-0.166983	-0.018172
BD	FTNOHD	0.067203	0.000000	0.008236	0.000000	-0.033491	0.012197	0.148520
EL	FTLOHD	0.000000	-0.005493	-0.263842	0.000000	-0.054579	-0.202033	0.071996
WE	FTUPOK	0.211919	0.112610	0.174149	0.000000	0.168458	0.000000	0.364012
AE	FTLOHD	0.000000	-0.221068	-0.019557	0.000000	-0.210607	-0.237209	0.137175
RL	FTLOHD	0.000000	-0.232430	-0.086137	0.000000	-0.073558	-0.242294	0.177563
OS	FTUPOK	0.128828	-0.020186	0.054362	0.000000	0.079239	0.000000	0.144288
OH	FTLOHD	0.000000	-0.154634	-0.087145	0.000000	-0.071133	-0.204189	0.120468
OT	NONE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 4.7.1.4 Forest type mapping by forest type group of the diameter increment model for the SN variant.

Forest Type Group Code	Forest Type Group Name	FIA Forest Types (see Appendix B, Dixon 2002)
FTLOHD	Lowland Hardwoods	168, 508, 601, 602, 605, 606, 607, 608, 702, 703, 704, 705, 706, 708
FTNOHD	Northern Hardwoods	701, 801, 805
FTOKPN	Oak – Pine	165, 403, 404, 405, 406, 407, 409
FTSFHP	Spruce – Fir – Hemlock – Pine	104, 105, 121, 124
FTUPHD	Upland Hardwoods	103, 167, 181, 401, 402, 506, 511, 512, 513, 519, 520, 802, 807, 809
FTUPOK	Upland Oak	501, 502, 503, 504, 505, 510, 514, 515
FTYLPN	Yellow Pine	141, 142, 161, 162, 163, 164, 166

Table 4.7.1.5 *ECOUNIT* values by species and ecological unit group for the SN variant.

Species Code	Base ECOUNIT	Model Coefficients[1]					
		M221	M222	M231	221	222	231T
FR	M221	0.000000	0.000000	0.000000	-0.121082	0.000000	0.022498
JU	231T	0.131771	0.217904	0.436986	0.083896	-0.005539	0.000000
PI	M221	0.000000	0.000000	0.000000	-0.121082	0.000000	0.022498
PU	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SP	231L	-0.569409	-0.252741	-0.265699	-0.694484	-0.285112	-0.504565
SA	232	0.000000	0.000000	0.000000	0.000000	0.000000	-0.025549

Species Code	Base ECOUNIT	Model Coefficients[1]					
		M221	M222	M231	221	222	231T
SR	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
LL	232	0.000000	0.000000	0.000000	0.000000	0.000000	-0.175073
TM	231T	-0.157516	0.000000	0.000000	-0.107642	-0.034553	0.000000
PP	M221	0.000000	0.000000	0.000000	0.020105	-0.297952	0.236656
PD	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
WP	M221	0.000000	0.000000	0.000000	-0.065630	-0.450665	0.102041
LP	232	-0.069716	0.581967	0.790149	-0.584818	-0.364073	-0.183317
VP	231T	-0.157516	0.000000	0.000000	-0.107642	-0.034553	0.000000
BY	232	0.000000	0.000000	0.000000	0.000000	0.230225	0.457755
PC	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
HM	M221	0.000000	0.000000	0.000000	-0.121082	0.000000	0.022498
FM	231T	0.000000	0.044974	-0.121719	0.000000	0.289979	0.000000
BE	234	-0.202911	-0.354429	0.371150	-0.282925	-0.250799	-0.351211
RM	232	-0.010003	-0.157820	-0.046780	0.171661	0.170429	-0.031739
SV	232	-0.010003	-0.157820	-0.046780	0.171661	0.170429	-0.031739
SM	222	-0.074887	-0.216260	0.000000	0.064792	0.000000	-0.207182
BU	M221	0.000000	0.000000	0.000000	0.168179	0.024888	0.029753
BB	M221	0.000000	0.379877	-0.528365	0.306760	0.167634	0.178981
SB	M221	0.000000	0.379877	-0.528365	0.306760	0.167634	0.178981
AH	232	-0.260665	-0.170424	-0.314804	-0.114680	0.043550	-0.090864
HI	231T	0.034070	-0.221662	-0.172720	0.042510	-0.012725	0.000000
CA	234	0.000000	0.000000	0.000000	0.000000	-0.010636	-0.380297
HB	234	-0.435211	-0.117993	-0.495339	-0.347813	-0.336521	-0.325780
RD	231T	0.147356	0.184427	-0.070292	0.281057	0.322736	0.000000
DW	231T	0.101205	0.352912	0.166296	0.233779	0.104553	0.000000
PS	232	0.111933	-0.023333	0.289483	0.480859	0.215139	-0.049742
AB	232	-0.191377	-0.370162	-0.181571	-0.105676	0.093229	0.006941
AS	232	0.424837	0.000000	0.000000	-0.181787	0.000000	0.073246
WA	222	-0.082465	-0.149061	-0.241677	-0.146698	0.000000	-0.208643
BA	234	0.146900	-0.443396	-0.448423	-0.133024	-0.079056	-0.119819
GA	234	0.146900	-0.443396	-0.448423	-0.133024	-0.079056	-0.119819
HL	234	-0.256637	-0.149473	0.047390	-0.341690	-0.215198	-0.396963
LB	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
HA	M221	0.000000	0.000000	0.000000	0.000000	0.000000	-0.211742
HY	232	-0.126229	0.000000	0.000000	-0.278119	-0.179796	0.019636
BN	222	-0.071073	0.374367	-0.058790	-0.072556	0.000000	-0.015672
WN	222	-0.071073	0.374367	-0.058790	-0.072556	0.000000	-0.015672
SU	232	0.214847	-0.027123	-0.098745	0.311384	0.203471	-0.034773
YP	231T	-0.035012	0.000000	0.000000	0.114831	0.255257	0.000000

Species Code	Base ECOUNIT	Model Coefficients[1]					
		M221	M222	M231	221	222	231T
MG	232	-1.721210	0.000000	0.000000	-0.438669	0.000000	-0.316872
CT	M221	0.000000	-0.333954	0.000000	0.326227	-0.158005	-0.089037
MS	232	-0.184013	-0.708021	0.000000	-0.947356	0.000000	-0.256347
MV	232	-1.721210	0.000000	0.000000	-0.438669	0.000000	-0.316872
ML	232	-0.184013	-0.708021	0.000000	-0.947356	0.000000	-0.256347
AP	231L	0.352576	0.128982	0.243569	0.269060	0.000219	-0.253490
MB	231L	0.352576	0.128982	0.243569	0.269060	0.000219	-0.253490
WT	232	0.000000	0.000000	0.000000	0.000000	0.186240	-1.048379
BG	232	-0.014903	-0.266804	-0.251634	-0.000477	0.058798	-0.116789
TS	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.018150
HH	232	-0.041534	0.130420	0.212883	0.110701	-0.130543	-0.025850
SD	231T	0.012432	0.000000	0.000000	0.160384	0.079502	0.000000
RA	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
SY	234	-0.308437	-0.468897	-0.573635	-0.163987	-0.291934	-0.312825
CW	234	0.000000	0.000000	0.000000	0.000000	-0.010636	-0.380297
BT	234	0.000000	0.000000	0.000000	0.000000	-0.010636	-0.380297
BC	231T	0.290593	0.163528	-0.111387	0.060201	0.089278	0.000000
WO	231T	-0.191164	-0.155148	-0.154994	-0.063321	-0.031876	0.000000
SO	231T	-0.258781	0.000000	0.000000	-0.063421	-0.023554	0.000000
SK	231L	-0.294531	-0.267829	-0.113549	-0.146202	-0.078697	-0.142921
CB	231L	-0.303022	-0.568197	-0.001804	-0.301395	-0.106435	-0.139157
TO	232	0.000000	0.000000	0.000000	0.000000	0.000000	-0.141504
LK	232	0.000000	0.000000	0.000000	0.000000	0.000000	-0.184740
OV	234	0.000000	0.000000	-0.506825	0.000000	0.074902	-0.083491
BJ	232	-0.172582	0.107373	-0.084775	0.127193	-0.066699	-0.052485
SN	232	-0.252410	0.000000	-0.278470	-0.201638	0.222377	-0.053375
CK	222	-0.039862	-0.110433	-0.170239	0.024645	0.000000	0.126865
WK	232	0.197053	0.108061	-0.061415	-0.343207	-0.056293	-0.113493
CO	M221	0.000000	0.000000	0.000000	0.151380	0.200026	0.204279
RO	M221	0.000000	0.023769	0.058308	0.043448	0.036206	0.132129
QS	231L	-0.854641	-0.590369	-0.160338	-0.190715	-0.329148	-0.237106
PO	231L	-0.042633	-0.252560	-0.243734	-0.162999	-0.160463	-0.048463
BO	222	-0.122266	-0.144853	-0.163130	0.021869	0.000000	-0.048649
LO	232	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
BK	M221	0.000000	-0.174431	0.170467	0.016664	0.035772	0.047888
WI	234	-0.316154	0.000000	0.000000	-0.360580	0.031358	0.151013
SS	222	-0.109616	0.068664	-0.981901	-0.066394	0.000000	-0.153195
BD	M221	0.000000	0.022312	0.378775	0.195305	0.106462	-0.145798
EL	231T	0.340206	-0.330585	0.261703	0.431384	-0.107188	0.000000

Species Code	Base ECOUNIT	Model Coefficients[1]					
		M221	M222	M231	221	222	231T
WE	231L	0.117770	-0.235842	-0.435920	-0.036156	-0.229106	0.125704
AE	234	-0.312702	-0.097041	-0.361568	-0.127373	-0.293653	-0.413743
RL	231L	-0.167102	-0.292978	0.084842	-0.229308	-0.287173	-0.014656
OS	231T	0.131771	0.217904	0.436986	0.083896	-0.005539	0.000000
OH	232	-0.041534	0.130420	0.212883	0.110701	-0.130543	-0.025850
OT	NONE	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

1 - Mapping of ecological unit codes (subsection level) into the *ECOUNIT* groups is found in Appendix A.

Table 4.7.1.6 *ECOUNIT* values by species and ecological unit group for the SN variant.

Species Code	Base ECOUNIT	Model Coefficients				
		231L	232	234	255	411
FR	M221	-0.097721	0.000000	0.000000	0.000000	0.000000
JU	231T	0.490740	0.399497	0.938548	1.088152	0.000000
PI	M221	-0.097721	0.000000	0.000000	0.000000	0.000000
PU	232	0.000000	0.000000	0.000000	0.000000	0.000000
SP	231L	0.000000	-0.113258	0.114097	0.092458	0.000000
SA	232	0.324111	0.000000	0.306793	0.000000	-0.342293
SR	232	-0.155764	0.000000	-0.112223	0.000000	0.000000
LL	232	-0.067793	0.000000	0.123262	0.000000	0.000000
TM	231T	0.025073	-0.150946	0.000000	0.000000	0.000000
PP	M221	0.000000	0.000000	0.000000	0.000000	0.000000
PD	232	0.000000	0.000000	0.000000	0.000000	-0.205608
WP	M221	0.000000	0.000000	0.000000	0.000000	0.000000
LP	232	0.256273	0.000000	0.281790	0.274618	0.000000
VP	231T	0.025073	-0.150946	0.000000	0.000000	0.000000
BY	232	0.154525	0.000000	0.021935	0.288209	-0.033047
PC	232	0.000000	0.000000	0.000000	0.000000	0.156623
HM	M221	-0.097721	0.000000	0.000000	0.000000	0.000000
FM	231T	0.416909	0.163106	0.451765	0.000000	0.000000
BE	234	-0.156560	-0.233523	0.000000	-0.011673	0.000000
RM	232	0.111637	0.000000	0.283893	0.000000	-0.340066
SV	232	0.111637	0.000000	0.283893	0.000000	-0.340066
SM	222	-0.145892	0.707850	0.289780	0.000000	0.000000
BU	M221	0.000000	0.000000	0.000000	0.000000	0.000000
BB	M221	0.365419	0.236959	0.417591	1.151813	0.000000
SB	M221	0.365419	0.236959	0.417591	1.151813	0.000000
AH	232	0.087924	0.000000	0.215406	0.000000	0.000000
HI	231T	0.116846	0.113816	0.183886	0.441744	0.000000
CA	234	-0.091346	-0.145951	0.000000	-0.227224	0.000000

Species Code	Base ECOUNIT	Model Coefficients				
		231L	232	234	255	411
HB	234	-0.130359	-0.212093	0.000000	-0.208957	0.000000
RD	231T	0.452072	0.552309	0.255957	0.576422	0.000000
DW	231T	0.359721	0.093627	0.488202	0.000000	0.000000
PS	232	0.249350	0.000000	0.363787	0.317870	0.000000
AB	232	-0.003611	0.000000	-0.031277	0.000000	0.000000
AS	232	0.000000	0.000000	0.000000	0.000000	-0.795646
WA	222	-0.015617	-0.004213	0.151449	-0.056292	0.000000
BA	234	-0.116966	-0.075746	0.000000	-0.003469	0.000000
GA	234	-0.116966	-0.075746	0.000000	-0.003469	0.000000
HL	234	0.095929	-0.078848	0.000000	0.115297	0.000000
LB	232	0.000000	0.000000	0.000000	0.000000	0.000000
HA	M221	0.000000	0.000000	0.000000	0.000000	0.000000
HY	232	0.163182	0.000000	-0.283774	0.941544	0.000000
BN	222	0.349608	0.255119	0.259162	0.352483	0.000000
WN	222	0.349608	0.255119	0.259162	0.352483	0.000000
SU	232	0.115389	0.000000	0.129382	0.492438	0.000000
YP	231T	0.095383	0.113058	0.111540	0.000000	0.000000
MG	232	0.014928	0.000000	0.161649	0.000000	0.000000
CT	M221	0.587498	0.575938	0.572974	0.000000	0.000000
MS	232	-0.181586	0.000000	0.493509	0.000000	0.000000
MV	232	0.014928	0.000000	0.161649	0.000000	0.000000
ML	232	-0.181586	0.000000	0.493509	0.000000	0.000000
AP	231L	0.000000	-0.119399	0.032415	0.498573	0.000000
MB	231L	0.000000	-0.119399	0.032415	0.498573	0.000000
WT	232	0.031801	0.000000	-0.054588	0.000000	0.000000
BG	232	0.138867	0.000000	-0.031436	0.375820	0.000000
TS	232	0.688179	0.000000	0.202859	0.000000	0.000000
HH	232	0.087497	0.000000	0.018385	0.255056	0.000000
SD	231T	0.295282	0.057285	0.424776	0.000000	0.000000
RA	232	0.712083	0.000000	0.489307	0.000000	-0.147600
SY	234	-0.204430	-0.167438	0.000000	0.122950	0.000000
CW	234	-0.091346	-0.145951	0.000000	-0.227224	0.000000
BT	234	-0.091346	-0.145951	0.000000	-0.227224	0.000000
BC	231T	0.239920	0.125890	0.264833	1.901340	0.000000
WO	231T	0.164710	0.031862	0.089972	0.448682	0.000000
SO	231T	0.067643	0.087098	0.000000	0.000000	0.000000
SK	231L	0.000000	-0.137069	0.044499	0.189435	0.000000
CB	231L	0.000000	0.000058	-0.035715	-0.198361	0.000000
TO	232	0.987526	0.000000	1.109686	1.446041	0.000000

Species Code	Base ECOUNIT	Model Coefficients				
		231L	232	234	255	411
LK	232	0.183278	0.000000	0.238162	0.768121	-1.328540
OV	234	0.045341	0.062981	0.000000	-0.065887	0.000000
BJ	232	0.178459	0.000000	-0.037201	0.380348	-0.741911
SN	232	0.006612	0.000000	0.007600	0.000000	0.000000
CK	222	-0.010615	0.755389	0.471921	0.606309	0.000000
WK	232	0.076125	0.000000	0.122936	0.249718	-0.261750
CO	M221	0.295079	0.085617	0.080911	0.585065	0.000000
RO	M221	0.163239	0.205401	0.433254	0.000000	0.000000
QS	231L	0.000000	-0.089086	-0.190850	-0.036830	0.000000
PO	231L	0.000000	-0.081158	0.159575	0.171401	0.000000
BO	222	0.151382	0.084829	0.369759	-0.051983	0.000000
LO	232	0.000000	0.000000	0.268416	0.000000	-0.639461
BK	M221	0.371885	0.171124	0.240479	0.444606	0.000000
WI	234	-0.120265	-0.059706	0.000000	-0.203095	0.000000
SS	222	0.075592	-0.040417	0.333962	0.393517	0.000000
BD	M221	-0.155027	-0.071987	0.920288	0.644926	0.000000
EL	231T	0.045265	0.036098	-0.318940	0.270984	0.000000
WE	231L	0.000000	0.070072	-0.022479	0.235360	0.000000
AE	234	-0.127535	-0.043112	0.000000	0.119860	0.000000
RL	231L	0.000000	-0.029868	0.210046	-0.360256	0.000000
OS	231T	0.490740	0.399497	0.938548	1.088152	0.000000
OH	232	0.087497	0.000000	0.018385	0.255056	0.000000
OT	NONE	0.000000	0.000000	0.000000	0.000000	0.000000

Table 4.7.1.7 *PLANT* values by species for the SN variant.

Species Code	*PLANT*
PU	0.173758
SA	0.227572
LL	0.110751
WP	0.098090
LP	0.245669

Table 4.7.1.8 *DBHLOW* and *DBHHI* values of the diameter bounding function by species in the SN variant.

Species Code	DBH_{LOW}	DBH_{HI}
FR	26.0	34.0
JU	998.0	999.0
PI	38.0	52.0

Species Code	DBH_{LOW}	DBH_{HI}
MG	32.5	43.0
CT	27.0	72.0
MS	36.5	84.0

Species Code	DBH_{LOW}	DBH_{HI}
PU	18.9	24.0
SP	998.0	999.0
SA	998.0	999.0
SR	32.6	48.0
LL	998.0	999.0
TM	18.7	28.0
PP	24.2	40.0
PD	28.7	40.0
WP	998.0	999.0
LP	998.0	999.0
VP	998.0	999.0
BY	79.8	144.0
PC	998.0	999.0
HM	39.3	84.0
FM	26.1	34.0
BE	26.7	60.0
RM	998.0	999.0
SV	998.0	999.0
SM	998.0	999.0
BU	998.0	999.0
BB	38.4	54.0
SB	998.0	999.0
AH	17.3	27.0
HI	998.0	999.0
CA	46.5	144.0
HB	32.9	60.0
RD	11.3	13.4
DW	9.7	12.0
PS	22.4	27.0
AB	42.8	60.0
AS	30.7	60.0
WA	33.4	84.0
BA	36.0	48.0
GA	37.0	48.0
HL	33.2	72.0
LB	28.1	33.4
HA	20.5	36.0
HY	998.0	999.0
BN	30.0	36.0
WN	32.9	96.0

Species Code	DBH_{LOW}	DBH_{HI}
MV	32.5	43.0
ML	36.5	84.0
AP	21.2	22.0
MB	23.6	30.0
WT	63.8	89.0
BG	998.0	999.0
TS	33.0	60.0
HH	18.6	24.0
SD	16.7	24.0
RA	19.2	36.0
SY	56.6	125.0
CW	46.5	144.0
BT	48.0	60.0
BC	26.9	84.0
WO	998.0	999.0
SO	34.5	48.0
SK	42.3	84.0
CB	46.2	84.0
TO	17.2	26.0
LK	48.1	84.0
OV	48.0	60.0
BJ	22.7	27.0
SN	47.2	108.0
CK	37.2	72.0
WK	47.6	72.0
CO	998.0	999.0
RO	998.0	999.0
QS	40.6	96.0
PO	38.9	52.0
BO	998.0	999.0
LO	58.8	69.0
BK	30.8	60.0
WI	38.8	60.0
SS	25.6	31.6
BD	998.0	999.0
EL	31.4	38.0
WE	23.9	27.0
AE	46.7	130.0
RL	35.8	80.0
OS	24.1	29.0

Species Code	DBH_{LOW}	DBH_{HI}
SU	39.6	60.0
YP	998.0	999.0

Species Code	DBH_{LOW}	DBH_{HI}
OH	998.0	999.0
OT	20.5	25.0

4.7.2 Large Tree Height Growth

In the SN variant, the large-tree height growth model follows the approach of Wensel and others (1987) where the potential height growth is calculated for every tree and modified based on individual tree crown ratio and relative height in the stand using equation {4.7.2.1}. Potential height growth is calculated using the methodology described in the small-tree height increment model.

The crown ratio modifying function uses Hoerl's Special Function (HSF) form (Cuthbert and Wood 1971, p. 23) identified in equation {4.7.2.2} with a range of 0.0 to 1.0. The a-c parameters are chosen so that height growth is maximized for crown ratios between 45 and 75%.

{4.7.2.1} *HTG* = *POTHTG* * (0.25 * *HGMDCR* + 0.75 * *HGMDRH*)

{4.7.2.2} *HGMDCR* = 100 * *CR*^3.0 * exp(-5.0*CR)

where:

HTG is periodic height growth
POTHTG is the potential periodic height growth, see section 4.6.1.
HGMDCR is the crown ratio modifier (bounded to *HGMDCR* < 1.0)
HGMDRH is the relative height modifier
CR is crown ratio expressed as a proportion

The relative height modifying function (HGMDRH) is based on the height of the tree record compared to the top height of the stand, adjusted for shade tolerance. The modifying function is based on the Generalized Chapman-Richards function (Donnelly and Betters 1991, Donnelly and others 1992, and Pienaar and Turnbull 1973), whose parameters are set to attenuate height growth based on relative height and shade tolerance, see equation {4.7.2.3} – {4.7.2.7}. Coefficients for these equations are shown in tables 4.7.2.1 and 4.7.2.2. The modifier value (HGMDRH) decreases with decreasing relative height and species intolerance with a range between 0.0 and 1.0. Height growth reaches an upper asymptote of 1.0 at a relative height of 1.0 for intolerant species and 0.7 for tolerant species.

{4.7.2.3} *FCTRKX* = ((RHK / RHYXS)^(RHM – 1)) – 1

{4.7.2.4} *FCTRRB* = (-1.0 * RHR) / (1 – RHB)

{4.7.2.5} *FCTRXB* = *RELHT*^ (1 – RHB) – RHXS^ (1 – RHB)

{4.7.2.6} *FCTRM* = 1 / (1 – RHM)

{4.7.2.7} *HGMDRH* = RHK * (1 + *FCTRKX* * exp(*FCTRRB***FCTRXB*))^*FCTRM*

where:

RELHT is the subject tree's height relative to the 40 tallest trees in the stand

HGMDRH is the relative height modifier used in equation {4.7.2.1} above
RH… are coefficients based on shade tolerance of a species shown in table 4.7.2.1

Table 4.7.2.1 Shade tolerance coefficients for equations {4.7.2.3} – {4.7.2.7} the SN variant.

Shade Tolerance	RHR	RHYXS	RHM	RHB	RHXS	RHK
Very Tolerant	20	0.20	1.1	-1.10	0	1
Tolerant	16	0.15	1.1	-1.20	0	1
Intermediate	15	0.10	1.1	-1.45	0	1
Intolerant	13	0.05	1.1	-1.60	0	1
Very Intolerant	12	0.01	1.1	-1.60	0	1

Table 4.7.2.2 Shade tolerance by species in the SN variant.

Species Code	Shade Tolerance
FR	Very Tolerant
JU	Intolerant
PI	Tolerant
PU	Intolerant
SP	Intolerant
SA	Intolerant
SR	Very Tolerant
LL	Intolerant
TM	Intolerant
PP	Intolerant
PD	Intolerant
WP	Intermediate
LP	Intolerant
VP	Intolerant
BY	Intermediate
PC	Intermediate
HM	Very Tolerant
FM	Tolerant
BE	Tolerant
RM	Tolerant
SV	Tolerant
SM	Very Tolerant
BU	Tolerant
BB	Intolerant
SB	Intolerant
AH	Very Tolerant
HI	Intermediate

Species Code	Shade Tolerance
MG	Tolerant
CT	Intermediate
MS	Tolerant
MV	Intermediate
ML	Tolerant
AP	Intolerant
MB	Tolerant
WT	Intolerant
BG	Tolerant
TS	Intolerant
HH	Tolerant
SD	Tolerant
RA	Tolerant
SY	Intermediate
CW	Very Intolerant
BT	Very Intolerant
BC	Intolerant
WO	Intermediate
SO	Very Intolerant
SK	Intermediate
CB	Intolerant
TO	Intolerant
LK	Tolerant
OV	Intermediate
BJ	Intolerant
SN	Intolerant
CK	Intolerant

Species Code	Shade Tolerance
CA	Intolerant
HB	Intermediate
RD	Tolerant
DW	Very Tolerant
PS	Very Tolerant
AB	Very Tolerant
AS	Tolerant
WA	Intolerant
BA	Intolerant
GA	Tolerant
HL	Intolerant
LB	Tolerant
HA	Tolerant
HY	Very Tolerant
BN	Intolerant
WN	Intolerant
SU	Intolerant
YP	Intolerant

Species Code	Shade Tolerance
WK	Intolerant
CO	Intermediate
RO	Intermediate
QS	Intolerant
PO	Intolerant
BO	Intermediate
LO	Intermediate
BK	Very Intolerant
WI	Very Intolerant
SS	Intolerant
BD	Tolerant
EL	Intermediate
WE	Tolerant
AE	Intermediate
RL	Tolerant
OS	Intermediate
OH	Intermediate
OT	Intermediate

5.0 Mortality Model

The SN variant uses an SDI-based mortality model as described in Section 7.3.2 of Essential FVS: A User's Guide to the Forest Vegetation Simulator (Dixon 2002, referred to as EFVS). This SDI-based mortality model is comprised of two steps: 1) determining the amount of stand mortality (section 7.3.2.1 of EFVS) and 2) dispersing stand mortality to individual tree records (section7.3.2.2 of EFVS). In determining the amount of stand mortality, the summation of individual tree background mortality rates is used when stand density is below the minimum level for density dependent mortality (default is 55% of maximum SDI), while stand level density-related mortality rates are used when stands are above this minimum level.

The equation used to calculate individual tree background mortality rates for all species is shown in equation {5.0.1}, and this is then adjusted to the length of the cycle by using a compound interest formula as shown in equation {5.0.2}. Coefficients for these equations are shown in table 5.0.1. The overall amount of mortality calculated for the stand is the summation of the final mortality rate (*RIP*) across all live tree records.

{5.0.1} $RI = [1 / (1 + \exp(p_0 + p_1 * DBH))]$

{5.0.2} $RIP = 1 – (1 – RI)^Y$

where:

RI	is the proportion of the tree record attributed to mortality
RIP	is the final mortality rate adjusted to the length of the cycle
DBH	is tree diameter at breast height
Y	is length of the current projection cycle in years
p_0 and p_1	are species-specific coefficients shown in table 5.0.1

Table 5.0.1 Coefficients used in the background mortality equation {5.0.1} in the SN variant.

Species Code	p_0	p_1
FR	5.1676998	-0.0077681
JU	9.6942997	-0.0127328
PI	5.1676998	-0.0077681
PU	5.5876999	-0.0053480
SP	5.5876999	-0.0053480
SA	5.5876999	-0.0053480
SR	5.1676998	-0.0077681
LL	5.5876999	-0.0053480
TM	5.5876999	-0.0053480
PP	5.5876999	-0.0053480
PD	5.5876999	-0.0053480
WP	5.5876999	-0.0053480
LP	5.5876999	-0.0053480
VP	5.5876999	-0.0053480
BY	5.5876999	-0.0053480
MG	5.1676998	-0.0077681
CT	5.9617000	-0.0340128
MS	5.1676998	-0.0077681
MV	5.9617000	-0.0340128
ML	5.1676998	-0.0077681
AP	5.9617000	-0.0340128
MB	5.1676998	-0.0077681
WT	5.9617000	-0.0340128
BG	5.1676998	-0.0077681
TS	5.9617000	-0.0340128
HH	5.1676998	-0.0077681
SD	5.1676998	-0.0077681
RA	5.1676998	-0.0077681
SY	5.9617000	-0.0340128
CW	5.9617000	-0.0340128

PC	5.5876999	-0.0053480		BT	5.9617000	-0.0340128
HM	5.1676998	-0.0077681		BC	5.9617000	-0.0340128
FM	5.1676998	-0.0077681		WO	5.9617000	-0.0340128
BE	5.1676998	-0.0077681		SO	5.9617000	-0.0340128
RM	5.1676998	-0.0077681		SK	5.9617000	-0.0340128
SV	5.1676998	-0.0077681		CB	5.9617000	-0.0340128
SM	5.1676998	-0.0077681		TO	5.9617000	-0.0340128
BU	5.1676998	-0.0077681		LK	5.1676998	-0.0077681
BB	5.9617000	-0.0340128		OV	5.9617000	-0.0340128
SB	5.1676998	-0.0077681		BJ	5.9617000	-0.0340128
AH	5.1676998	-0.0077681		SN	5.9617000	-0.0340128
HI	5.9617000	-0.0340128		CK	5.9617000	-0.0340128
CA	5.9617000	-0.0340128		WK	5.9617000	-0.0340128
HB	5.9617000	-0.0340128		CO	5.9617000	-0.0340128
RD	5.1676998	-0.0077681		RO	5.9617000	-0.0340128
DW	5.1676998	-0.0077681		QS	5.9617000	-0.0340128
PS	5.1676998	-0.0077681		PO	5.9617000	-0.0340128
AB	5.1676998	-0.0077681		BO	5.9617000	-0.0340128
AS	5.1676998	-0.0077681		LO	5.9617000	-0.0340128
WA	5.9617000	-0.0340128		BK	5.1676998	-0.0077681
BA	5.9617000	-0.0340128		WI	5.1676998	-0.0077681
GA	5.1676998	-0.0077681		SS	5.1676998	-0.0077681
HL	5.9617000	-0.0340128		BD	5.1676998	-0.0077681
LB	5.1676998	-0.0077681		EL	5.1676998	-0.0077681
HA	5.1676998	-0.0077681		WE	5.1676998	-0.0077681
HY	5.1676998	-0.0077681		AE	5.1676998	-0.0077681
BN	5.9617000	-0.0340128		RL	5.1676998	-0.0077681
WN	5.9617000	-0.0340128		OS	5.5876999	-0.0053480
SU	5.9617000	-0.0340128		OH	5.9617000	-0.0340128
YP	5.9617000	-0.0340128		OT	5.9617000	-0.0340128

When stand density-related mortality is in effect, the total amount of stand mortality is determined based on the trajectory developed from the relationship between stand SDI and the maximum SDI for the stand. This is explained in section 7.3.2.1 of EFVS.

Once the amount of stand mortality is determined based on either the summation of background mortality rates or density-related mortality rates, mortality is dispersed to individual tree records in relation to a tree's height relative to the average stand height (*RELHT*) using equation {5.0.3}. This value is then adjusted by a species-specific mortality modifier representing the species shade tolerance shown in equation {5.0.4}.

The mortality model makes multiple passes through the tree records multiplying a record's trees-per-acre value times the final mortality rate (*MORT*), accumulating the results, and reducing the trees-per-acre representation until the desired mortality level has been reached. If the stand still exceeds the basal area maximum sustainable on the site the mortality rates are proportionally adjusted to reduce the stand to the specified basal area maximum.

{5.0.3} $MR = 0.84525 – (0.01074 * PCT_i) + (0.0000002 * PCT_i\text{^}3)$

{5.0.4} $MORT = MR * (MWT) * 0.1$

where:

MR	is the proportion of the tree record attributed to mortality (bounded: $0.01 \leq MR \leq 1$)
PCT_i	is tree percentile in the distribution of stand basal area
MORT	is the final mortality rate of the tree record
MWT	is a mortality weight value shown in Table 5.0.2

Table 5.0.2 *MWT* values for the mortality equation {5.0.4} in the SN variant.

Species Code	*MWT*	Species Code	*MWT*	Species Code	*MWT*
FR	0.1	DW	0.1	BT	0.9
JU	0.7	PS	0.1	BC	0.7
PI	0.3	AB	0.1	WO	0.5
PU	0.7	AS	0.3	SO	0.9
SP	0.7	WA	0.7	SK	0.5
SA	0.7	BA	0.7	CB	0.7
SR	0.1	GA	0.3	TO	0.7
LL	0.7	HL	0.7	LK	0.3
TM	0.7	LB	0.3	OV	0.5
PP	0.7	HA	0.3	BJ	0.7
PD	0.7	HY	0.1	SN	0.7
WP	0.5	BN	0.7	CK	0.7
LP	0.7	WN	0.7	WK	0.7
VP	0.7	SU	0.7	CO	0.5
BY	0.5	YP	0.7	RO	0.5
PC	0.5	MG	0.3	QS	0.7
HM	0.1	CT	0.5	PO	0.7
FM	0.3	MS	0.3	BO	0.5
BE	0.3	MV	0.5	LO	0.5
RM	0.3	ML	0.3	BK	0.9
SV	0.3	AP	0.7	WI	0.9
SM	0.1	MB	0.3	SS	0.7
BU	0.3	WT	0.7	BD	0.3
BB	0.7	BG	0.3	EL	0.5
SB	0.7	TS	0.7	WE	0.3
AH	0.1	HH	0.3	AE	0.5
HI	0.5	SD	0.3	RL	0.3

Species Code	*MWT*
CA	0.7
HB	0.5
RD	0.3

Species Code	*MWT*
RA	0.3
SY	0.5
CW	0.9

Species Code	*MWT*
OS	0.5
OH	0.5
OT	0.5

6.0 Regeneration

The SN variant contains a partial establishment model which may be used to input regeneration and ingrowth into simulations. A more detailed description of how the partial establishment model works can be found in section 5.4.5 of the Essential FVS Guide (Dixon 2002).

The regeneration model is used to simulate stand establishment from bare ground, or to bring seedlings and sprouts into a simulation with existing trees. Sprouts are automatically added to the simulation following harvest or burning of known sprouting species, see table 6.0.1.

Table 6.0.1 Regeneration parameters by species in the SN variant.

Species Code	Sprouting Species?	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
FR	No	0.1	0.50	23
JU	No	0.3	2.08	27
PI	No	0.2	0.50	21
PU	No	0.5	1.00	21
SP	Yes	0.5	1.32	22
SA	No	0.5	2.51	20
SR	No	0.5	0.50	24
LL	No	0.5	2.53	18
TM	No	0.5	2.75	18
PP	No	0.5	0.50	17
PD	No	0.5	5.05	22
WP	No	0.4	0.50	20
LP	No	0.5	4.70	20
VP	No	0.5	0.50	20
BY	Yes	0.2	1.33	20
PC	Yes	0.2	1.33	20
HM	No	0.1	0.66	20
FM	Yes	0.2	2.40	20
BE	Yes	0.2	1.35	20
RM	Yes	0.2	1.35	20
SV	Yes	0.2	2.03	20
SM	Yes	0.2	0.50	20
BU	Yes	0.3	0.50	20
BB	Yes	0.1	0.50	20
SB	Yes	0.1	0.50	20
AH	Yes	0.2	2.08	20
HI	Yes	0.3	0.51	20
CA	Yes	0.3	0.63	20
HB	Yes	0.1	2.08	20

Species Code	Sprouting Species?	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
RD	Yes	0.2	2.08	20
DW	Yes	0.1	2.08	20
PS	Yes	0.2	2.08	20
AB	Yes	0.1	0.50	20
AS	Yes	0.2	0.50	20
WA	Yes	0.2	0.50	20
BA	Yes	0.2	0.92	20
GA	Yes	0.2	0.50	20
HL	Yes	0.1	5.98	20
LB	Yes	0.2	0.94	20
HA	Yes	0.2	2.08	20
HY	Yes	0.1	0.50	20
BN	Yes	0.3	3.28	20
WN	Yes	0.4	3.28	20
SU	Yes	0.2	1.33	20
YP	Yes	0.2	0.89	20
MG	Yes	0.2	1.53	20
CT	Yes	0.2	1.38	20
MS	Yes	0.2	3.59	20
MV	Yes	0.2	3.59	20
ML	Yes	0.2	3.59	20
AP	Yes	0.2	2.08	20
MB	Yes	0.2	2.08	20
WT	Yes	0.2	4.15	20
BG	Yes	0.2	3.59	20
TS	Yes	0.2	3.59	20
HH	Yes	0.2	2.08	20
SD	Yes	0.2	2.08	20
RA	No	0.2	2.08	20
SY	Yes	0.1	0.89	20
CW	Yes	0.1	0.50	20
BT	Yes	0.2	0.50	20
BC	Yes	0.1	0.50	20
WO	Yes	0.2	1.38	20
SO	Yes	0.2	1.38	20
SK	Yes	0.1	1.38	20
CB	Yes	0.1	0.50	20
TO	Yes	0.2	2.75	20
LK	Yes	0.1	2.75	20
OV	Yes	0.2	0.50	20

Species Code	Sprouting Species?	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
BJ	Yes	0.2	2.75	20
SN	Yes	0.2	0.50	20
CK	Yes	0.1	1.38	20
WK	Yes	0.1	0.50	20
CO	Yes	0.2	1.38	20
RO	Yes	0.2	1.38	20
QS	Yes	0.1	0.50	20
PO	Yes	0.1	2.75	20
BO	Yes	0.2	1.38	20
LO	Yes	0.2	0.50	20
BK	Yes	0.1	5.98	20
WI	Yes	0.1	4.70	20
SS	Yes	0.1	2.08	20
BD	Yes	0.1	0.55	20
EL	Yes	0.1	0.50	20
WE	Yes	0.1	0.50	20
AE	Yes	0.1	0.50	20
RL	Yes	0.1	0.50	20
OS	No	0.3	2.08	20
OH	No	0.2	2.08	20
OT	No	0.2	2.08	20

The number of sprout records created for each sprouting species is found in table 6.0.2. For more prolific root suckering hardwood species, logic rule {6.0.1} is used to determine the number of sprout records. The trees-per-acre represented by each sprout record is determined using the general sprouting probability equation {6.0.2}. See table 6.0.2 for species-specific sprouting probabilities, number of sprout records created, and reference information.

Users wanting to modify or turn off automatic sprouting can do so with the SPROUT or NOSPROUT keywords, respectively. Sprouts are not subject to maximum and minimum tree heights found in table 6.0.2 and do not need to be grown to the end of the cycle because estimated heights and diameters are end of cycle values.

{6.0.1} For root suckering hardwood species

$DSTMP_i \leq 5$: $NUMSPRC = 1$
$5 < DSTMP_i \leq 10$: $NUMSPRC = \mathrm{NINT}(-1.0 + 0.4 * DSTMP_i)$
$DSTMP_i > 10$: $NUMSPRC = 3$

{6.0.2} $TPA_s = TPA_i * PS$

{6.0.3} $PS = [1 / (1 + \exp(-(b_0 + b_1 * DSTMP_{i\ i}))]$

{6.0.4} $PS = ((57.3 - 0.0032 * (DSTMP_i\text{^}3) / 100)$

{6.0.5} $PS = (1 / (1 + \exp(-(2.3656 - 0.2781 * (DSTMP_i / 0.7801)))))$

{6.0.6} $PS = (1 / (1+\exp(-(-2.8058 + 22.6839 * (1 / ((DSTMP_i / 0.7788) - 0.4403))))))$

where:

$DSTMP_i$	is the diameter at breast height of the parent tree
NUMSPRC	is the number of sprout tree records
NINT	rounds the value to the nearest integer
TPA_s	is the trees per acre represented by each sprout record
TPA_i	is the trees per acre removed/killed represented by the parent tree
PS	is a sprouting probability (see table 6.0.2)
b_0, b_1	are species-specific coefficients

Table 6.0.1 Regeneration parameters by species in the SN variant.

Species Code	Sprouting Probability	b_0	b_1	Number of Sprout Records	Source
SP	0.42 for DBH < 7”, 0 for DBH > 7”			1, 0	Wayne Clatterbuck (personal communication), Ag. Handbook 654
BY	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
PC	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
FM	0.94			1	Keyser and Loftis, 2014
BE	0.94			1	Keyser and Loftis, 2014
RM	{6.0.3}	4.1975	-0.1821	1	Keyser and Loftis, 2014
SV	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
SM	0.73			1	Keyser and Loftis, 2014
BU	0.96			1	Keyser and Loftis, 2014
BB	{6.0.3}	3.3670	-0.5159	1	Keyser and Loftis, 2014
SB	{6.0.3}	3.3670	-0.5159	1	Keyser and Loftis, 2014
AH	0.94			1	Keyser and Loftis, 2014
HI	0.95			1	Keyser and Loftis, 2014
CA	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
HB	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
RD	0.94			1	Keyser and Loftis, 2014
DW	0.94			1	Keyser and Loftis, 2014
PS	0.94			1	Keyser and Loftis, 2014
AB	0.93			{6.0.1}	Keyser and Loftis, 2014
AS	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
WA	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BA	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
GA	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
HL	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
LB	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
HA	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
HY	0.94			1	Keyser and Loftis, 2014

Species Code	Sprouting Probability	b_0	b_1	Number of Sprout Records	Source
BN	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
WN	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
SU	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
YP	0.79			1	Keyser and Loftis, 2014
MG	0.95			1	Keyser and Loftis, 2014
CT	0.69			1	Keyser and Loftis, 2014
MS	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
MV	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
ML	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
AP	0.94			1	Keyser and Loftis, 2014
MB	0.94			1	Keyser and Loftis, 2014
WT	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BG	0.72			1	Keyser and Loftis, 2014
TS	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
HH	0.94			1	Keyser and Loftis, 2014
SD	0.97			1	Keyser and Loftis, 2014
SY	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
CW	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BT	{6.0.3}	2.7386	-0.1076	{6.0.1}	Keyser and Loftis, 2014
BC	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
WO	{6.0.3}	2.4608	-0.3093	1	Keyser and Loftis, 2014
SO	{6.0.3}	3.8897	-0.2260	1	Keyser and Loftis, 2014
SO*	{6.0.4}			1	Johnson 1975 Ag. Handbook 654
SK	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
CB	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
CB*	{6.0.4}			1	Johnson 1975 Ag. Handbook 654
TO	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
LK	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
OV	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BJ	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BJ*	{6.0.5}			1	Johnson 1977 Ag. Handbook 654
SN	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
CK	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
WK	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
CO	0.78			1	Keyser and Loftis, 2014
RO	{6.0.3}	3.2586	-0.1120	1	Keyser and Loftis, 2014
RO*	{6.0.4}			1	Johnson 1975

Species Code	Sprouting Probability	b_0	b_1	Number of Sprout Records	Source
					Ag. Handbook 654
QS	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
PO	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
PO*	{6.0.6}			1	Johnson 1977 Ag. Handbook 654
BO	{6.0.3}	3.1070	-0.2128	1	Keyser and Loftis, 2014
LO	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
BK	0.86			{6.0.1}	Keyser and Loftis, 2014
WI	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
SS	0.94			{6.0.1}	Keyser and Loftis, 2014
BD	0.99			1	Keyser and Loftis, 2014
EL	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
WE	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
AE	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014
RL	{6.0.3}	2.7386	-0.1076	1	Keyser and Loftis, 2014

*For location codes 809**, 810**, 905** and 908** these species use the specified different equation.

Regeneration of seedlings must be specified by the user with the partial establishment model by using the PLANT or NATURAL keywords. Height of the seedlings is estimated in two steps. First, the height is estimated when a tree is 5 years old (or the end of the cycle – whichever comes first) by using the small-tree height growth equations found in section 4.6.1. Users may override this value by entering a height in field 6 of the PLANT or NATURAL keyword; however the height entered in field 6 is not subject to minimum height restrictions and seedlings as small as 0.05 feet may be established. The second step also uses the equations in section 4.6.1, which grow the trees in height from the point five years after establishment to the end of the cycle.

Seedlings and sprouts are passed to the main FVS model at the end of the growth cycle in which regeneration is established. Unless noted above, seedlings being passed are subject to minimum and maximum height constraints and a minimum budwidth constraint shown in table 6.0.2. After seedling height is estimated, diameter growth is estimated using equations described in section 4.6.2. Crown ratios on newly established trees are estimated as described in section 4.3.1.

Regenerated trees and sprouts can be identified in the treelist output file with tree identification numbers beginning with the letters “ES”.

7.0 Volume

Volume is calculated for three merchantability standards: merchantable stem cubic feet, sawlog stem cubic feet, and sawlog stem board feet (calculated using International ¼-inch rule for the George Washington and Jefferson, Ouachita, Ozark and Saint Francis, and Francis Marion and Sumter National Forests, excluding the Andrew Pickens District, and calculated using Scribner rule for all other locations). Volume estimation is based on methods contained in the National Volume Estimator Library maintained by the Forest Products Measurements group in the Forest Management Service Center (Volume Estimator Library Equations 2009). The default merchantability standards for Southern Region forests in the SN variant are shown in table 7.0.1. The default merchantability standards for Eastern Region forests in the SN variant are shown in table 7.0.2.

Table 7.0.1 Volume merchantability standards for Southern Region (Region 8) forests in the SN variant.

Pulpwood Volume	**Minimum DBH / Top Diameter Outside Bark**
Softwoods Default	4 / 4
SR	6 / 4
LP	6 / 4
Softwoods on 81102, 81104, 81105, 81106, 81107, 81108, 81109, 81111	8 / 3.5
Softwoods on 81103, 81110	5.6 / 3.5
Hardwoods - Default	4 / 4
LB	6 / 4
WN	6 / 4
SU	6 / 4
MB	6 / 4
WT	6 / 4
TS	6 / 4
WO	6 / 4
Hardwoods on 81102, 81104, 81105, 81106, 81107, 81108, 81109, 81111	8 / 3.5
Hardwoods on 81103, 81110	6 / 3.5
Stump Height	0.5 feet
Sawtimber Volume	**Minimum DBH / Top Diameter Outside Bark**
Softwoods - Default	10 / 7
JU on Ozark & St. Francis NFs	9 / 7
Softwoods on 81102, 81104, 81105, 81106, 81107, 81108, 81109, 81111	10 / 6.3
JU	12 / 9
WP	12 / 9
BY	12 / 9

PC	12 / 9
HM	12 / 9
Softwoods on 81103, 81110	11 / 6.3
Hardwoods - Default	12 / 9
Hardwoods on 81102, 81104, 81105, 81106, 81107, 81108, 81109, 81111	15 / 11
Hardwoods on 81103, 81110	13 / 8
Stump Height	1.0 foot

Table 7.0.2 Volume merchantability standards for Eastern Region (Region 9) forests in the SN variant.

Pulpwood Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
905 – Mark Twain	5.0 / 4.0 inches	5.0 / 4.0 inches
908 – Shawnee	6.0 / 5.0 inches	5.0 / 4.0 inches
Stump Height	0.5 feet	0.5 feet
Sawtimber Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
905 – Mark Twain RC	9.0 / 7.6 inches	6.0 / 5.0 inches
905 – Mark Twain OT	9.0 / 7.6 inches	9.0 / 7.6 inches
908 – Shawnee	11.0 / 9.6 inches	9.0 / 7.6 inches
Stump Height	1.0 foot	1.0 foot

For both cubic foot and board foot prediction, Clark's profile models (Clark et al. 1991) are used for all species and all location codes in the SN variant. Equation number is 831CLKE***, where *** signifies the three-digit FSH species code.

8.0 Fire and Fuels Extension (FFE-FVS)

The Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) (Reinhardt and Crookston 2003) integrates FVS with models of fire behavior, fire effects, and fuel and snag dynamics. This allows users to simulate various management scenarios and compare their effect on potential fire hazard, surface fuel loading, snag levels, and stored carbon over time. Users can also simulate prescribed burns and wildfires and get estimates of the associated fire effects such as tree mortality, fuel consumption, and smoke production, as well as see their effect on future stand characteristics. FFE-FVS, like FVS, is run on individual stands, but it can be used to provide estimates of stand characteristics such as canopy base height and canopy bulk density when needed for landscape-level fire models.

For more information on FFE-FVS and how it is calibrated for the SN variant, refer to the updated FFE-FVS model documentation (Rebain, comp. 2010) available on the FVS website.

9.0 Insect and Disease Extensions

FVS Insect and Disease models have been developed through the participation and contribution of various organizations led by Forest Health Protection. The models are maintained by the Forest Management Service Center and regional Forest Health Protection specialists. There are no insect and disease models currently available for the SN variant. However, FVS addfiles that simulate the effects of known agents within the SN variant may be found in chapter 8 of the Essential FVS Users Guide (Dixon 2002).

10.0 Literature Cited

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11.0 Appendices

11.1 Appendix A. Ecological Unit Codes (EUC)

Table 11.1.1 Ecological Unit codes (EUC) recognized in the SN variant.

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
1	221Db	Piedmont Upland	0	221
2	221Dd	Triassic Basins	2	231T
3	221De	Northern Piedmont	2	231T
4	221Eb	Teays Plateau	0	221
5	221Eg	Lower Scioto River Plateau	2	222
6	221Ej	Eastern Knobs Transition	2	222
7	221En	Kinniconick and Licking Knobs	2	222
8	221Ha	Rugged Eastern Hills	0	221
9	221Hb	Kinniconick and Licking Knobs	2	221
10	221Hc	Southwestern Escarpment	0	221
11	221Hd	Sequatchie Valley	0	221
12	221He	Miami-Scioto Plain-Tipton Till Plain	0	221
13	221Ja	Rolling Limestone Hills	0	221
14	221Jb	Sandstone Hills	0	221
15	221Jc	Holston Valley	0	221
16	222Ab	Central Plateau	1	222
17	222Ag	White River Hills	1	222
18	222Ah	Elk River Hills	1	222
19	222Al	Black River Ozark Border	1	222
20	222Am	Springfield Plain	1	222
21	222An	Springfield Plateau	1	222
22	222Cb	Northern Deep Loess Hills and Bluffs	1	222
23	222Cc	Deep Loess Hills and Bluffs	1	222
24	222Cd	Clay Hills	1	222
25	222Ce	Northern Loessial Hills	1	222
26	222Cf	Northern Pontotoc Ridge	1	222
27	222Cg	Upper Loam Hills	1	222
28	222Ch	Ohio and Cache River Alluvial Plain	1	222
29	222Da	Interior Western Coalfields	1	222
30	222Db	Lower Ohio-Cache-Wabash Alluvial plains	1	222
31	222Dc	Outer Western Coalfields	1	222
32	222Dd	Marion Hills	1	222
33	222De	Crawford Uplands	1	222
34	222Dg	Southern Dripping Springs	1	222

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
35	222Di	Lesser Shawnee Hills	1	222
36	222Dj	Northern Dripping Springs	1	222
37	222Ea	Eastern Highland Rim	1	222
38	222Eb	Eastern Karst Plain	1	222
39	222Ec	Outer Nashville Basin	1	222
40	222Ed	Inner Nashville Basin	1	222
41	222Ee	Highland Rim-Hilly and Rolling	1	222
42	222Ef	Tennessee-Gasper Valley	1	222
43	222Eg	Western Pennyroyal Karst Plain	1	222
44	222Eh	Penneroyal Karst Plain	1	222
45	222Ei	Western Knobs	1	222
46	222Ej	Eastern Knobs Transition	1	222
47	222Ek	Mitchell Karst Plains	1	222
48	222En	Kinniconick and Licking Knobs	1	222
49	222Eo	The Cliffs	1	222
50	222Fa	Outer Bluegrass	1	222
51	222Fb	Inner Bluegrass	1	222
52	222Fc	Western Bluegrass	1	222
53	222Fd	Northern Bluegrass	1	222
54	222Ff	Scottsburg Lowland	1	222
55	223Ab	Central Plateau	2	222
56	223Ag	White River Hills	2	222
57	223Ah	Elk River Hills	2	222
58	223Am	Springfield Plain	2	222
59	223An	Springfield Plateau	2	222
60	223Bb	Brush Creek Hills	2	222
61	223Bc	Mitchell Karst Plains	2	222
62	223Bd	Western Knobs	2	222
63	223Da	Interior Western Coalfields	2	222
64	223Db	Lower Ohio-Cache-Wabash Alluvial Plains	2	222
65	223Dc	Outer Western Coalfields	2	222
66	223Dd	Marion Hills	2	222
67	223De	Crawford Uplands	2	222
68	223Dg	Southern Dripping Springs	2	222
69	223Di	Lesser Shawnee Hills	2	222
70	223Dj	Northern Dripping Springs	2	222
71	223Ea	Eastern Highland Rim	2	222
72	223Eb	Eastern Karst Plain	2	222
73	223Ec	Outer Nashville Basin	2	222

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
74	223Ed	Inner Nashville Basin	2	222
75	223Ee	Highland Rim-Hilly and Rolling	2	222
76	223Ef	Tennessee-Gasper Valley	2	222
77	223Eg	Western Pennyroyal Karst Plain	2	222
78	223Eh	Pennyroyal Karst Plain	2	222
79	223Fa	Outer Bluegrass	2	222
80	223Fb	Inner Bluegrass	2	222
81	223Fc	Western Bluegrass	2	222
82	223Fd	Northern Bluegrass	2	222
83	223Ff	Scottsburg Lowland	2	222
84	231Aa	Midland Plateau Central Uplands	0	231T
85	231Ab	Piedmont Ridge	0	231T
86	231Ac	Schist Plains	0	231T
87	231Ad	Lower Foot Hills	0	231T
88	231Ae	Charlotte Belt	0	231T
89	231Af	Carolina Slate	0	231T
90	231Ag	Schist Hills	0	231T
91	231Ah	Granite Hills	0	231T
92	231Ai	Opelika Plateau	0	231T
93	231Aj	Mica Rich Plateau	0	231T
94	231Ak	Lynchburg Belt	1	231T
95	231Al	Northern Piedmont	1	231T
96	231Am	Triassic Uplands	1	231T
97	231An	Western Coastal Plain-Piedmont Transition	1	231T
98	231Ao	Southern Triassic Uplands	1	231T
99	231Ap	Triassic Basins	1	231T
100	231Ba	Black Belt	0	231L
101	231Bb	Interior Flatwoods	0	231L
102	231Bc	Upper Clay Hills	0	231L
103	231Bd	Upper Loam Hills	0	231L
104	231Be	Transition Loam Hills	0	231L
105	231Bf	Floodplains and Terraces	0	231L
106	231Bg	Northern Loessial Hills	1	231L
107	231Bh	Deep Loess Hills and Bluffs	1	231L
108	231Bi	Deep Loess Plains	1	231L
109	231Bj	Jackson Hills	0	231L
110	231Bk	Northern or Southern Pontotoc Ridge	0	231L
111	231Bl	Jackson Prairie	0	231L
112	231Ca	Shale Hills and Mountain	0	231T

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
113	231Cb	Sandstone Plateau	0	231T
114	231Cc	Table Plateau	0	231T
115	231Cd	Sandstone Mountain	0	231T
116	231Ce	Moulton Valley	0	231T
117	231Cf	Southern Cumberland Valleys	0	231T
118	231Cg	Sequatchie Valley	0	231T
119	231Da	Chert Valley	0	231T
120	231Db	Sandstone-Shale and Chert Ridge	0	231T
121	231Dc	Sandstone Ridge	0	231T
122	231Dd	Quartzite and Talladega Slate Ridge	0	231T
123	231De	Shaley Limestone Valley	0	231T
124	231Ea	South Central Arkansas	0	231L
125	231Eb	Southwestern Arkansas	0	231L
126	231Ec	Ouachita Alluvial Valleys	0	231L
127	231Ed	Sabine Alluvial Valley	1	231L
128	231Ee	Southern Oklahoma Subsection	0	231L
129	231Ef	Piney Woods Transition	0	231L
130	231Eg	Sand Hills	0	231L
131	231Eh	Southern Loam Hills	1	231L
132	231Ei	Southwest Flatwoods	1	231L
133	231Ej	South Central Arkansas Flatwoods	0	231L
134	231Ek	Southwestern Arkansas Blackland Prairies	0	231L
135	231El	Trinity Alluvial Valley	1	231L
136	231Em	Red River Alluvial Plain	1	231L
137	231En	East Texas Timberlands-Cross Timbers	1	231L
138	231Eo	Red River Alluvial Plain	2	231L
139	231Fa	Gulf Coast Praries	1	231L
140	231Fb	Marshes and Inland Bays	1	231L
141	231Ga	Eastern Arkansas Valley and Ridges	0	231L
142	231Gb	Mount Magazine	0	231L
143	231Gc	Western Arkansas Valley and Ridges	0	231L
144	231Ha	Deep Loess Hills and Bluffs	2	231L
145	231Hb	Northern Loessial Hills	2	231L
146	231Hc	Deep Loess Plains	2	231L
147	231Hd	Clay Hills	2	222
148	231He	Northern Deep Loess Hills and Bluffs	2	222
149	231Hf	Ohio and Cache River Alluvial Plain	2	222
150	231Hh	Southern Loessial Plains	2	232
151	231Hi	Delmarva Upland	2	232

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
152	231Ia	Midland Plateau Central Uplands-North	2	231T
153	231Ib	Lynchburg Belt	2	231T
154	231Ic	Charlotte Belt-North	2	231T
155	231Id	Carolina Slate-North	2	231T
156	231Ie	Southern Triassic Uplands	2	231T
157	231If	Western Coastal Plain-Piedmont Transition	2	231T
158	231Ig	Triassic Uplands	2	231T
159	232Ad	Western Chesapeake Uplands	0	232
160	232Ba	Fragipan Loam Hills	0	232
161	232Bb	Southern Loessial Plains	1	232
162	232Bc	Cintronelle Plains	0	232
163	232Bd	Southern Deep Loess Hills and Bluffs	1	232
164	232Be	Florida Northern Highlands	1	232
165	232Bf	Florida Central Highlands	1	232
166	232Bg	South Coastal Plains	0	232
167	232Bh	Gulf Southern Loam Hills	0	232
168	232Bi	The Plains	0	232
169	232Bj	Southern Loam Hills	0	232
170	232Bk	Southern Clay Hills	0	232
171	232Bl	Lower Loam and Clay Hills	0	232
172	232Bm	Lower Clay Hills	0	232
173	232Bn	Lower Loam Hills	0	232
174	232Bo	Border Sand Hills	0	232
175	232Bp	Wiregrass Plains	0	232
176	232Bq	Sand Hills	1	232
177	232Br	Atlantic Southern Loam Hills	1	232
178	232Bs	Floodplains and Terraces	0	232
179	232Bt	Delmarva Uplands	1	232
180	232Bu	Southwestern Loam Hills	1	232
181	232Bv	Northern Loam Plains	1	232
182	232Bx	Eastern Chesapeake Lowland	1	232
183	232Bz	Delmarva Outer Coastal Plain, Bays, and Islands	1	232
184	232Ca	Upper Terraces	0	232
185	232Cb	Lower Terraces	0	232
186	232Cc	Okefenokee Uplands	0	232
187	232Cd	Okefenokee Swamp	0	232
188	232Ce	Coastal Marsh and Island	0	232
189	232Cf	Bacon Terraces	0	232

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
190	232Cg	Flatwoods Floodplains and Terraces	0	232
191	232Ch	Tidal Area	1	232
192	232Ci	Pamlico and Albemarle Sounds and Barrier Islands	1	232
193	232Cj	Chesapeake Bay	1	232
194	232Da	Immokalee Rise	0	232
195	232Db	Gulf Coastal Lowlands	0	232
196	232Dc	Gulf Coast Flatwoods-Bays and Barrier Islands	1	232
197	232Dd	Mobile Bay, Sounds and Islands	1	232
198	232De	Florida Gulf Coastal Bays and Islands	1	232
199	232Ea	Gulf Coast Prairies	0	232
200	232Eb	LA-TX Gulf Coast Marshes and Inland Bays	0	232
201	232Ec	Lake Ponchartrain	1	232
202	232Ed	Gulf Coast Bays and Islands	1	232
203	232Ee	Lake Borgne, Sounds and Islands	1	232
204	232Ef	LA Gulf Coast Marshes and Inland Bays	2	232
205	232Fa	Southern Loam Hills	0	232
206	232Fb	Southwest Flatwoods	0	232
207	232Fc	Sabine Alluvial Valley	0	232
208	232Fd	Neches Alluvial Valley	1	232
209	232Fe	Piney Woods Transition	0	232
210	232Ff	Red River Alluvial Plain	2	234
211	232Ga	Eastern Beach and Lagoons	0	232
212	232Gb	Eastern Beach and Dunes	0	232
213	232Gc	Okeechobee Plain	0	232
214	232Gd	Kissimmee River	0	232
215	232Ha	Atlantic Southern Loam Hills	2	232
216	232Hb	Eastern Chesapeake Lowland	2	232
217	232Hc	Delmarva Outer Coastal Plain Bays and Islands	2	232
218	232Ia	Lower Terraces	2	232
219	232Ib	Tidal Area	2	232
220	232Ja	Sand Hills	2	232
221	232Jb	Northern Loam Plains	2	232
222	232Jc	Southwestern Loam Hills	2	232
223	232Jd	Lower Loam Hills	2	232
224	232Je	Atlantic Southern Loam Hills	2	232
225	232Jf	Gulf Southern Loam Hills	2	232

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
226	232Jg	Floodplains and Terraces	2	232
227	232Ka	Florida Northern Highlands	2	232
228	232Kb	Florida Central Highlands	2	232
229	232La	LA-MS Gulf Coast Flatwoods-Bays and Barrier Islands	2	232
230	232Lb	GA-FL Gulf Coast Flatwoods-Bays and Barrier Islands	2	232
231	232Lc	FL Gulf Coast Flatwoods-Bays and Barrier Islands	2	232
232	234Aa	Southern Mississippi River Alluvial Plain	0	234
233	234Ab	Crowleys Ridge	1	234
234	234Ac	White and Black Rivers Alluvial Plain	1	234
235	234Ad	Baton Rouge Terrace	0	234
236	234Ae	Arkansas Grand Prairie	1	234
237	234Af	Atchafalaya Alluvial Plain	1	234
238	234Ag	Arkansas Alluvial Plain	1	234
239	234Ah	Macon Ridge	0	234
240	234Ai	Red River Alluvial Plain	1	234
241	234Aj	Bastrop Ridge	1	234
242	234Ak	Opelousas Ridge	1	234
243	234Al	Teche Terrace	1	234
244	234Am	St. Francis River Alluvial Plain	1	234
245	234An	North Mississippi River Alluvial Plain	1	234
246	234Ca	Red River Alluvial Plain	2	234
247	234Cb	Atchafalaya Alluvial Plain	2	234
248	234Cc	Teche Terrace	2	234
249	234Cd	Opelousas Ridge	2	234
250	234Da	North Mississippi River Alluvial Plain	2	234
251	234Db	Crowley's Ridge	2	234
252	234Dc	White and Black Rivers Alluvial Plain	2	234
253	234Do	St. Francis River Alluvial Plain	2	234
254	234Ea	Arkansas Alluvial Plain	2	234
255	234Eb	Arkansas Grand Prairie	2	234
256	234Ec	Bastrop Ridge	2	234
257	251Ea	Scarped Osage Plains	0	255
258	251Ec	Central Tallgrass	1	255
259	251Ed	Elk Prairie	1	255
260	251Fb	Eastern Flint Hills	0	255
261	251Fc	Southern Flint Hills	0	255

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
262	255Aa	Cross Timbers-Cherokee Prairies	0	255
263	255Ab	Central Oklahoma Cross Timbers	0	255
264	255Ac	Central Red Rolling Prairies	0	255
265	255Ad	Southern Oklahoma Grand Prairies	0	255
266	255Ae	Cross Timbers and Central Rolling Red Prairies	0	255
267	255Af	Cross Timbers - Southern Oklahoma	0	255
268	255Ag	Red River Alluvial Plain	1	255
269	255Ah	Texas Eastern Cross Timbers	1	255
270	255Ai	Texas Grand Prairie	1	255
271	255Aj	Texas Western Cross Timbers	1	255
272	255Ak	Southwestern Timbers	1	255
273	255Am	Central Tall Grass Prairie	2	255
274	255Ba	Blackland Prairie	0	255
275	255Ca	Texas Claypan Savannah	0	255
276	255Cc	Interior Savannah	0	255
277	255Cd	Interior Blackland Prairie	0	255
278	255Ce	Trinity Alluvial Valley	0	255
279	255Cf	Blackland Prairie	0	255
280	255Cg	Southern Texas Claypan Savannah	0	255
281	255Ch	East Texas Timberlands-Cross Timbers	2	231L
282	255Da	Texas Coastal Prairies	0	255
283	255Db	Brazos and Brazonia Alluvial Valley	0	255
284	255Dc	Marshes-Inlands Bays-and Barrier Islands	0	255
285	255Dd	Southern Texas Coastal Prarie and Savannah	0	255
286	255Ea	Red River Alluvial Plain	2	255
287	255Eb	Western Cross Timbers	2	255
288	255Ec	Southwestern Cross Timbers	2	255
289	255Ed	Texas Grand Prairie	2	255
290	255Ee	Texas Eastern Cross Timbers	2	255
291	411Aa	Lake Okeechobee	1	411
292	411Ab	Everglades	0	411
293	411Ac	Southern Slope	0	411
294	411Ad	Atlantic Coastal Ridge	0	411
295	411Ae	Coastal Lowlands-Tidal Marshes and Bays	0	411
296	411Af	Big Cypress Spur	0	411
297	411Ag	Florida Keys and Biscayne Bay	1	411
298	M221Aa	Ridge and Valley	0	M221

FVS Sequence Number	EUC Code	Name	Source[1]	Ecoregion Category
299	M221Ab	Great Valley of Virginia	0	M221
300	M221Ac	Northern Ridge and Valley	2	M221
301	M221Ba	Northern High Allegheny Mountains	0	M221
302	M221Bd	Eastern Allegheny Mountain and Valley	0	M221
303	M221Be	Western Allegheny Mountain and Valley	0	M221
304	M221Ca	Western Coal Fields	0	M221
305	M221Cb	Eastern Coal Fields	0	M221
306	M221Cc	Black Mountains	0	M221
307	M221Cd	Southern Cumberland Mountains	0	M221
308	M221Ce	Pine and Cumberland Mountains	0	M221
309	M221Da	Northern Blue Ridge Mountains	0	M221
310	M221Db	Central Blue Ridge Mountains	0	M221
311	M221Dc	Southern Blue Ridge Mountains	0	M221
312	M221Dd	Metasedimentary Mountains	0	M221
313	M222Aa	The Boston Mountain	1	M222
314	M222Ab	Boston Hills	1	M222
315	M223Aa	Boston Mountains	2	M222
316	M223Ab	Boston Hills	2	M222
317	M231Aa	Fourche Mountains	0	M231
318	M231Ab	West Central Ouachita Mountains	0	M231
319	M231Ac	East Central Ouachita Mountains	0	M231
320	M231Ad	Athens Piedmont Plateau	0	M231

1 - 0=both, 1= Keys and others (1995), 2 = Cleland and others 2007

Table 11.1.2 Ecoregion categories in the SN variant.

Ecoregion Category	Province Description (Keys and others 1995)
M221	Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow
M222	Ozark Broadleaf Forest Meadow
M231	Ouachita Mixed Forest - Meadow
221	Eastern Broadleaf Forest (Oceanic)
222	Eastern Broadleaf Forest (Continental)
231T	Southeastern Mixed Forest (FVS Atlantic Piedmont)
231L	Southeastern Mixed Forest (FVS Gulf Piedmont/Plains)
232	Outer Coastal Plain Mixed Forest
234	Lower Mississippi Riverine Forest
255	Prairie Parkland (Subtropical)
411	Everglades

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