Forest Service
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Northeast (NE) Variant Overview of the Forest Vegetation Simulator

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White Mountain NF
(John Williams, FS-R9)

Northeast (NE) 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 1995. The original author was Renate Bush. In 2006, Gary Dixon reformulated many of the model components, created a test version of the variant and wrote this new variant overview. 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. Gary Dixon cross-checked information contained in this variant overview with the FVS source code.

FVS Staff. 2008 (revised April 16, 2024). Northeast (NE) Variant Overview – Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 56p.

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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	10 years	
Location Code (National Forest)	922 – White Mountain	
Slope	5 percent	
Aspect	0 (no meaningful aspect)	
Elevation (default location)	20 (2000 feet)	
Latitude (Default location)	43.53	
Longitude (Default location)	71.47	
Site Species	SM	
Site Index	56 feet (total age; 50 years)	
Maximum Stand Density Index	Species specific	
Maximum Basal Area	Species specific	
Volume Equations	National Volume Estimator Library	
Pulpwood Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
919 – Allegheny	6.0 / 5.0 inches	5.0 / 4.0 inches
920 – Green Mountain-Finger Lakes	8.0 / 4.0 inches	5.0 / 4.0 inches
921 – Monongahela	5.0 / 4.0 inches	5.0 / 4.0 inches
914 – Wayne, 911 – Wayne-Hoosier	6.0 / 4.0 inches	5.0 / 4.0 inches
922 – White Mountain	5.0 / 4.0 inches	5.0 / 4.0 inches
Stump Height	0.5 feet	0.5 feet
Sawtimber Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
All location codes	11.0 / 9.6 inches	9.0 / 7.6 inches
Stump Height	1.0 foot	1.0 foot
Sampling Design:		
Large Trees (variable radius plot)	40 BAF	
Small Trees (fixed radius plot)	1/300th acre	
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 Northeast (NE) variant was originally developed in 1995 based on relationships in the NE-TWIGS model (Hilt and Teck 1989), and equations from other variants for FVS relationships not present in NE-TWIGS. The model was reformulated in 2006 to improve model estimates; the only remnant of the original NE-TWIGS formulation is in the large tree diameter growth equations.

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 NE variant covers forest areas in the northeastern states of Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and West Virginia. This includes Green Mountain, White Mountain, Allegheny, Wayne, and Monongahela National Forests. The suggested geographic range of use for the NE variant is shown in figure 2.0.1.

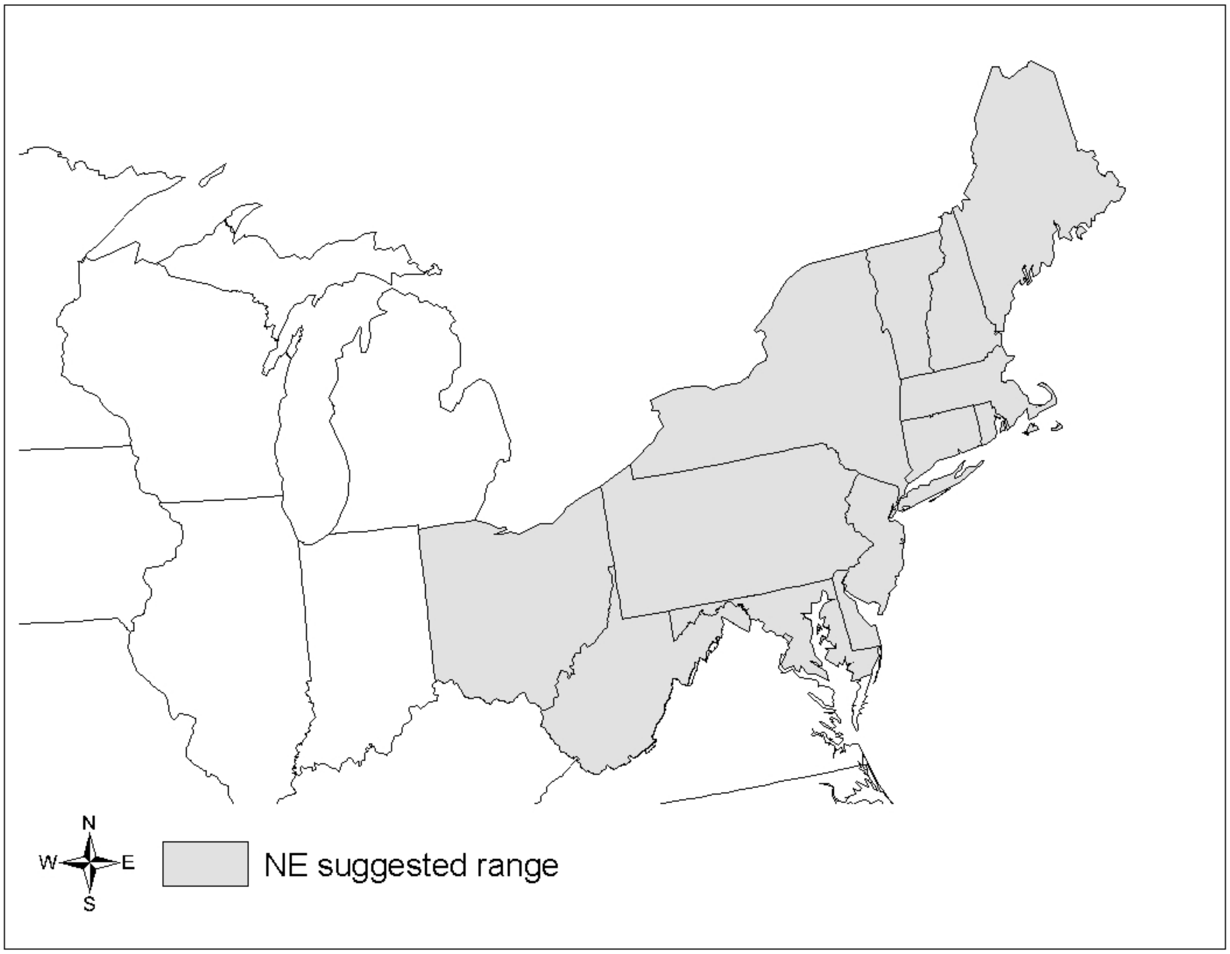

Figure 2.0.1 Suggested geographic range of use for the NE variant.

3.0 Control Variables

FVS users need to specify certain variables used by the NE 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

The location code is a 3- or 4-digit code where, in general, the first digit of the code represents the Forest Service Region Number, and the last two digits represent the Forest Number within that region. 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 NE variant, a default forest code of 922 (White Mountain National Forest) will be used. Location codes recognized in the NE variant – and their associated default latitude, longitude, and elevation values – are shown in tables 3.1.1 and 3.1.2.

Table 3.1.1 Location codes used in the NE variant.

Location Code	Location	Latitude	Longitude	Elevation
914	Wayne National Forest	39.33	82.10	9 (900 feet)
919	Allegheny National Forest	41.84	79.15	17 (1700 feet)
920	Green Mountain – Finger Lakes National Forest	43.61	72.97	19 (1900 feet)
921	Monongahela National Forest	38.93	79.85	30 (3000 feet)
922	White Mountain National Forest	43.53	71.47	20 (2000 feet)
911	Wayne – Hoosier National Forest (Map to Wayne)	39.33	82.10	9 (900 feet)
930	Finger Lakes National Forest (Map to Green Mountain – Finger Lakes)	43.61	72.97	19 (1900 feet)

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

Location Code	Location
8200	Passamaquoddy Reservation (mapped to 922)
8201	Penobscot Off-Reservation Tl (mapped to 922)
8202	Houlton Maliseet Reservation (mapped to 922)
8203	Mashantucket Pequot Reservation (mapped to 922)
8204	Paucatuck Eastern Pequot Res (mapped to 922)
8206	Narragansett Reservation (mapped to 922)
8208	Wampanoag-Aquinnah Tl (mapped to 922)
8209	Aroostook Band Of Micmac Tl (mapped to 922)
8211	Mohegan Reservation (mapped to 922)

Location Code	Location
8214	Cayuga Nation Tdsa (mapped to 930)
8215	Onondaga Nation Reservation (mapped to 930)
8216	Tonawanda Reservation (mapped to 930)
8217	Tuscarora Nation Reservation (mapped to 930)
8218	Oneida Nation Reservation (mapped to 930)

3.2 Species Codes

The NE variant recognizes 105 species, plus two 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 hardwood" 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 NE variant.

Table 3.2.1 Species codes used in the NE variant.

Species Group	Species Number[1]	Species Code	FIA Code	PLANTS Symbol	Scientific Name[2]	Common Name[2]
1	1	BF	012	ABBA	*Abies balsamea*	balsam fir
2	2	TA	071	LALA	*Larix laricina*	tamarack
3	3	WS	094	PIGL	*Picea glauca*	white spruce
4	4	RS	097	PIRU	*Picea rubens*	red spruce
4	5	NS	091	PIAB	*Picea abies*	Norway spruce
4	6	BS	095	PIMA	*Picea mariana*	black spruce
4	7	PI	090	PICEA	*Picea*	spruce
5	8	RN	125	PIRE	*Pinus resinosa*	red pine
6	9	WP	129	PIST	*Pinus strobus*	eastern white pine
7	10	LP	131	PITA	*Pinus taeda*	loblolly pine
8	11	VP	132	PIVI2	*Pinus viginiana*	Virginia pine
9	12	WC	241	THOC2	*Thuja occidentalis*	arborvitae
9	13	AW	043	CHTH2	*Chamaecyparis thyoides*	Atlantic white cedar
9	14	RC	068	JUVI	*Juniperus virginiana*	eastern redcedar
9	15	JU	057	JUNIP	*Juniperus*	juniper
10	16	EH	261	TSCA	*Tsuga canadensis*	eastern hemlock
10	17	HM	260	TSUGA	*Tsuga*	hemlock
11	18	OP	100	PINUS	*Pinus*	pine

Species Group	Species Number[1]	Species Code	FIA Code	PLANTS Symbol	Scientific Name[2]	Common Name[2]
11	19	JP	105	PIBA2	*Pinus banksiana*	jack pine
11	20	SP	110	PIEC2	*Pinus echinata*	shortleaf pine
11	21	TM	123	PIPU5	*Pinus pungens*	Table Mountain pine
11	22	PP	126	PIRI	*Pinus rigida*	pitch pine
11	23	PD	128	PISE	*Pinus serotina*	pond pine
11	24	SC	130	PISY	*Pinus sylvestris*	Scots pine
11	25	OS	299	2TN		other softwood[3]
12	26	RM	316	ACRU	*Acer rubrum*	red maple
13	27	SM	318	ACSA3	*Acer saccharum*	sugar maple
13	28	BM	314	ACNI5	*Acer nigrum*	black maple
13	29	SV	317	ACSA2	*Acer saccharinum*	silver maple
14	30	YB	371	BEAL2	*Betula alleghaniensis*	yellow birch
14	31	SB	372	BELE	*Betula lenta*	sweet birch
14	32	RB	373	BENI	*Betula nigra*	river birch
15	33	PB	375	BEPA	*Betula papyrifera*	paper birch
15	34	GB	379	BEPO	*Betula populifolia*	gray birch
16	35	HI	400	CARYA	*Carya*	hybrid hickory
16	36	PH	403	CAGL8	*Carya glabra*	pignut hickory
16	37	SL	405	CALA21	*Carya laciniosa*	shellbark hickory
16	38	SH	407	CAOV2	*Carya ovata*	shagbark hickory
16	39	MH	409	CAAL27	*Carya alba*	mockernut hickory
17	40	AB	531	FAGR	*Fagus grandifolia*	American beech
18	41	AS	540	FRAXI	*Fraxinus*	ash
18	42	WA	541	FRAM2	*Fraxinus americana*	white ash
18	43	BA	543	FRNI	*Fraxinus nigra*	black ash
18	44	GA	544	FRPE	*Fraxinus pennsylvanica*	green ash
18	45	PA	545	FRPR	*Fraxinus profunda*	pumpkin ash
19	46	YP	621	LITU	*Liriodendron tulipifera*	tuliptree
19	47	SU	611	LIST2	*Liquidamber styraciflua*	sweetgum
19	48	CT	651	MAAC	*Magnolia acuminata*	cucumber tree
20	49	QA	746	POTR5	*Populus tremuloides*	quaking aspen
20	50	BP	741	POBA2	*Populus balsamifera*	balsam poplar
20	51	EC	742	PODE3	*Populus deltoides*	eastern cottonwood
20	52	BT	743	POGR4	*Populus grandidentata*	bigtooth aspen
20	53	PY	744	POHE4	*Populus*	swamp cottonwood

Species Group	Species Number[1]	Species Code	FIA Code	PLANTS Symbol	Scientific Name[2]	Common Name[2]
					heterophylla	
21	54	BC	762	PRSE2	*Prunus serotina*	black cherry
22	55	WO	802	QUAL	*Quercus alba*	white oak
22	56	BR	823	QUMA2	*Quercus macrocarpa*	bur oak
22	57	CK	826	QUMU	*Quercus muehlenbergii*	chinkapin oak
22	58	PO	835	QUST	*Quercus stellata*	post oak
22	59	OK	800	QUERC	*Quercus*	oak
23	60	SO	806	QUCO2	*Quercus coccinea*	scarlet oak
23	61	QI	817	QUIM	*Quercus imbricaria*	shingle oak
23	62	WK	827	QUNI	*Quercus nigra*	water oak
23	63	PN	830	QUPA2	*Quercus palustris*	pin oak
24	64	CO	832	QUPR2	*Quercus prinus*	chestnut oak
24	65	SW	804	QUBI	*Quercus bicolor*	swamp white oak
24	66	SN	825	QUMI	*Quercus michauxii*	swamp chestnut oak
25	67	RO	833	QURU	*Quercus rubra*	northern red oak
25	68	SK	812	QUFA	*Quercus falcata*	southern red oak
26	69	BO	837	QUVE	*Quercus velutina*	black oak
26	70	CB	813	QUPA5	*Quercus pagoda*	cherrybark oak
27	72	BU	330	AESCU	*Aesculus*	buckeye
27	73	YY	332	AEFL	*Aesculus flava*	yellow buckeye
27	74	WR	374	BEOC2	*Betula occidentalis*	water birch
27	75	HK	462	CEOC	*Celtis occidentalis*	common hackberry
27	76	PS	521	DIVI5	*Diospyros virginiana*	common persimmon
27	77	HY	591	ILOP	*Ilex opaca*	American holly
27	78	BN	601	JUCI	*Juglans cinerea*	butternut
27	79	WN	602	JUNI	*Juglans nigra*	black walnut
27	80	OO	641	MAPO	*Maclura pomifera*	Osage-orange
27	81	MG	650	MAGNO	*Magnolia*	magnolia
27	82	MV	653	MAVI2	*Magnolia virginiana*	sweetbay
27	83	AP	660	MALUS	*Malus*	apple
27	84	WT	691	NYAQ2	*Nyssa aquatica*	water tupelo
27	85	BG	693	NYSY	*Nyssa sylvatica*	blackgum
27	86	SD	711	OXAR	*Oxydendrum arboreum*	sourwood
27	87	PW	712	PATO2	*Paulownia tomentosa*	princesstree
27	88	SY	731	PLOC	*Platanus occidentalis*	American sycamore
27	89	WL	831	QUPH	*Quercus phellos*	willow oak

Species Group	Species Number[1]	Species Code	FIA Code	PLANTS Symbol	Scientific Name[2]	Common Name[2]
27	90	BK	901	ROPS	*Robinia pseudoacacia*	black locust
27	91	BL	922	SANI	*Salix nigra*	black willow
27	92	SS	931	SAAL5	*Sassafras albidum*	sassafras
27	93	BW	951	TIAM	*Tilia americana*	American basswood
27	94	WB	952	TIAMH	*Tilia americana* var. *heterophylla*	white basswood[4]
27	95	EL	970	ULMUS	*Ulmus*	elm
27	96	AE	972	ULAM	*Ulmus americana*	American elm
27	97	RL	975	ULRU	*Ulmus rubra*	slippery elm
28	98	OH	998	2TB		other hardwood[3]
28	99	BE	313	ACNE2	*Acer negundo*	boxelder
28	100	ST	315	ACPE	*Acer pensylvanicum*	striped maple
28	101	AI	341	AIAL	*Ailanthus altissima*	tree of heaven
28	102	SE	356	AMELA	*Amelanchier*	serviceberry
28	103	AH	391	CACA18	*Carpinus caroliniana*	American hornbeam
28	104	DW	491	COFL2	*Cornus florida*	flowering dogwood
28	105	HT	500	CRATA	*Crataegus*	hawthorn
28	106	HH	701	OSVI	*Ostrya virginiana*	hophornbeam
28	107	PL	760	PRUNU	*Prunus*	plum
28	108	PR	761	PRPE2	*Prunus pensylvanica*	pin cherry

[1]Species numbers 14, 68, and 78 represent removed species groups.
[2]Set based on the USDA Forest Service NRM TAXA lists and the USDA Plants database.
[3]Other categories use FIA codes and NRM TAXA codes that best match the other category.
[4]Common name of white basswood is used to differentiate from American basswood.

3.3 Habitat Type, Plant Association, and Ecological Unit Codes

Habitat type, plant association, and ecological unit codes are not used in the NE variant.

3.4 Site Index

Site index is used in some of the growth equations in the NE variant. Users should always use the site index curves from Carmean and others (1989) to estimate site index. In assigning site index, users should use site curves based on total age at an index age of 50. 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. If site index is missing or incorrect, the site species is set to sugar maple with a default site index set to 56. Site indices for other species are then estimated from this sugar maple site index as described below.

Site indices for species not assigned a site index are converted from the site species value using a site index conversion equation from Hilt (1989) and Teck & Fuller (1987) as shown in equation {3.4.1}.

Species are grouped according to similar growth rates and then ranked from fastest to slowest growing; β_1 is then looked up in Table 3.4.1. If the site index of the faster growing species is known, the equation can be solved to estimate the site index of the slower growing species.

{3.4.1} $SI(FGS) = B_1 + 1.104 * SI(SGS)$

where:

SI(FGS)	is site index of the faster growing species
SI(SGS)	is site index of the slower growing species
B_1	is a species-specific coefficient shown in table 3.4.1

Table 3.4.1 Coefficients for converting site index between species groups in the NE variant.

Site Index Ranking	Site Index[1]	Species Group	Slower Growing Species Group								
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	65	5,6,7,8,11		-1.240	-0.136	0.986	3.176	7.592	9.8	10.904	18.632
2	60	19,20,21			-5.136	-4.032	-1.824	2.592	4.8	5.904	13.632
3	59	18				-5.032	-2.824	1.592	3.8	4.904	12.632
4	58	23,25,26					-3.824	0.592	2.8	3.904	11.632
5	56	12-17,22,24						-1.408	0.8	1.904	9.632
6	52	1,10							-3.2	-2.096	5.632
7	50	2,3,4,27								-4.096	3.632
8	49	None in NE									2.632
9	42	9,28									

[1] Site index values assigned by species group if the default sugar maple site index of 56 is used.

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 proportion, 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 NE variant.

Species Code	SDI Maximum*	Mapped to
BF	655	
TA	387	
WS	412	
RS	506	
NS	412	white spruce
BS	500	
PI	412	white spruce
RN	505	
WP	529	
LP	480	
VP	499	
WC	771	
AW	771	northern white-cedar
RC	354	
JU	354	eastern redcedar
EH	510	
HM	518	eastern hemlock
OP	529	eastern white pine
JP	356	
SP	490	
TM	398	pitch pine
PP	398	
PD	310	
SC	408	
OS	354	eastern redcedar
RM	421	

Species Code	SDI Maximum*	Mapped to
WO	361	
BR	423	
CK	336	
PO	311	
OK	361	white oak
SO	315	
QI	370	black oak
WK	365	
PN	455	
CO	417	
SW	361	white oak
SN	336	chestnut oak
RO	414	
SK	342	
BO	370	
CB	405	
BU	371	sugar maple
YY	371	sugar maple
WR	400	river birch
HK	420	
PS	147	
HY	155	
BN	283	black walnut
WN	283	
OO	404	
MG	492	sweetbay

Species Code	SDI Maximum*	Mapped to
SM	371	
BM	371	sugar maple
SV	590	
YB	369	
SB	350	
RB	400	
PB	466	
GB	466	paper birch
HI	302	shagbark hickory
PH	276	
SL	302	shagbark hickory
SH	302	
MH	230	
AB	364	
AS	414	green ash
WA	408	
BA	423	
GA	414	
PA	408	white ash
YP	478	
SU	430	
CT	415	
QA	562	
BP	384	
EC	648	
BT	520	
PY	648	eastern cottonwood
BC	384	

Species Code	SDI Maximum*	Mapped to
MV	492	
AP	422	eastern redbud
WT	726	
BG	430	
SD	164	
PW	164	sourwood
SY	499	
WL	315	
BK	343	
BL	447	
SS	492	
BW	526	
WB	526	American basswood
EL	282	American elm
AE	282	
RL	227	
OH	257	flowering dogwood
BE	344	
ST	243	
AI	343	black locust
SE	657	
AH	375	
DW	257	
HT	463	
HH	304	
PL	463	hawthorn
PR	463	hawthorn

*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 are used to estimate tree heights missing in the input data and periodic small-tree diameter growth. In the NE variant, height is estimated using either the Curtis-Arney equation (Curtis 1967, Arney 1985) or the Wykoff equation (Wykoff and others 1982). The equation used by default is indicated by a C or W, in the third column of table 4.1.1. By default, the NE variant does not calibrate the height-diameter relationship for estimating missing tree heights based on measured heights in the input data. To override this, the user must use the NOHTDREG keyword and “turn on” calibration. When calibration is turned on, FVS will use the Wykoff equation form with a calibrated B_1 value, if there are at least 3 measured heights for that species over 3 inches DBH in the stand.

The functional form of the Curtis-Arney equation for trees three inches DBH and larger is shown in equation {4.1.1}. For trees less than three inches DBH using the Curtis-Arney equation, a modified Curtis-Arney equation combined with a simple linear equation is used. The functional form of the Wykoff equation is shown in equation {4.1.2}. Equation coefficients and which equation is used for which species are shown in table 4.1.1.

{4.1.1} Curtis-Arney equation

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

{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

Coefficients for the height-diameter relationships in the NE variant are from three sources. Wykoff and Curtis-Arney coefficients for all species are shown in table 4.1.1. These are used for all forests and species with the exception of certain species on the Allegheny National Forest which are shown in Table 4.1.2. These coefficients are from equations fit to data for the Southern variant of FVS. Species for which there was not enough data to fit these relationships use coefficients from a similar species.

For the Allegheny National Forest, Wykoff coefficients for red maple, sugar maple, yellow birch, American beech, white ash, black cherry, American basswood, and hophornbeam were fit to data presented by Hough (1935) for Allegheny hardwoods. The yellow birch coefficients are also used for sweet birch and paper birch, white ash coefficients are used for ash and green ash, hophornbeam coefficients are used for the "other hardwoods" and serviceberry, and black cherry coefficients are used for pin cherry. Also, Wykoff coefficients for oaks (white, scarlet, chestnut, northern red, and black) were estimated from FIA site index data from a four county area that includes the Allegheny National Forest.

Table 4.1.1 Coefficients, equation, and surrogate species for height-diameter relationships in the NE variant.

Species Code	W or C	SN Variant Surrogate / source	Curtis-Arney Coefficients				Wykoff Coefficients	
			P_2	P_3	P_4	D_{bw}	Default B_1	B_2
BF	C	spruce/fir	2163.9468	6.2688	-0.2161	0.1	4.5084	-6.0116
TA	C	spruce/fir	2163.9468	6.2688	-0.2161	0.1	4.5084	-6.0116
WS	C	spruce/fir	2163.9468	6.2688	-0.2161	0.2	4.5084	-6.0116
RS	C	spruce/fir	2163.9468	6.2688	-0.2161	0.2	4.5084	-6.0116
NS	C	spruce/fir	2163.9468	6.2688	-0.2161	0.2	4.5084	-6.0116
BS	C	spruce/fir	2163.9468	6.2688	-0.2161	0.2	4.5084	-6.0116
PI	C	spruce/fir	2163.9468	6.2688	-0.2161	0.2	4.5084	-6.0116
RN	C	hemlock	266.4562	3.9931	-0.3860	0.1	4.5084	-6.0116
WP	C	eastern white pine	2108.8442	5.6595	-0.1856	0.4	4.6090	-6.1896
LP	W	loblolly pine	243.8606	4.2846	-0.4713	0.5	4.6897	-6.8801
VP	W	Virginia pine	926.1803	4.4621	-0.2005	0.5	4.4718	-5.0078
WC	W	spruce/fir	2163.9468	6.2688	-0.2161	0.1	4.5084	-6.0116
AW	W	hemlock	266.4562	3.9931	-0.3860	0.1	4.5084	-6.0116
RC	W	Virginia pine	926.1803	4.4621	-0.2005	0.5	4.4718	-5.0078
JU	W	Virginia pine	926.1803	4.4621	-0.2005	0.5	4.4718	-5.0078
EH	C	hemlock	266.4562	3.9931	-0.3860	0.1	4.5084	-6.0116
HM	W	hemlock	266.4562	3.9931	-0.3860	0.1	4.5084	-6.0116
OP	W	pitch pine	208.7773	3.7281	-0.4109	0.5	4.3898	-5.7183
JP	W	hemlock	266.4562	3.9931	-0.3860	0.1	4.5084	-6.0116
SP	W	shortleaf pine	444.0922	4.1188	-0.3062	0.4	4.6271	-6.4095
TM	W	pitch pine	208.7773	3.7281	-0.4109	0.5	4.3898	-5.7183
PP	C	pitch pine	208.7773	3.7281	-0.4109	0.5	4.3898	-5.7183
PD	W	pond pine	142.7468	3.9726	-0.5871	0.5	4.5457	-6.8000
SC	W	pond pine	142.7468	3.9726	-0.5871	0.5	4.5457	-6.8000
OS	W	juniper species	212.7933	3.4715	-0.3259	0.3	4.0374	-4.2964
RM	W	red maple	268.5564	3.1143	-0.2941	0.2	4.3379	-3.8214
SM	W	sugar maple	209.8555	2.9528	-0.3679	0.2	4.4834	-4.5431

Species Code	W or C	SN Variant Surrogate / source	Curtis-Arney Coefficients P_2	P_3	P_4	D_{bw}	Wykoff Coefficients Default B_1	B_2
BM	C	sugar maple	209.8555	2.9528	-0.3679	0.2	4.4834	-4.5431
SV	C	silver maple	80.5118	26.9833	-2.0220	0.2	4.5991	-6.6706
YB	W	birch species	170.5253	2.6883	-0.4008	0.1	4.4388	-4.0872
SB	W	sweet birch	68.9223	43.3383	-2.4445	0.1	4.4522	-4.5758
RB	W	birch species	170.5253	2.6883	-0.4008	0.1	4.4388	-4.0872
PB	W	birch species	170.5253	2.6883	-0.4008	0.1	4.4388	-4.0872
GB	W	birch species	170.5253	2.6883	-0.4008	0.1	4.4388	-4.0872
HI	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
PH	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
SL	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
SH	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
MH	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
AB	W	American beech	526.1393	3.8923	-0.2259	0.1	4.4772	-4.7206
AS	W	ash species	251.4043	3.2692	-0.3591	0.2	4.4819	-4.5314
WA	W	white ash	91.3528	6.9961	-1.2294	0.2	4.5959	-6.4497
BA	W	black ash	178.9308	4.9286	-0.6378	0.2	4.6155	-6.2945
GA	W	green ash	404.9692	3.3902	-0.2551	0.2	4.6155	-6.2945
PA	W	ash species	251.4043	3.2692	-0.3591	0.2	4.4819	-4.5314
YP	C	yellow-poplar	625.7697	3.8732	-0.2335	0.2	4.6892	-4.9605
SU	W	sweetgum	290.9055	3.6240	-0.3720	0.2	4.5920	-5.1719
CT	C	cucumbertree	660.1997	3.9208	-0.2112	0.2	4.6067	-5.2030
QA	W	hickory species	337.6685	3.6273	-0.3208	0.3	4.5128	-4.9918
BP	W	white ash	91.3528	6.9961	-1.2294	0.2	4.5959	-6.4497
EC	W	cottonwood species	190.9797	3.6928	-0.5273	0.1	4.9396	-8.1838
BT	W	white ash	91.3528	6.9961	-1.2294	0.2	4.5959	-6.4497
PY	W	white ash	91.3528	6.9961	-1.2294	0.2	4.5959	-6.4497
BC	W	black cherry	364.0248	3.5599	-0.2726	0.1	4.3286	-4.0922
WO	W	white oak	170.1331	3.2782	-0.4874	0.2	4.5463	-5.2287
BR	W	scarlet oak	196.0565	3.0067	-0.3850	0.2	4.5225	-4.9401
CK	W	chinkapin oak	72.7907	3.6707	-1.0988	0.1	4.3420	-5.1193
PO	W	post oak	765.2908	4.2238	-0.1897	0.1	4.2496	-4.8061
OK	W	scarlet oak	196.0565	3.0067	-0.3850	0.2	4.5225	-4.9401
SO	W	scarlet oak	196.0565	3.0067	-0.3850	0.2	4.5225	-4.9401
QI	W	chestnut oak	94.5447	3.4203	-0.8188	0.2	4.4618	-4.8786
WK	W	water oak	470.0617	3.7889	-0.2512	0.1	4.5577	-4.9595
PN	W	scarlet oak	196.0565	3.0067	-0.3850	0.2	4.5225	-4.9401
CO	W	chestnut oak	94.5447	3.4203	-0.8188	0.2	4.4618	-4.8786
SW	W	cherrybark/swamp oak	182.6306	3.1290	-0.4639	0.1	4.7342	-6.2674

Species Code	W or C	SN Variant Surrogate / source	Curtis-Arney Coefficients				Wykoff Coefficients	
			P_2	P_3	P_4	D_{bw}	Default B_1	B_2
SN	W	swamp chestnut oak	281.3413	3.5170	-0.3336	0.2	4.6135	-5.7613
RO	W	northern red oak	700.0636	4.1061	-0.2139	0.2	4.5202	-4.8896
SK	W	southern red oak	150.4300	3.1327	-0.4993	0.1	4.5142	-5.2205
BO	W	black oak	224.7163	3.1165	-0.3598	0.2	4.4747	-4.8698
CB	W	cherrybark/swamp oak	182.6306	3.1290	-0.4639	0.1	4.7342	-6.2674
BU	W	basswood	293.5715	3.5226	-0.3512	0.1	4.5820	-5.0903
YY	W	basswood	293.5715	3.5226	-0.3512	0.1	4.5820	-5.0903
WR	W	birch species	170.5253	2.6883	-0.4008	0.1	4.4388	-4.0872
HK	C	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
PS	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
HY	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
BN	W	butternut	285.8798	3.5214	-0.3194	0.3	4.5018	-5.6123
WN	W	black walnut	93.7104	3.6575	-0.8825	0.4	4.5018	-5.6123
OO	W	misc. hardwoods	109.7324	2.2503	-0.4130	0.1	4.0322	-3.0833
MG	W	magnolia species	585.6609	3.4197	-0.1766	0.2	4.4004	-4.7519
MV	W	sweetbay	184.1932	2.8457	-0.3695	0.2	4.3609	-4.1423
AP	W	apple species	574.0201	3.8637	-0.1632	0.2	3.9678	-3.2510
WT	W	water tupelo	163.9728	2.7682	-0.4410	0.2	4.3330	-4.5383
BG	C	blackgum	319.9788	3.6731	-0.3065	0.2	4.3802	-4.7903
SD	W	sourwood	690.4918	4.1598	-0.1861	0.2	4.1352	-3.7450
PW	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
SY	W	sycamore	644.3568	3.9205	-0.2144	0.1	4.6355	-5.2776
WL	W	cottonwood species	190.9797	3.6928	-0.5273	0.1	4.9396	-8.1838
BK	C	black locust	880.2845	4.5964	-0.2182	0.1	4.4299	-4.9920
BL	W	willow species	408.2772	3.8181	-0.2721	0.1	4.4911	-5.7928
SS	C	sassafras	755.1038	4.3950	-0.2178	0.1	4.3383	-4.5018
BW	W	basswood	293.5715	3.5226	-0.3512	0.1	4.5820	-5.0903
WB	W	basswood	293.5715	3.5226	-0.3512	0.1	4.5820	-5.0903
EL	W	elm species	1005.8067	4.6474	-0.2034	0.1	4.3744	-4.5257
AE	W	American elm	418.5942	3.1704	-0.1896	0.1	4.6008	-7.2732
RL	W	slippery elm	1337.5472	4.4895	-0.1475	0.1	4.6238	-7.4847
OH	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
BE	W	butternut	285.8798	3.5214	-0.3194	0.3	4.5018	-5.6123
ST	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
AI	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
SE	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
AH	C	eastern hophornbeam	109.7324	2.2503	-0.4130	0.2	4.0322	-3.0833
DW	W	flowering dogwood	863.0501	4.3856	-0.1481	0.1	3.7301	-2.7758

Species Code	W or C	SN Variant Surrogate / source	Curtis-Arney Coefficients				Wykoff Coefficients	
			P_2	P_3	P_4	D_{bw}	Default B_1	B_2
HT	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435
HH	W	eastern hophornbeam	109.7324	2.2503	-0.4130	0.2	4.0322	-3.0833
PL	W	apple species	574.0201	3.8637	-0.1632	0.2	3.9678	-3.2510
PR	W	hackberry species	484.7530	3.9393	-0.2600	0.1	4.4207	-5.1435

Table 4.1.2 Coefficients for Wykoff height-diameter relationship fit for the Allegheny National Forest in the NE variant.

Species Code	Surrogate Species	Wykoff Coefficients	
		B_1	B_2
RM		4.6839	-4.9622
SM		4.6354	-4.7168
YB		4.4635	-3.6456
SB	YB	4.4635	-3.6456
PB	YB	4.4635	-3.6456
AB		4.5497	-4.6727
AS	WA	4.6804	-4.5561
WA		4.6804	-4.5561
GA	WA	4.6804	-4.5561
BC		4.7614	-5.3776
WO		4.9100	-7.2941
SO		4.9100	-7.2941
CO		4.9100	-7.2941
RO		4.9100	-7.2941
BO		4.9100	-7.2941
BW		4.6855	-4.8690
SE	HH	4.4393	-4.0711
HH		4.4393	-4.0711
PR	BC	4.7614	-5.3776

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 the appropriate bark ratios by species group are given in Table 4.2.1 The bark ratio values in the NE variant are from three sources. Those for red maple, sugar maple, hickory, American beech, ash, yellow-poplar, black cherry, white oak, scarlet oak, chestnut oak, red oak, black oak, commercial and non-commercial hardwoods are from Hilt (1985); the value for yellow birch is from Martin (1981); and values for balsam-fir and red spruce were calculated from stand data collected by Dale Solomon in 1977 in Northern Maine and Northern New Hampshire. The yellow birch value is also used for paper birch. For other species, surrogate values from species with similar bark attributes were used.

{4.2.1} $DIB = BRATIO * DOB$

where:

BRATIO is species-specific bark ratio
DIB is tree diameter inside bark at breast height
DOB is tree diameter outside bark at breast height

Table 4.2.1 Bark ratios by species groups for the NE variant.

Species Group	Bark Ratio
1, 2	0.9349
3	0.956
4	0.9324
5, 6, 13	0.920
7	0.890
8, 11	0.964
9, 12, 17	0.950
10	0.934
14, 15	0.948
16, 18, 19, 20, 23, 25, 26, 27, 28	0.900
21	0.940
22	0.910
24	0.880

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 NE variant, crown ratios missing in the input data, for both live and dead trees, are predicted using equation {4.3.1.1} by Holdaway (1986) with coefficients for this equation shown in table 4.3.1.1.

{4.3.1.1} $CR = 10 * (b_1 / (1 + b_2 * BA) + (b_3 * (1 – \exp(-b_4 * DBH))))$

where:

CR is crown ratio expressed as a percent
BA is total stand basal area

DBH is tree diameter at breast height
$b_1 - b_4$ are species-specific coefficients shown in table 4.3.1.1

Table 4.3.1.1 Coefficients of the crown ratio equation {4.3.1.1} in the NE variant.

Species Group	b_1	b_2	b_3	b_4
1	5.630	0.0047	3.523	-0.0689
2	6.000	0.0053	0.431	-0.0012
3	7.840	0.0057	1.272	-0.1420
4, 5	5.540	0.0072	4.200	-0.0530
6	6.640	0.0135	3.200	-0.0518
7	5.350	0.0053	1.528	-0.0330
8	6.790	0.0058	7.590	-0.0103
9, 10	5.710	0.0077	2.290	-0.2530
11	4.350	0.0046	1.820	-0.2740
12	3.400	0.0066	2.870	-0.4340
13, 14	4.180	0.0025	1.410	-0.5120
15	5.000	0.0066	4.920	-0.0263
16, 23, 27, 28	4.000	0.0024	-2.830	0.0210
17	6.210	0.0073	9.990	-0.0100
18, 19, 21, 24	3.733	0.0040	3.632	-0.0412
20	4.500	0.0032	0.795	-0.1050
22	4.110	0.0054	1.650	-0.1100
25	5.840	0.0082	3.260	-0.0490
26	4.200	0.0016	2.760	-0.0250

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 equation {4.3.1.1} by Holdaway (1986) and the coefficients shown in Table 4.3.1.1. 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.

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 NE 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 NE 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 Eastern white pine has the number: 12901.

{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

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

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 NE variant.

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
BF	01201	0.6564	0.8403		0.0792		FCW $\leq$ 34
TA	07101	-0.3276	1.3865		0.0517		FCW $\leq$ 29
WS	09401	0.3789	0.8658		0.0878		FCW $\leq$ 30
RS	09701	-1.2151	1.6098	-0.0277	0.0674	-0.0474	DBH $\leq$ 30
NS	09101	1.8336	0.9932		0.0431	0.1012	FCW $\leq$ 27
BS	09501	-0.8566	0.9693		0.0573		FCW $\leq$ 27
PI	09401	0.3789	0.8658		0.0878		FCW $\leq$ 30
RN	12501	-3.6548	1.9565	-0.0409	0.0577		DBH $\leq$ 24
WP	12901	0.3914	0.9923		0.1080		FCW $\leq$ 45
LP	13101	-0.8277	1.3946		0.0768		FCW $\leq$ 55
VP	13201	-0.1211	1.2319		0.1212		FCW $\leq$ 34
WC	24101	-0.0634	0.7057		0.0837		FCW $\leq$ 27
AW	24101	-0.0634	0.7057		0.0837		FCW $\leq$ 27
RC	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
JU	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
EH	26101	6.1924	1.4491	-0.0178		0.0341	DBH $\leq$ 40
HM	26101	6.1924	1.4491	-0.0178		0.0341	DBH $\leq$ 40
OP	12901	0.3914	0.9923		0.1080		FCW $\leq$ 45
JP	10501	0.7478	0.8712		0.0913		FCW $\leq$ 25
SP	11001	-2.2564	1.3004		0.1031	-0.0562	FCW $\leq$ 34
TM	12601	-0.9442	1.4531		0.0543	-0.1144	FCW $\leq$ 34
PP	12601	-0.9442	1.4531		0.0543	-0.1144	FCW $\leq$ 34
PD	12801	-8.7711	3.7252	-0.1063			DBH $\leq$ 18
SC	13001	3.5522	0.6742		0.0985		FCW $\leq$ 27
OS	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
RM	31601	2.7563	1.4212	-0.0143	0.0993	-0.0276	DBH $\leq$ 50
SM	31801	4.9399	1.0727		0.1096	-0.0493	FCW $\leq$ 54
BM	31801	4.9399	1.0727		0.1096	-0.0493	FCW $\leq$ 54
SV	31701	3.3576	1.1312		0.1011	-0.1730	FCW $\leq$ 45
YB	37101	-1.1151	2.2888	-0.0493	0.0985	-0.0396	DBH $\leq$ 30
SB	37201	4.6725	1.2968		0.0787		FCW $\leq$ 54
RB	37301	11.6634	1.0028				FCW $\leq$ 68
PB	37501	2.8399	1.2398		0.0855	-0.0282	FCW $\leq$ 42
GB	37501	2.8399	1.2398		0.0855	-0.0282	FCW $\leq$ 42
HI	40701	4.5453	1.3721		0.0430		FCW $\leq$ 54
PH	40301	3.9234	1.5220		0.0405		FCW $\leq$ 53
SL	40701	4.5453	1.3721		0.0430		FCW $\leq$ 54

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
SH	40701	4.5453	1.3721		0.0430		FCW ≤ 54
MH	40901	1.5838	1.6318		0.0721		FCW ≤ 55
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
PA	54101	1.7625	1.3413		0.0957		FCW ≤ 62
YP	62101	3.3543	1.1627		0.0857		FCW ≤ 61
SU	61101	1.8853	1.1625		0.0656	-0.0300	FCW ≤ 50
CT	65101	4.1711	1.6275				FCW ≤ 39
QA	74601	0.7315	1.3180		0.0966		FCW ≤ 39
BP	74101	6.2498	0.8655				FCW ≤ 25
EC	74201	3.4375	1.4092				FCW ≤ 80
BT	74301	0.6847	1.1050		0.1420	-0.0265	FCW ≤ 43
PY	74201	3.4375	1.4092				FCW ≤ 80
BC	76201	3.0237	1.1119		0.1112	-0.0493	FCW ≤ 52
WO	80201	3.2375	1.5234		0.0455	-0.0324	FCW ≤ 69
BR	82301	1.7827	1.6549		0.0343		FCW ≤ 61
CK	82601	0.5189	1.4134		0.1365	-0.0806	FCW ≤ 45
PO	83501	1.6125	1.6669		0.0536		FCW ≤ 45
OK	80201	3.2375	1.5234		0.0455	-0.0324	FCW ≤ 69
SO	80601	0.5656	1.6766		0.0739		FCW ≤ 66
QI	81701	9.8187	1.1343				FCW ≤ 54
WK	82701	1.6349	1.5443		0.0637	-0.0764	FCW ≤ 57
NP	80901	4.8935	1.6069				FCW ≤ 44
CO	83201	2.1480	1.6928	-0.0176	0.0569		DBH ≤ 50
SW	80201	3.2375	1.5234		0.0455	-0.0324	FCW ≤ 69
SN	83201	2.1480	1.6928	-0.0176	0.0569		DBH ≤ 50
RO	83301	2.8908	1.4077		0.0643		FCW ≤ 82
SK	81201	2.1517	1.6064		0.0609		FCW ≤ 56
BO	83701	2.8974	1.3697		0.0671		FCW ≤ 52
CB	81201	2.1517	1.6064		0.0609		FCW ≤ 56
BU	40701	4.5453	1.3721		0.0430		FCW ≤ 54
YY	40701	4.5453	1.3721		0.0430		FCW ≤ 54
WR	37301	11.6634	1.0028				FCW ≤ 68
HK	46201	7.1043	1.3041		0.0456		FCW ≤ 51
PS	52101	3.5393	1.3939		0.0625		FCW ≤ 36
HY	59101	4.5803	1.0747		0.0661		FCW ≤ 31
BN	60201	3.6031	1.1472		0.1224		FCW ≤ 37

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
WN	60201	3.6031	1.1472		0.1224		FCW ≤ 37
OO	93101	4.6311	1.0108		0.0564		FCW ≤ 29
MG	65301	8.2119	0.9708				FCW ≤ 41
MV	65301	8.2119	0.9708				FCW ≤ 41
AP	76102	4.1027	1.3960	1.0775			FCW ≤ 52
WT	69101	5.3409	0.7499		0.1047		FCW ≤ 37
BG	69301	5.5037	1.0567		0.0880	0.0610	FCW ≤ 50
SD	71101	7.9750	0.8303		0.0423	-0.0706	DBH ≤ 36
PW	93101	4.6311	1.0108		0.0564		FCW ≤ 29
SY	73101	-1.3973	1.3756		0.1835		FCW ≤ 66
WL	83101	1.6477	1.3672		0.0846		FCW ≤ 74
BK	90101	3.0012	0.8165		0.1395		FCW ≤ 48
BL	97201	1.7296	2.0732		0.0590	-0.0869	DBH ≤ 50
SS	93101	4.6311	1.0108		0.0564		FCW ≤ 29
BW	95101	1.6871	1.2110		0.1194	-0.0264	FCW ≤ 61
WB	95101	1.6871	1.2110		0.1194	-0.0264	FCW ≤ 61
EL	97201	1.7296	2.0732		0.0590	-0.0869	FCW ≤ 50
AE	97201	1.7296	2.0732		0.0590	-0.0869	FCW ≤ 50
RL	97501	9.0023	1.3933			-0.0785	FCW ≤ 49
OH	93101	4.6311	1.0108		0.0564		FCW ≤ 29
BE	31301	6.4741	1.0778		0.0719	-0.0637	FCW ≤ 57
ST	31301	6.4741	1.0778		0.0719	-0.0637	FCW ≤ 57
AI	49101	2.9646	1.9917		0.0707		FCW ≤ 36
SE	35601	6.9814	1.6032				FCW ≤ 27
AH	39101	0.9219	1.6303		0.1150	-0.1113	FCW ≤ 42
DW	49101	2.9646	1.9917		0.0707		FCW ≤ 36
HT	49101	2.9646	1.9917		0.0707		FCW ≤ 36
HH	70101	7.8084	0.8129		0.0941	-0.0817	FCW ≤ 39
PL	76102	4.1027	1.3960	1.0775			FCW ≤ 52
PR	76102	4.1027	1.3960	1.0775			FCW ≤ 52

[1] Equation number is a combination of the species FIA code (###) and source (##), see equations on previous page. Maximum crown widths and DBH have been assigned to prevent poor behavior beyond the source data.

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

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
BF	01203	0.3270	5.1160	0.5035			FCW ≤ 34
TA	07103	2.2050	3.4750	0.7506			FCW ≤ 29
WS	09403	3.5940	1.9630	0.8820			FCW ≤ 37

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
RS	09701	-1.2151	1.6098	-0.0277	0.0674	-0.0474	DBH $\leq$ 30
NS	09104	5.0570	1.1313				FCW $\leq$ 47
BS	09503	3.6550	1.3980	1.0000			FCW $\leq$ 27
PI	09403	3.5940	1.9630	0.8820			FCW $\leq$ 37
RN	12503	4.2330	1.4620	1.0000			FCW $\leq$ 39
WP	12903	1.6200	3.1970	0.7981			FCW $\leq$ 58
LP	13105	0.7380	0.2450	0.000809			FCW $\leq$ 66
VP	13201	-0.1211	1.2319		0.1212		FCW $\leq$ 34
WC	24101	-0.0634	0.7057		0.0837		FCW $\leq$ 27
AW	24101	-0.0634	0.7057		0.0837		FCW $\leq$ 27
RC	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
JU	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
EH	26101	6.1924	1.4491	-0.0178		-0.0341	DBH $\leq$ 40
HM	26101	6.1924	1.4491	-0.0178		-0.0341	DBH $\leq$ 40
OP	12903	1.6200	3.1970	0.7981			FCW $\leq$ 58
JP	10503	0.2990	5.6440	0.6036			FCW $\leq$ 30
SP	11005	0.5830	0.2450	0.0009			FCW $\leq$ 45
TM	12601	-0.9442	1.4531		0.0543	-0.1144	FCW $\leq$ 34
PP	12601	-0.9442	1.4531		0.0543	-0.1144	FCW $\leq$ 34
PD	12801	-8.7711	3.7252	-0.1063			DBH $\leq$ 18
SC	13001	3.5522	0.6742		0.0985		FCW $\leq$ 27
OS	06801	1.2359	1.2962		0.0545		FCW $\leq$ 33
RM	31603		4.7760	0.7656			FCW $\leq$ 55
SM	31803	0.8680	4.1500	0.7514			FCW $\leq$ 54
BM	31803	0.8680	4.1500	0.7514			FCW $\leq$ 54
SV	31701	3.3576	1.1312		0.1011	-0.1730	FCW $\leq$ 45
YB	37101	-1.1151	2.2888	-0.0493	0.0985	-0.0396	DBH $\leq$ 24
SB	37201	4.6725	1.2968		0.0787		FCW $\leq$ 54
RB	37301	11.6634	1.0028				FCW $\leq$ 68
PB	37503	3.6390	1.9530	1.0000			FCW $\leq$ 42
GB	37503	3.6390	1.9530	1.0000			FCW $\leq$ 42
HI	40703	2.3600	3.5480	0.7986			FCW $\leq$ 54
PH	40301	3.9234	1.5220		0.0405		FCW $\leq$ 53
SL	40703	2.3600	3.5480	0.7986			FCW $\leq$ 54
SH	40703	2.3600	3.5480	0.7986			FCW $\leq$ 54
MH	40901	1.5838	1.6318		0.0721		FCW $\leq$ 55
AB	53101	3.9361	1.1500		0.1237	-0.0691	FCW $\leq$ 80
AS	54403		4.7550	0.7381			FCW $\leq$ 61
WA	54101	1.7625	1.3413		0.0957		FCW $\leq$ 62
BA	54301	5.2824	1.1184				FCW $\leq$ 34

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
GA	54403		4.7550	0.7381			FCW $\leq$ 61
PA	54101	1.7625	1.3413		0.0957		FCW $\leq$ 62
YP	62101	3.3543	1.1627		0.0857		FCW $\leq$ 61
SU	61101	1.8853	1.1625		0.0656	-0.0300	FCW $\leq$ 50
CT	65101	4.1711	1.6275				FCW $\leq$ 39
QA	74603	4.2030	2.1290	1.0000			FCW $\leq$ 43
BP	74101	6.2498	0.8655				FCW $\leq$ 25
EC	74203	2.9340	2.5380	0.8617			FCW $\leq$ 80
BT	74301	0.6847	1.1050		0.1420	-0.0265	FCW $\leq$ 43
PY	74203	2.9340	2.5380	0.8617			FCW $\leq$ 80
BC	76203	0.6210	7.0590	0.5441			FCW $\leq$ 52
WO	80204	1.8000	1.8830				FCW $\leq$ 69
BR	82303	0.9420	3.5390	0.7952			FCW $\leq$ 78
CK	82601	0.5189	1.4134		0.1365	-0.0806	FCW $\leq$ 45
PO	83501	1.6125	1.6669		0.0536		FCW $\leq$ 45
OK	80204	1.8000	1.8830				FCW $\leq$ 69
SO	80601	0.5656	1.6766		0.0739		FCW $\leq$ 66
QI	81701	9.8187	1.1343				FCW $\leq$ 54
WK	82701	1.6349	1.5443		0.0637	-0.0764	FCW $\leq$ 57
NP	80901	4.8935	1.6069				FCW $\leq$ 44
CO	83201	2.1480	1.6928	-0.0176	0.0569		DBH $\leq$ 50
SW	80204	1.8000	1.8830				FCW $\leq$ 69
SN	83201	2.1480	1.6928	-0.0176	0.0569		DBH $\leq$ 50
RO	83303	2.8500	3.7820	0.7968			FCW $\leq$ 82
SK	81201	2.1517	1.6064		0.0609		FCW $\leq$ 56
BO	83704	4.5100	1.6700				FCW $\leq$ 52
CB	81201	2.1517	1.6064		0.0609		FCW $\leq$ 56
BU	40703	2.3600	3.5480	0.7986			DBH $\leq$ 54
YY	40703	2.3600	3.5480	0.7986			FCW $\leq$ 54
WR	37301	11.6634	1.0028				FCW $\leq$ 68
HK	46201	7.1043	1.3041		0.0456		FCW $\leq$ 51
PS	52101	3.5393	1.3939		0.0625		FCW $\leq$ 36
HY	59101	4.5803	1.0747		0.0661		FCW $\leq$ 31
BN	60201	3.6031	1.1472		0.1224		FCW $\leq$ 37
WN	60201	3.6031	1.1472		0.1224		FCW $\leq$ 37
OO	93101	4.6311	1.0108		0.0564		FCW $\leq$ 29
MG	65301	8.2119	0.9708				FCW $\leq$ 41
MV	65301	8.2119	0.9708				FCW $\leq$ 41
AP	76102	4.1027	1.3960	1.0775			FCW $\leq$ 52
WT	69101	5.3409	0.7499		0.1047		FCW $\leq$ 37

Species Code	Equation Number[1]	a_1	a_2	a_3	a_4	a_5	Limits and Bounds
BG	69301	5.5037	1.0567		0.0880	0.0610	FCW $\leq$ 50
SD	71101	7.9750	0.8303		0.0423	-0.0706	FCW $\leq$ 36
PW	93101	4.6311	1.0108		0.0564		FCW $\leq$ 29
SY	73101	-1.3973	1.3756		0.1835		FCW $\leq$ 66
WL	83101	1.6477	1.3672		0.0846		FCW $\leq$ 74
BK	90101	3.0012	0.8165		0.1395		FCW $\leq$ 48
BL	97203	2.8290	3.4560	0.8575			FCW $\leq$ 72
SS	93101	4.6311	1.0108		0.0564		FCW $\leq$ 29
BW	95101	1.6871	1.2110		0.1194	-0.0264	FCW $\leq$ 61
WB	95101	1.6871	1.2110		0.1194	-0.0264	FCW $\leq$ 61
EL	97203	2.8290	3.4560	0.8575			FCW $\leq$ 72
AE	97203	2.8290	3.4560	0.8575			FCW $\leq$ 72
RL	97501	9.0023	1.3933			-0.0785	FCW $\leq$ 49
OH	93101	4.6311	1.0108		0.0564		FCW $\leq$ 29
NC	49101	2.9646	1.9917		0.0707		FCW $\leq$ 36
BE	31301	6.4741	1.0778		0.0719	-0.0637	FCW $\leq$ 57
ST	31301	6.4741	1.0778		0.0719	-0.0637	FCW $\leq$ 57
AI	49101	2.9646	1.9917		0.0707		FCW $\leq$ 36
SE	35601	6.9814	1.6032				FCW $\leq$ 27
AH	39101	0.9219	1.6303		0.1150	-0.1113	FCW $\leq$ 42
DW	49101	2.9646	1.9917		0.0707		FCW $\leq$ 36
HT	49101	2.9646	1.9917		0.0707		FCW $\leq$ 36
HH	70101	7.8084	0.8129		0.0941	-0.0817	FCW $\leq$ 39
PL	76102	4.1027	1.3960	1.0775			FCW $\leq$ 52
PR	76102	4.1027	1.3960	1.0775			FCW $\leq$ 52

[1] Equation number is a combination of the species FIA code (###) and source (##), see equations on previous page. Maximum crown widths and DBH have been assigned to prevent poor behavior beyond the source data.

4.5 Crown Competition Factor

The NE 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. In the NE variant, 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 5.0” for all species in the NE 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.

FVS blends small tree growth estimates with large tree growth estimates to assure a smooth transition between the two models. In the NE variant both height growth and diameter growth estimates use this blending technique. Small and large tree estimates are weighted over the diameter range 1.5”-5.0” *DBH* for all species. The weight is calculated using equation {4.6.1} and applied as shown in equation {4.6.2}.

{4.6.1}

$DBH \leq 1.5”: XWT = 0$
$1.5” < DBH < 5.0”: XWT = (DBH – 1.5) / (5.0 – 1.5)$
$DBH \geq 5.0”: XWT = 1$

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

where:

XWT	is the weight applied to the growth estimates
DBH	is tree diameter at breast height
STGE	is the growth estimate obtained using the small-tree growth model
LTGE	is the growth estimate obtained using the large-tree growth model

For example, the closer a tree's *DBH* value is to the minimum diameter of 1.5", the more the growth estimate will be weighted towards the small-tree growth model estimate. The closer a tree's *DBH* value is to the maximum diameter of 5.0", the more the growth estimate will be weighted towards the large-tree growth model estimate. If a tree's *DBH* value falls outside of the range 1.5" – 5.0", then only the small-tree or large-tree growth model estimate is used.

4.6.1 Small Tree Height Growth

Small tree height growth is estimated by calculating a potential height growth and modifying the estimate based on intra-stand competition. The estimate is then adjusted by cycle length, scaling factors computed by FVS based on the input small-tree height increment data, and any growth multipliers entered by the user. Potential height growth and the modifier value are estimated using the same equations described in section 4.7.2 to calculate large tree height growth. However, the scaling factor, 0.8, shown in equation {4.7.2.3} is not applied when estimating small tree height growth. Small tree height growth estimates are weighted with large tree height growth estimates as described above.

4.6.2 Small Tree Diameter Growth

Small tree diameter increment is estimated using the height-diameter relationships discussed in section 4.1. The functions are algebraically solved to estimate diameter as a function of height. Height at the start of the projection cycle is known. Height at the end of the projection cycle is obtained by adding the height growth (section 4.6.1) to the starting height. Diameter is predicted at the start of the projection cycle based on the height at the start of the projection cycle; diameter at the end of the projection cycle is estimated from the height at the end of the projection cycle. Small tree diameter growth is calculated as the difference between the predicted diameter at the start of the projection cycle and predicted diameter at the end of the projection cycle, and adjusted for bark ratio. Small tree diameter growth estimates are weighted with large tree diameter growth estimates as described above.

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 5.0" for all species in the NE 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 large tree diameter growth model is adapted from Teck and Hilt (1991), which was used in the NE-TWIGS model. Potential annual basal area growth is computed using equation {4.7.1.1} and then, a modifier value based on basal area in trees at least as large as two 1-inch diameter classes below the subject tree is computed using equation {4.7.1.2}. Estimated annual basal area growth is given as the product of these two values as shown in equation {4.7.1.3}. Coefficients for these equations are given in table 4.7.1.1.

{4.7.1.1} $POTBAG = B_1 * SI * (1 - \exp(-B_2 * DBH)) * 0.7$

{4.7.1.2} $GMOD = \exp(-B_3 * BAL)$

{4.7.1.3} $ABAG = POTBAG * GMOD$

where:

POTBAG	is potential basal area growth
SI	is species site index
DBH	is tree diameter at breast height
GMOD	is a growth modifier (bounded to $0.5 \leq GMOD$)
BAL	is basal area in trees two 1-inch diameter classes below the subject tree and larger
ABAG	is estimated annual basal area growth
$B_1 - B_3$	are species-specific coefficients

Table 4.7.1.1. Coefficients ($B_1 - B_3$) for the large tree diameter growth model in the NE variant.

Species Group	B_1	B_2	B_3	Species Group	B_1	B_2	B_3
1	0.0008829	0.0602785	0.012785	16	0.0007993	0.0779654	0.015963
2	0.0009933	0.0816995	0.018831	17	0.0006911	0.0730441	0.013029
3	0.0008721	0.0578650	0.013427	18	0.0008992	0.0925395	0.015004
4	0.0008236	0.0549439	0.011942	19	0.0008815	0.1419212	0.019904
5, 7	0.0009252	0.1134195	0.017300	20	0.0011885	0.0920050	0.016877
6	0.0011303	0.0934796	0.015496	21	0.0007929	0.1568904	0.016537
8, 11	0.0006634	0.1083470	0.016835	22	0.0007417	0.0867535	0.014235
9	0.0009050	0.0517297	0.012329	23	0.0008769	0.0866621	0.018560
10	0.0008737	0.0940538	0.009149	24	0.0008238	0.0790660	0.013762
12	0.0007906	0.0651982	0.016191	25	0.0008920	0.0979702	0.018024
13	0.0007439	0.0706905	0.016240	26	0.0008550	0.0957964	0.020843
14	0.0006668	0.0768212	0.019046	27	0.0009567	0.1038458	0.020653
15	0.0009766	0.0832328	0.023978	28	0.0003604	0.0328767	0.011620

Basal area growth is then added to current tree basal area, and converted to a new tree diameter. These steps of calculating an estimated annual basal growth and calculating a new tree diameter are repeated for 10 years. Estimated 10-year diameter growth is then calculated as the difference between the estimated new diameter resulting from this iteration process, and the beginning of cycle tree diameter, adjusted for bark ratio. This is converted to a natural logarithm of basal area increment scale for application of calculated scale values, input user multipliers, and adjustment for cycle lengths other than 10-years.

4.7.2 Large Tree Height Growth

The large-tree height growth model also uses the modeling technique of estimating a potential height growth and modifying this potential growth based on tree competition. Potential height growth is estimated using site index curves from Carmean et al (1989). Surrogate curves, based on general growth form for the species, were chosen for species for which curves were not given in Carmean et al. The general form of the equation to estimate height given tree age and site index is shown in equation {4.7.2.1}. Algebraic manipulation to estimate tree age from height and site index yields the equation shown in {4.7.2.2}. Coefficients by species and which of the Carmean et al equations are used for which species are shown in table 4.7.2.1.

{4.7.2.1} $HT = b_6 + b_1 * SI\text{^}b_2 * (1 - \exp(b_3 * A))\ \text{^}\ (b_4 * SI\text{^}b_5)$

{4.7.2.2} $A = 1./b_3*(\ln(1-((HT-b_6)/b_1/SI\text{^}b_2)\text{^}(1./b_4/SI\text{^}b_5)))$

where:

HT	is tree height
SI	is species site index
A	is tree age
$b_1 - b_6$	are coefficients shown in table 4.7.2.1

$b_6 = 0$ for total age curves; $b_6 = 4.5$ for breast-height age curves

First, tree age is estimated using site index and the height of the tree at the beginning of the cycle. Next, age is incremented by 10 years and a new height is estimated using the updated age and site index. The difference between the new estimated height and the tree height at the beginning of the cycle is potential height growth. A small random component is applied to insure some distribution in estimated heights.

Potential height growth gets modified by a combination of two factors. One factor is the same modifier, GMOD, calculated using equation {4.7.1.2} and applied to large-tree diameter growth. The other is a function of individual tree height relative to the average height of the 40-largest diameter trees in the stand. The potential height growth modifier is shown in equation {4.7.2.3}, and the resulting height growth estimate is shown in equation {4.7.2.4}. Estimated height growth is then adjusted for cycle length and user-supplied growth multipliers.

{4.7.2.3} $MOD = [1 - ((1 - GMOD) * (1 - RELHT))] * 0.8$

{4.7.2.4} $HTG = POTHTG * PHMOD$

where:

POTHTG	is potential height growth
H10	is estimated height of the tree in ten years
HT	is tree height
PHMOD	is a height growth modifier
GMOD	is a growth modifier (bounded to $0.5 \leq GMOD$; calculated in section 4.7.1)

RELHT	is tree height divided by average height of the 40 largest diameter trees in the stand
HTG	is estimated height growth for the cycle

Table 4.7.2.1 Coefficients for the height growth equation by species group in the NE variant.

Species Code	Carmean et al Figure	Model Coefficients					
		b_1	b_2	b_3	b_4	b_5	b_6
BF	55	2.0770	0.9303	-0.0285	2.8937	-0.1414	0.0
TA	59	1.1151	1.0000	-0.0504	1.3076	0.0009	0.0
WS	68	1.3342	1.0008	-0.0401	1.8068	0.0248	0.0
RS	73	1.3307	1.0442	-0.0496	3.5829	0.0945	0.0
NS	63	6.7791	0.6876	-0.0280	12.1447	-0.4142	0.0
BS	70	1.7620	1.0000	-0.0201	1.2307	0.0000	0.0
PI	73	1.3307	1.0442	-0.0496	3.5829	0.0945	0.0
RN	95	1.8900	1.0000	-0.0198	1.3892	0.0000	0.0
WP	104	3.2425	0.7980	-0.0435	52.0549	-0.7064	0.0
LP	110	1.1421	1.0042	-0.0374	0.7632	0.0358	0.0
VP	125	0.7716	1.1087	-0.0348	0.1099	0.5274	0.0
WC	126	1.9730	1.0000	-0.0154	1.0895	0.0000	0.0
AW	57	1.5341	1.0013	-0.0208	0.9986	-0.0012	0.0
RC	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
JU	126	1.9730	1.0000	-0.0154	1.0895	0.0000	0.0
EH	127	2.1493	0.9979	-0.0175	1.4086	-0.0008	0.0
HM	127	2.1493	0.9979	-0.0175	1.4086	-0.0008	0.0
OP	95	1.8900	1.0000	-0.0198	1.3892	0.0000	0.0
JP	74	1.6330	1.0000	-0.0223	1.2419	0.0000	0.0
SP	78	1.4232	0.9989	-0.0285	1.2156	0.0088	0.0
TM	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
PP	125	0.7716	1.1087	-0.0348	0.1099	0.5274	0.0
PD	102	1.1266	1.0051	-0.0367	0.6780	0.0404	0.0
SC	108	1.2096	1.0027	-0.0671	1.2282	0.0335	0.0
OS	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
RM	1	2.9435	0.9132	-0.0141	1.6580	-0.1095	0.0
SM	2	3.3721	0.8407	-0.0150	2.6208	-0.2661	0.0
BM	2	3.3721	0.8407	-0.0150	2.6208	-0.2661	0.0
SV	4	1.0645	0.9918	-0.0812	1.5754	-0.0272	0.0
YB	5	2.2835	0.9794	-0.0054	0.5819	-0.0281	0.0
SB	5	2.2835	0.9794	-0.0054	0.5819	-0.0281	0.0
RB	5	2.2835	0.9794	-0.0054	0.5819	-0.0281	0.0
PB	8	1.7902	0.9522	-0.0173	1.1668	-0.1206	0.0
GB	5	2.2835	0.9794	-0.0054	0.5819	-0.0281	0.0
HI	10	1.8326	1.0015	-0.0207	1.4080	-0.0005	0.0
PH	10	1.8326	1.0015	-0.0207	1.4080	-0.0005	0.0

Species Code	Carmean et al Figure	Model Coefficients					
		b_1	b_2	b_3	b_4	b_5	b_6
SL	10	1.8326	1.0015	-0.0207	1.4080	-0.0005	0.0
SH	10	1.8326	1.0015	-0.0207	1.4080	-0.0005	0.0
MH	10	1.8326	1.0015	-0.0207	1.4080	-0.0005	0.0
AB	11	29.7300	0.3631	-0.0127	16.7616	-0.6804	0.0
AS	12	1.5768	0.9978	-0.0156	0.6705	0.0182	0.0
WA	12	1.5768	0.9978	-0.0156	0.6705	0.0182	0.0
BA	14	4.2286	0.7857	-0.0178	4.6219	-0.3591	0.0
GA	15	1.6505	0.9096	-0.0644	125.7045	-0.8908	0.0
PA	15	1.6505	0.9096	-0.0644	125.7045	-0.8908	0.0
YP	25	1.2941	0.9892	-0.0315	1.0481	-0.0368	0.0
SU	19	1.5932	1.0124	-0.0122	0.6245	0.0130	0.0
CT	25	1.2941	0.9892	-0.0315	1.0481	-0.0368	0.0
QA	32	5.2188	0.6855	-0.0301	50.0071	-0.8695	0.0
BP	25	1.2941	0.9892	-0.0315	1.0481	-0.0368	0.0
EC	28	1.3615	0.9813	-0.0675	1.5494	-0.0767	0.0
BT	32	5.2188	0.6855	-0.0301	50.0071	-0.8695	0.0
PY	30	1.2834	0.9571	-0.0680	100.0000	-0.9223	0.0
BC	35	7.1846	0.6781	-0.0222	13.9186	-0.5268	0.0
WO	41	4.5598	0.8136	-0.0132	2.2410	-0.1880	0.0
BR	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
CK	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
PO	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
OK	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
SO	42	1.6763	0.9837	-0.0220	0.9949	0.0240	0.0
QI	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
WK	44	1.3466	0.9590	-0.0574	8.9538	-0.3454	0.0
PN	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
CO	46	1.9044	0.9752	-0.0162	0.9262	0.0000	0.0
SW	44	1.3466	0.9590	-0.0574	8.9538	-0.3454	0.0
SN	44	1.3466	0.9590	-0.0574	8.9538	-0.3454	0.0
RO	38	0.4737	1.2905	-0.0236	0.0979	0.6121	0.0
SK	37	1.2866	0.9962	-0.0355	1.4485	-0.0316	0.0
BO	49	2.9989	0.8435	-0.0200	3.4635	-0.3020	0.0
CB	43	1.0945	0.9938	-0.0755	2.5601	0.0114	0.0
BU	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
YY	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
WR	5	2.2835	0.9794	-0.0054	0.5819	-0.0281	0.0
HK	19	1.5932	1.0124	-0.0122	0.6245	0.0130	0.0
PS	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
HY	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0

Species Code	Carmean et al Figure	Model Coefficients					
		b_1	b_2	b_3	b_4	b_5	b_6
BN	16	1.2898	0.9982	-0.0289	0.8546	0.0171	0.0
WN	16	1.2898	0.9982	-0.0289	0.8546	0.0171	0.0
OO	50	0.9680	1.0301	-0.0468	0.1639	0.4127	0.0
MG	27	1.3213	0.9995	-0.0254	0.8549	-0.0016	0.0
MV	27	1.3213	0.9995	-0.0254	0.8549	-0.0016	0.0
AP	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
WT	26	1.2721	0.9995	-0.0256	0.7447	-0.0019	0.0
BG	27	1.3213	0.9995	-0.0254	0.8549	-0.0016	0.0
SD	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
PW	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
SY	25	1.2941	0.9892	-0.0315	1.0481	-0.0368	0.0
WL	36	2.1037	0.9140	-0.0275	3.7962	-0.2530	0.0
BK	50	0.9680	1.0301	-0.0468	0.1639	0.4127	0.0
BL	50	0.9680	1.0301	-0.0468	0.1639	0.4127	0.0
SS	50	0.9680	1.0301	-0.0468	0.1639	0.4127	0.0
BW	51	4.7633	0.7576	-0.0194	6.5110	-0.4156	0.0
WB	51	4.7633	0.7576	-0.0194	6.5110	-0.4156	0.0
EL	53	6.4362	0.6827	-0.0194	10.9767	-0.5477	0.0
AE	53	6.4362	0.6827	-0.0194	10.9767	-0.5477	0.0
RL	53	6.4362	0.6827	-0.0194	10.9767	-0.5477	0.0
OH	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
BE	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
ST	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
AI	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
SE	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
AH	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
DW	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
HT	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
HH	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
PL	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0
PR	58	0.9276	1.0591	-0.0424	0.3529	0.3114	0.0

5.0 Mortality Model

The NE 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} $RI = [1 / (1 + \exp(p_0 + p_1 * DBH))] * 0.5$

{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 NE variant.

Species Code	p_0	p_1
BF	5.1676998	-0.0077681
TA	5.1676998	-0.0077681
WS	5.1676998	-0.0077681
RS	5.1676998	-0.0077681
NS	5.1676998	-0.0077681
BS	5.1676998	-0.0077681
PI	5.1676998	-0.0077681
RN	5.1676998	-0.0077681
WP	5.5876999	-0.0053480
LP	5.5876999	-0.0053480
VP	5.5876999	-0.0053480
WC	5.1676998	-0.0077681
AW	5.1676998	-0.0077681

Species Code	p_0	p_1
RC	5.5876999	-0.0053480
JU	5.5876999	-0.0053480
EH	5.1676998	-0.0077681
HM	5.1676998	-0.0077681
OP	5.5876999	-0.0053480
JP	5.1676998	-0.0077681
SP	5.5876999	-0.0053480
TM	5.5876999	-0.0053480
PP	5.5876999	-0.0053480
PD	5.5876999	-0.0053480
SC	5.5876999	-0.0053480
OS	9.6942997	-0.0127328
RM	5.1676998	-0.0077681
SM	5.1676998	-0.0077681
BM	5.1676998	-0.0077681
SV	5.1676998	-0.0077681
YB	5.9617000	-0.0340128
SB	5.1676998	-0.0077681
RB	5.9617000	-0.0340128
PB	5.9617000	-0.0340128
GB	5.9617000	-0.0340128
HI	5.9617000	-0.0340128
PH	5.9617000	-0.0340128
SL	5.9617000	-0.0340128
SH	5.9617000	-0.0340128
MH	5.9617000	-0.0340128
AB	5.1676998	-0.0077681
AS	5.1676998	-0.0077681
WA	5.9617000	-0.0340128
BA	5.9617000	-0.0340128
GA	5.1676998	-0.0077681
PA	5.1676998	-0.0077681
YP	5.9617000	-0.0340128
SU	5.9617000	-0.0340128
CT	5.9617000	-0.0340128
QA	5.9617000	-0.0340128
BP	5.9617000	-0.0340128
EC	5.9617000	-0.0340128
BT	5.9617000	-0.0340128

Species Code	p_0	p_1
PY	5.9617000	-0.0340128
BC	5.9617000	-0.0340128
WO	5.9617000	-0.0340128
BR	5.9617000	-0.0340128
CK	5.9617000	-0.0340128
PO	5.9617000	-0.0340128
OK	5.9617000	-0.0340128
SO	5.9617000	-0.0340128
QI	5.9617000	-0.0340128
WK	5.9617000	-0.0340128
PN	5.9617000	-0.0340128
CO	5.9617000	-0.0340128
SW	5.9617000	-0.0340128
SN	5.9617000	-0.0340128
RO	5.9617000	-0.0340128
SK	5.9617000	-0.0340128
BO	5.9617000	-0.0340128
CB	5.9617000	-0.0340128
BU	5.1676998	-0.0077681
YY	5.1676998	-0.0077681
WR	5.9617000	-0.0340128
HK	5.9617000	-0.0340128
PS	5.9617000	-0.0340128
HY	5.9617000	-0.0340128
BN	5.9617000	-0.0340128
WN	5.9617000	-0.0340128
OO	5.9617000	-0.0340128
MG	5.1676998	-0.0077681
MV	5.9617000	-0.0340128
AP	5.9617000	-0.0340128
WT	5.9617000	-0.0340128
BG	5.1676998	-0.0077681
SD	5.1676998	-0.0077681
PW	5.9617000	-0.0340128
SY	5.9617000	-0.0340128
WL	5.9617000	-0.0340128
BK	5.1676998	-0.0077681
BL	5.1676998	-0.0077681
SS	5.1676998	-0.0077681

Species Code	p_0	p_1
BW	5.1676998	-0.0077681
WB	5.1676998	-0.0077681
EL	5.1676998	-0.0077681
AE	5.1676998	-0.0077681
RL	5.1676998	-0.0077681
OH	5.9617000	-0.0340128
BE	5.9617000	-0.0340128
ST	5.9617000	-0.0340128
AI	5.9617000	-0.0340128
SE	5.9617000	-0.0340128
AH	5.1676998	-0.0077681
DW	5.1676998	-0.0077681
HT	5.9617000	-0.0340128
HH	5.1676998	-0.0077681
PL	5.9617000	-0.0340128
PR	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} $MR = 0.84525 – (0.01074 * RELHT) + (0.0000002 * RELHT^3)$

{5.0.4} $MORT = MR * (1 – MWT) * 0.1$

where:

MR	is the proportion of the tree record attributed to mortality (bounded: $0.01 \leq MR \leq 1$)
RELHT	is tree height divided by average height of the 40 largest diameter trees in the stand
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 NE variant.

Species Code	*MWT*
BF	0.90
TA	0.10
WS	0.50
RS	0.80
NS	0.50
BS	0.70
PI	0.50
RN	0.30
WP	0.50
LP	0.30
VP	0.30
WC	0.70
AW	0.50
RC	0.20
JU	0.50
EH	0.70
HM	0.90
OP	0.30
JP	0.30
SP	0.30
TM	0.30
PP	0.30
PD	0.30
SC	0.30
OS	0.30
RM	0.85
SM	0.90
BM	0.10
SV	0.70
YB	0.50
SB	0.30
RB	0.30
PB	0.30
GB	0.30
HI	0.50
PH	0.50
SL	0.90
SH	0.50
MH	0.30

Species Code	*MWT*
WO	0.50
BR	0.50
CK	0.30
PO	0.30
OK	0.30
SO	0.10
QI	0.30
WK	0.30
PN	0.30
CO	0.50
SW	0.50
SN	0.30
RO	0.50
SK	0.50
BO	0.50
CB	0.30
BU	0.70
YY	0.70
WR	0.30
HK	0.50
PS	0.90
HY	0.90
BN	0.30
WN	0.30
OO	0.30
MG	0.70
MV	0.50
AP	0.40
WT	0.30
BG	0.30
SD	0.70
PW	0.30
SY	0.50
WL	0.30
BK	0.10
BL	0.10
SS	0.30
BW	0.70
WB	0.70

Species Code	*MWT*
AB	0.70
AS	0.30
WA	0.30
BA	0.30
GA	0.70
PA	0.50
YP	0.30
SU	0.30
CT	0.50
QA	0.10
BP	0.10
EC	0.10
BT	0.10
PY	0.30
BC	0.40

Species Code	*MWT*
EL	0.50
AE	0.50
RL	0.70
OH	0.30
BE	0.70
ST	0.90
AI	0.30
SE	0.50
AH	0.90
DW	0.90
HT	0.30
HH	0.70
PL	0.30
PR	0.10

6.0 Regeneration

The NE 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 for sprouting species).

Table 6.0.1 Regeneration parameters by species in the NE variant.

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
BF	No	0.1	0.33	20.0
TA	No	0.1	0.50	24.0
WS	No	0.2	0.25	18.0
RS	No	0.2	0.25	16.0
NS	No	0.2	0.25	18.0
BS	No	0.2	0.25	16.0
PI	No	0.2	0.25	16.0
RN	No	0.1	0.25	18.0
WP	No	0.4	0.33	20.0
LP	No	0.5	0.25	14.0
VP	No	0.5	0.42	14.0
WC	No	0.1	0.33	16.0
AW	No	0.1	0.33	16.0
RC	No	0.5	0.33	16.0
JU	No	0.5	0.33	16.0
EH	No	0.1	0.25	16.0
HM	No	0.1	0.25	16.0
OP	No	0.5	0.25	16.0
JP	No	0.1	0.33	14.0
SP	Yes	0.4	0.25	14.0
TM	No	0.5	0.25	16.0
PP	No	0.5	0.42	18.0
PD	No	0.5	0.25	12.0
SC	No	0.5	0.33	20.0
OS	No	0.3	0.25	16.0
RM	Yes	0.2	1.00	20.0
SM	Yes	0.2	0.25	16.0
BM	Yes	0.2	0.25	16.0

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
SV	Yes	0.2	0.42	18.0
YB	Yes	0.1	0.42	22.0
SB	Yes	0.1	0.42	20.0
RB	Yes	0.1	0.33	18.0
PB	Yes	0.1	0.42	18.0
GB	Yes	0.1	0.42	18.0
HI	Yes	0.3	0.33	14.0
PH	Yes	0.3	0.33	14.0
SL	Yes	0.3	0.33	14.0
SH	Yes	0.3	0.33	14.0
MH	Yes	0.3	0.33	18.0
AB	Yes	0.1	0.25	14.0
AS	Yes	0.2	0.42	24.0
WA	Yes	0.2	0.42	24.0
BA	Yes	0.2	0.33	18.0
GA	Yes	0.2	0.42	24.0
PA	Yes	0.2	0.42	28.0
YP	Yes	0.2	0.42	24.0
SU	Yes	0.2	0.33	18.0
CT	Yes	0.2	0.33	20.0
QA	Yes	0.3	0.42	20.0
BP	Yes	0.2	0.42	24.0
EC	Yes	0.1	0.42	24.0
BT	Yes	0.2	0.42	20.0
PY	Yes	0.2	0.42	20.0
BC	Yes	0.1	0.42	26.0
WO	Yes	0.2	0.33	16.0
BR	Yes	0.2	0.25	14.0
CK	Yes	0.1	0.33	12.0
PO	Yes	0.1	0.25	12.0
OK	Yes	0.2	0.33	16.0
SO	Yes	0.2	0.33	16.0
QI	Yes	0.2	0.25	14.0
WK	Yes	0.1	0.33	16.0
PN	Yes	0.2	0.25	14.0
CO	Yes	0.2	0.33	16.0
SW	Yes	0.1	0.33	16.0
SN	Yes	0.2	0.33	12.0
RO	Yes	0.2	0.42	20.0
SK	Yes	0.1	0.33	16.0

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
BO	Yes	0.2	0.33	16.0
CB	Yes	0.1	0.33	14.0
BU	Yes	0.1	0.25	12.0
YY	Yes	0.1	0.25	12.0
WR	Yes	0.1	0.25	12.0
HK	Yes	0.1	0.25	12.0
PS	Yes	0.1	0.25	12.0
HY	Yes	0.1	0.25	12.0
BN	Yes	0.3	0.33	18.0
WN	Yes	0.4	0.33	20.0
OO	Yes	0.1	0.25	12.0
MG	Yes	0.2	0.42	20.0
MV	Yes	0.2	0.42	20.0
AP	Yes	0.2	0.42	20.0
WT	Yes	0.2	0.33	20.0
BG	Yes	0.2	0.33	16.0
SD	Yes	0.2	0.33	16.0
PW	Yes	0.1	0.33	16.0
SY	Yes	0.1	0.58	24.0
WL	Yes	0.1	0.25	14.0
BK	Yes	0.1	0.58	24.0
BL	Yes	0.1	1.00	32.0
SS	Yes	0.1	0.50	18.0
BW	Yes	0.1	0.33	16.0
WB	Yes	0.1	0.33	16.0
EL	Yes	0.1	0.33	16.0
AE	Yes	0.1	0.33	16.0
RL	Yes	0.1	0.33	12.0
OH	No	0.1	0.33	10.0
BE	Yes	0.3	0.33	16.0
ST	Yes	0.1	0.25	18.0
AI	Yes	0.1	1.00	30.0
SE	Yes	0.1	0.42	20.0
AH	Yes	0.2	0.42	20.0
DW	Yes	0.1	0.25	18.0
HT	Yes	0.1	0.25	16.0
HH	Yes	0.2	0.42	20.0
PL	Yes	0.2	0.33	20.0
PR	Yes	0.1	0.33	30.0

The number of sprout records created for each sprouting species is found in table 6.0.2. For more prolific stump sprouting hardwood species, logic rule {6.0.1} is used to determine the number of sprout records, with logic rule {6.0.2} being used for root suckering species. The trees-per-acre represented by each sprout record is determined using the general sprouting probability equation {6.0.3}. 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 6.0.1 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 stump sprouting hardwood species

$DSTMP_i \leq 5$: $NUMSPRC = 1$
$5 < DSTMP_i \leq 10$: $NUMSPRC = \mathrm{NINT}(0.2 * DSTMP_i)$
$DSTMP_i > 10$: $NUMSPRC = 2$

{6.0.2} For root suckering hardwood species

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

{6.0.3} $TPA_s = TPA_i * PS$

{6.0.4} $PS = (1.6134 - 0.0184 * (((DSTMP_i / 0.7788 - 0.21525) * 2.54)))/(1 + \exp(1.6134 - 0.0184 * (((DSTMP_i / 0.7788) - 0.21525) * 2.54)))$

{6.0.5} $PS = (6.0065 - 0.0777*((DSTMP_i / 0.7801) * 2.54)) / (1 + \exp(6.0065 - 0.0777 * ((DSTMP_i / 0.7801) * 2.54)))$

{6.0.6} $PS = (6.4205 - 0.1097 * (((DSTMP_i / 0.8188 - 0.23065) * 2.54))) / (1 + \exp(6.4205 - 0.1097 * (((DSTMP_i / 0.8188) - 0.23065) * 2.54)))$

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

{6.0.8} $PS = (1 / (1 + \exp(-(2.7386 + (-0.1076 * DSTMP_i)))))$

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

{6.0.10} $PS = (TPA_i / (ASTPAR * 2)) * ((ASBAR / 198) * (40100.45 - 3574.02 * RSHAG^2 + 554.02 * RSHAG^3 - 3.5208 * RSHAG^5 + 0.011797 * RSHAG^7))$

{6.0.11} $PS = ((89.191 - 2.611 * DSTMP_i) / 100)$

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)
ASBAR is the aspen basal area removed
ASTPAR is the aspen trees per acre removed
RSHAG is the age of the sprouts at the end of the cycle in which they were created

Table 6.0.2 Sprouting algorithm parameters for sprouting species in the NE variant.

Species Code	Sprouting Probability	Number of Sprout Records	Source*
SP	0.42 for DBH < 7”, 0 for DBH > 7”	1, 0	Wayne Clatterbuck (personal communication) Ag. Handbook 654
RM	0.8 for DBH < 12”, 0.5 for DBH > 12”	{6.0.1}	Solomon and Barton 1967 Prager and Goldsmith 1977
SM	{6.0.11}	{6.0.1}	MacDonald and Powell 1983 Ag. Handbook 654
BM	{6.0.11}	{6.0.1}	Tirmenstein 1991
SV	0.8 for DBH < 12”, 0.5 for DBH > 12”	{6.0.1}	Ag. Handbook 654
YB	0.3	1	Solomon and Barton 1967 Perala 1974
SB	0.7	1	Ag. Handbook 654
RB	0.7	1	Sullivan 1993
PB	0.9	1	Hutnik and Cunningham 1965 Bjorkbom 1972
GB	0.7	1	Coladonato 1992
HI	0.95 for DBH < 24", 0.6 for DBH > 24"	1	Ag. Handbook 654
PH	0.75 for DBH < 24", 0.5 for DBH > 24"	1	Ag. Handbook 654
SL	0.75 for DBH < 24", 0.5 for DBH > 24"	1	Ag. Handbook 654
SH	0.95 for DBH < 24", 0.6 for DBH > 24"	1	Nelson 1965
MH	0.95 for DBH < 24", 0.6 for DBH > 24"	1	Nelson 1965
AB	0.93	{6.0.2}	Keyser and Loftis 2015

Species Code	Sprouting Probability	Number of Sprout Records	Source*
AS	0.8 for DBH < 12", 0.5 for DBH > 12"	1	Ag. Handbook 654
WA	0.8 for DBH < 12", 0.5 for DBH > 12"	1	Ag. Handbook 654
BA	0.8 for DBH < 12", 0.5 for DBH > 12"	{6.0.1}	Curtis 1959 Lees and West 1988
GA	0.8 for DBH < 12", 0.5 for DBH > 12"	1	Ag. Handbook 654
PA	0.8 for DBH < 12", 0.5 for DBH > 12"	{6.0.1}	Ag. Handbook 654
YP	0.8 for DBH < 25", 0.5 for DBH > 25"	{6.0.2}	Ag. Handbook 654
SU	0.7	1	Coladonato 1992 Ag. Handbook 654
CT	0.7	1	Ag. Handbook 654
QA	{6.0.10}	2	Keyser 2001
BP	0.8 for DBH < 25", 0.5 for DBH > 25"	{6.0.2}	Ag. Handbook 654
EC	0.4 for DBH < 25", 0 for DBH > 25"	1, 0	Ag. Handbook 654
BT	0.8	{6.0.2}	Ag. Handbook 654
PY	0.4 for DBH < 12", 0 for DBH > 12"	1, 0	Ag. Handbook 654
BC	0.8 for DBH < 25", 0.5 for DBH > 25"	{6.0.2}	Hough 1965 Powell and Tryon 1979
WO	{6.0.4}	{6.0.1}	Sands and Abrams 2009 Westfall 2010 Ag. Handbook 654
BR	0.8	1	Deitschmann 1965 Perala 1974
CK	0.7	1	Ag. Handbook 654
PO	{6.0.9}	{6.0.1}	Johnson 1977 Ag. Handbook 654
OK	{6.0.7}	{6.0.1}	See red oak (RO)
SO	{6.0.7}	{6.0.1}	Johnson 1975 Ag. Handbook 654
QI	{6.0.7}	{6.0.1}	Johnson 1975 Ag. Handbook 654
WK	0.7	1	Carey 1992
PN	0.8	1	Ag. Handbook 654

Species Code	Sprouting Probability	Number of Sprout Records	Source*
CO	{6.0.6}	1	Sands and Abrams 2009 Westfall 2010 Ag. Handbook 654
SW	90% of Eq. {6.0.1} predictions	1	Ag. Handbook 654
SN	{6.0.6}	1	Sands and Abrams 2009 Westfall 2010 Ag. Handbook 654
RO	{6.0.7}	{6.0.1}	Johnson 1975 Ag. Handbook 654
SK	0.8 for DBH < 10", 0.5 for DBH > 10"	{6.0.1}	Ag. Handbook 654
BO	{6.0.5}	1	Sands and Abrams 2009 Westfall 2010 Ag. Handbook 654
CB	{6.0.7}	{6.0.1}	Johnson 1975 Ag. Handbook 654
BU	0.4 for DBH < 8", 0 for DBH > 8"	1, 0	Ag. Handbook 654
YY	0.4 for DBH < 8", 0 for DBH > 8"	1, 0	Ag. Handbook 654
WR	0.5	1	Gucker 2012
HK	0.4 for DBH < 8", 0 for DBH > 8"	1, 0	Ag. Handbook 654
PS	0.7	1	Ag. Handbook 654
HY	0.5	1	Coladonato 1991 Ag. Handbook 654
BN	0.3 for DBH < 8", 0 for DBH > 8"	1, 0	Ag. Handbook 654
WN	0.8 for DBH < 8", 0.5 for DBH > 8"	1	Schlesinger 1977 Schlesinger 1989 Coladonato 1991
OO	0.8	1	Carey 1994-1
MG	{6.0.8}	1	Keyser and Loftis 2015
MV	0.8	{6.0.2}	Jones et al. 2000
AP	0.5	1	See American holly (HY)
WT	0.9	1	Hook and DeBell 1970 Ag. Handbook 654
BG	0.9	1	Coladonato 1992
SD	0.9	{6.0.1}	Ag. Handbook 654

Species Code	Sprouting Probability	Number of Sprout Records	Source*
PW	0.8	{6.0.2}	Tang et al. 1980
SY	0.7	1	Steinbeck et al. 1972 Sullivan 1994
WL	0.8 for DBH < 10", 0.5 for DBH > 10"	1	Ag. Handbook 654
BK	0.9	{6.0.1}	Ag. Handbook 654
BL	0.9	1	Ag. Handbook 654
SS	0.8	{6.0.2}	Ag. Handbook 654
BW	0.8	{6.0.2}	Ag. Handbook 654
WB	0.8	{6.0.2}	Ag. Handbook 654
EL	0.7	1	Ag. Handbook 654
AE	0.7	1	Ag. Handbook 654
RL	0.7	1	Ag. Handbook 654
BE	0.6 for DBH < 15", 0.3 for DBH > 15"	1	Maeglin and Ohman 1973 Eyre 1980
ST	0.3	1	Hibbs and Burnell 1979 Coladonato 1993
AI	0.8	[B]	Swingle 1916 Fryer 2010
SE	0.7	[A]	Snyder 1992
AH	No info available—default to 0.7	1	n/a
DW	0.7 for DBH < 8", 0.9 for DBH > 8"	[A]	Ag. Handbook 654
HT	No info available—default to 0.7	1	n/a
HH	0.8	1	Ag. Handbook 654
PL	0.7	1	See pin cherry (PR)
PR	0.7	1	Ag. Handbook 654

*Many of the sources stemmed from those referenced in Agricultural Handbook 654, Silvics of North America. For the sake of being concise, only "Ag. Handbook 654" was listed when multiple publications were referenced from that handbook. When necessary, species-specific probabilities were based upon similarities with other species, either due to documented similarities or an assumed similarity. In the latter cases, assumptions were necessary due to a lack of previous research findings for these species.

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 6.0.1. 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 (International ¼-inch). 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 the NE variant are shown in table 7.0.1.

Table 7.0.1 Volume merchantability standards for the NE variant.

Pulpwood Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
919 – Allegheny	6.0 / 5.0 inches	5.0 / 4.0 inches
920 – Green Mountain-Finger Lakes	8.0 / 4.0 inches	5.0 / 4.0 inches
921 – Monongahela	5.0 / 4.0 inches	5.0 / 4.0 inches
914 – Wayne, 911 – Wayne-Hoosier	6.0 / 4.0 inches	5.0 / 4.0 inches
922 – White Mountain	5.0 / 4.0 inches	5.0 / 4.0 inches
Stump Height	0.5 feet	0.5 feet
Sawtimber Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
All location codes	11.0 / 9.6 inches	9.0 / 7.6 inches
Stump Height	1.0 foot	1.0 foot

For both cubic and board foot prediction, Clark's profile models (Clark et al. 1991) are used for all species and all location codes in the NE variant. Equation number is 900CLKE***, where *** signifies the three-digit FIA 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 NE 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 NE variant. However, FVS addfiles that simulate the effects of known agents within the NE variant may be found in chapter 8 of the Essential FVS Users Guide (Dixon 2002).

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11.0 Appendices

There are no appendices for the NE variant.

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