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South Central Oregon and Northeast California (SO) Variant Overview

Forest Vegetation Simulator

Ponderosa pine stand in Northern California
(Amy Jo Krommes, FS-R6)

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Authors and Contributors:

The FVS staff has maintained model documentation for this variant in the form of a variant overview since its release in 1984. The original author was Gary Dixon. 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. Stephanie Rebain cross-checked information contained in this variant overview with the FVS source code.

FVS Staff. 2008 (revised June 28, 2021). South Central Oregon and Northeast California (SO) Variant Overview – Forest Vegetation Simulator. Internal Rep. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Forest Management Service Center. 100p.

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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)	601 – Deschutes	
Plant Association Code (Region 6 & Warm Springs Reservation)	49 (CPS111 PIPO/PUTR-ARTR/FEID)	
Slope	5 percent	
Aspect	0 (no meaningful aspect)	
Elevation	45 (4500 feet)	
Latitude / Longitude	Latitude	Longitude
All location codes	42	121
Site Species (Region 5 / Region 6 & Warm Springs Reservation)	WF / Plant Association Code Specific	
Site Index (Region 5 / Region 6 and Warm Springs Reservation)	50 feet / Plant Association Code Specific	
Maximum Stand Density Index	Species or Plant Association Code specific	
Maximum Basal Area	Based on maximum stand density index	
Volume Equations	National Volume Estimator Library	
Merchantable Cubic Foot Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
Region 5	9.0 / 6.0 inches	9.0 / 6.0 inches
Region 6 and Warm Springs Reservation	9.0 / 4.5 inches	9.0 / 4.5 inches
Stump Height	1.0 foot	1.0 foot
Merchantable Board Foot Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
Region 5	9.0 / 6.0 inches	9.0 / 6.0 inches
Region 6 and Warm Springs Reservation	9.0 / 4.5 inches	9.0 / 4.5 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 Southern Oregon / Northeastern California (SO) variant was developed in 1984. This variant includes all or part of the Deschutes, Fremont, Winema, Klamath, Lassen, Modoc, Plumas, Shasta, and Trinity National Forests, corresponding BLM and Industry lands, and lands managed by the Confederated Tribes of Warm Springs. Data used in building the original SO variant came from forest inventories, silviculture stand examinations, research plots, and tree plantation studies.

The SO variant was expanded from its original 11 species to 33 species in 2004. Growth relationships for the additional 22 species were drawn from other FVS variants including West Cascades (WC – noble fir, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, and other hardwoods), East Cascades (EC – Pacific silver fir, western larch, western redcedar), Inland California/Southern Cascades (CA – Shasta red fir and Oregon white oak), Utah (UT – western juniper and quaking aspen) and Tetons (TT – whitebark pine).

The SO variant is one of three variants used by the Confederated Tribes of Warm Springs. In 2015, after completion of an analysis by the FMSC regarding which variant performed the best for which species on the Reservation, the tribes decided to use the SO variant as the designated variant for their lands, requested their own unique location code be added, and when that location code is specified, large tree diameter growth would be predicted with a designated equation from one of the three variants they previously used (SO, EC, or WC).

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 SO variant was fit to data representing forest types in southern Oregon and northeastern California. Data used in building the original SO variant came from forest inventories, silviculture stand examinations, research plots, and tree plantation studies from national forest, BLM, and industry lands. Distribution of data samples for species fit from this data are shown in Appendix A.

The SO variant covers forest areas in south-central Oregon and northeastern California. The suggested geographic range of use for the SO variant is shown in figure 2.0.1.

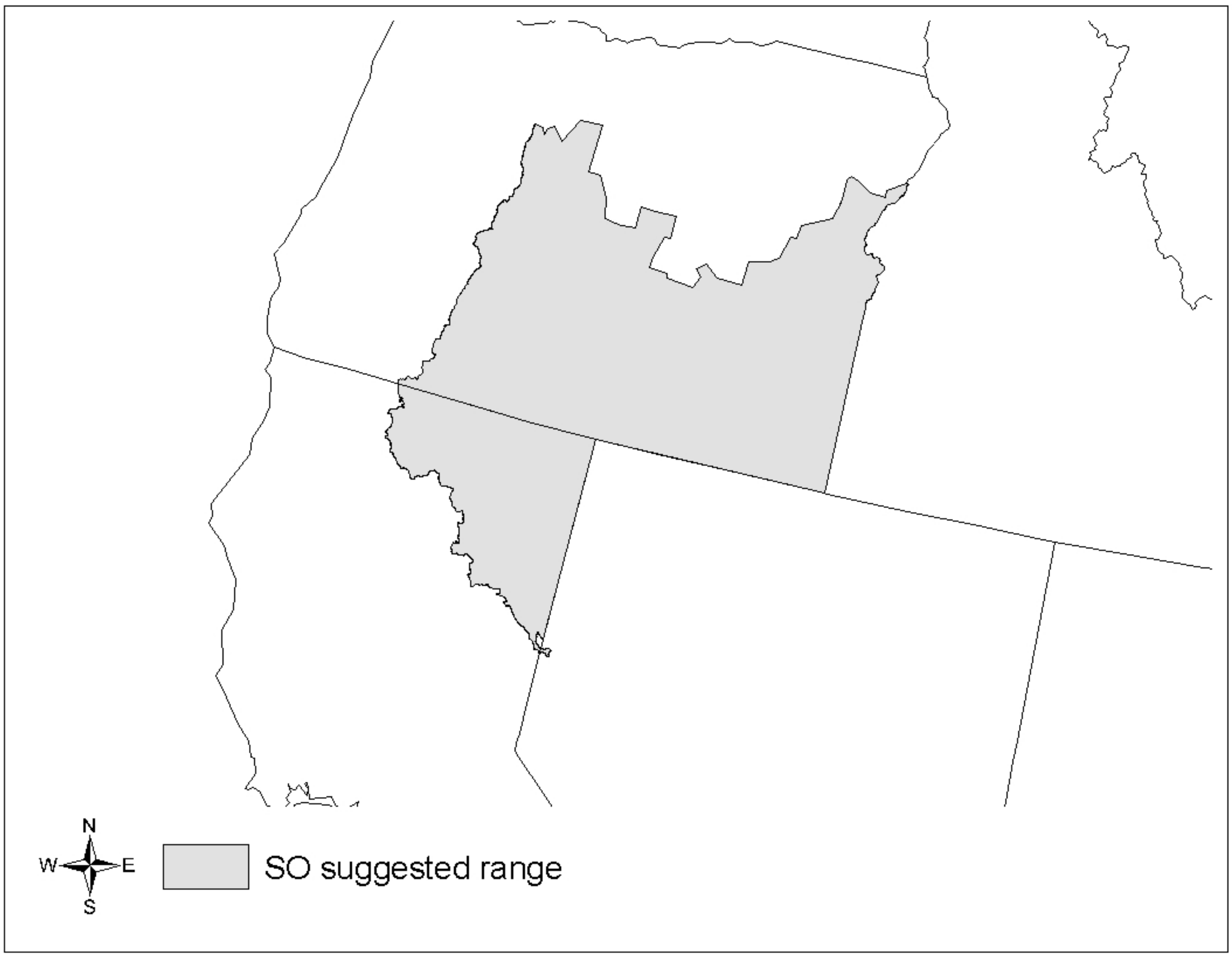

Figure 2.0.1 Suggested geographic range of use for the SO variant.

Within USFS Region 5, the following forests and districts should use the SO variant: Goosenest district of the Klamath NF, Eagle Lake district of the Lassen NF, all districts on the Modoc NF, and the McCloud district of the Shasta-Trinity NF (Warbington 2004, based on Spreadsheet provided by Ralph Warbington, R5 Ecosystem Planning Staff, Remote Sensing Lab, http://www.fs.fed.us/r5/rsl/).

3.0 Control Variables

FVS users need to specify certain variables used by the SO 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 SO variant, a default forest code of 601 (Deschutes National Forest) will be used. Location codes recognized in the SO variant are shown in tables 3.1.1 and 3.1.2.

Table 3.1.1 Location codes used in the SO variant.

Location Code	Location
505	Klamath National Forest
506	Lassen National Forest
509	Modoc National Forest
511	Plumas National Forest
601	Deschutes National Forest
602	Fremont National Forest
620	Winema National Forest
701, 702	Industry Lands (702 mapped to 701)
799	Confederated Tribes of Warm Springs
514	Shasta-Trinity (mapped to 505)

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

Location Code	Location
7711	Fort Mcdermitt Reservation (mapped to 602)
7836	Fort Bidwell Reservation (mapped to 509)
7838	Susanville Indian Rancheria (mapped to 506)
7844	Cedarville Rancheria (mapped to 509)

3.2 Species Codes

The SO variant recognizes 33 species. 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 western species codes identifying species not recognized by the variant will be mapped to the most similar species in the variant. The species mapping crosswalk is available on the variant documentation webpage of the FVS website. Any non-valid species code will default to the “other hardwoods” 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 SO variant.

Table 3.2.1 Species codes used in the SO variant.

Species Number	Species Code	Common Name	FIA Code	PLANTS Symbol	Scientific Name
1	WP	western white pine	119	PIMO3	*Pinus monticola*
2	SP	sugar pine	117	PILA	*Pinus lambertiana*
3	DF	Douglas-fir	202	PSME	*Pseudotsuga menziesii*
4	WF	white fir	015	ABCO	*Abies concolor*
5	MH	mountain hemlock	264	TSME	*Tsuga mertensiana*
6	IC	incense-cedar	081	CADE27	*Libocedrus decurrens*
7	LP	lodgepole pine	108	PICO	*Pinus contorta*
8	ES	Engelmann spruce	093	PIEN	*Picea engelmannii*
9	SH	Shasta red fir	021	ABSH	*Abies magnifica (shastensis)*
10	PP	ponderosa pine/Jeffrey pine	122	PIPO	*Pinus ponderosa/Pinus jeffreyi*
11	WJ	western juniper	064	JUOC	*Juniperus occidentalis*
12	GF	grand fir	017	ABGR	*Abies grandis*
13	AF	subalpine fir	019	ABLA	*Abies lasiocarpa*
14	SF	Pacific silver fir	011	ABAM	*Abies amabilis*
15	NF	noble fir	022	ABPR	*Abies procera*
16	WB	whitebark pine	101	PIAL	*Pinus albicaulis*
17	WL	western larch	073	LAOC	*Larix occidentalis*
18	RC	western redcedar	242	THPL	*Thuja plicata*
19	WH	western hemlock	263	TSHE	*Tsuga heterophylla*
20	PY	Pacific yew	231	TABR2	*Taxus brevifolia*
21	WA	white alder	352	ALRH2	*Alnus rhombifolia*
22	RA	red alder	351	ALRU2	*Alnus rubra*
23	BM	bigleaf maple	312	ACMA3	*Acer macrophyllum*
24	AS	quaking aspen	746	POTR5	*Populus tremuloides*
25	CW	black cottonwood	747	POBAT	*Populus trichocarpa*
26	CH	bitter cherry	768	PREM	*Prunus emarginata*
27	WO	Oregon white oak	815	QUGA4	*Quercus garryana*
28	WI	willow species	920	SALIX	*Salix spp.*
29	GC	giant chinquapin	431	CHCHC4	*Chrysolepis chrysophylla*
30	MC	curl-leaf mtn. mahogany	475	CELE3	*Cercocarpus ledifolius*
31	MB	birchleaf mtn. mahogany	478	CEMOM4	*Cercocarpus betuloides*

Species Number	Species Code	Common Name	FIA Code	PLANTS Symbol	Scientific Name
32	OS	other softwoods	298	2TE	
33	OH	other hardwoods	998	2TD	

3.3 Habitat Type, Plant Association, and Ecological Unit Codes

Plant association codes recognized in the SO variant are shown in Appendix B. If an incorrect plant association code is entered or no code is entered FVS will use the default plant association code, which is 49 (CPS111 PIPO/PUTR-ARTR/FEID) for Region 6 forests and the Warm Springs Reservation, and 0 (unknown) in Region 5 forests. For Region 6 forests and the Warm Springs Reservation, plant association codes are used to set default site information such as site species, site indices, and maximum stand density indices as well as in predicting snag dynamics in FFE-FVS. The site species, site index and maximum stand density indices can be reset via FVS keywords. In Region 5, plant association is only used to estimate surface fuels when no live trees are present in the first cycle. Users may enter the plant association code or the plant association 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 plant association.

3.4 Site Index

Site index is used in some of the growth equations in the SO variant. Users should always use the same site curves that FVS uses as shown 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. A site index value must be greater than or equal to 8, otherwise the value is considered a R5 site class code, see section 3.4.1.

Table 3.4.1 Site index reference curves used for species in the SO variant.

Species Code	Reference	BHA or TTA[1]	Base Age
WP	Brickell, J.E. (1970), USDA-FS Res. Pap. INT-75	TTA	50
SP, PP	Barrett, J.W. (1978), USDA-FS Res. Pap. PNW-232	BHA	100
DF, OS	Cochran, P.H. (1979), USDA-FS Res. Pap. PNW-251	BHA	50
WF, IC, GF, SF	Cochran, P.H. (1979), USDA-FS Res. Pap. PNW-252	BHA	50
MH	Means, et. al. (1986)[2], unpublished FIR Report. Vol. 10, No. 1, OSU	BHA	100
LP	Dahms, W.G. (1964), USDA-FS Res. Pap. PNW-8	TTA	50
ES	Alexander, R.R. (1967), USDA-FS Res. Pap. RM-32	BHA	100
SH, WO (R5)	Dunning (1942); Dunning & Reineke (1933)	BHA	50
SH (R6)	Dolph (1991), Res. Pap. PSW206	BHA	50
WO (R6)	Powers (1972), Res. Note PSW-262	BHA	50
WJ, WB	Alexander, Tackle, and Dahms. (1967), Res. Pap. RM-29	TTA	100
AF	Demars, Herman, and Bell (1970), PNW-119	BHA	100
NF	Herman, F.R., et. al. (1978), USDA-FS Res. Pap. PNW-243, P.4	BHA	100

Species Code	Reference	BHA or TTA[1]	Base Age
WL	Cochran, P.H. (1985), USDA-FS Res. Note PNW-424, p.23	BHA	50
RC	Hegyi, R.P.F., et. al. (1979), Province of B.C., Forest Inv. Rep. No. 1. p. 6.	TTA	100
WH	Wiley, K.N. (1978), Weyerhaeuser Forestry Paper, No. 17, p.4.	BHA	50
PY, WA, BM, CW, CH, WI, GC, MC, MB, OH	Curtis, R.O., et. al. (1974), Forest Science, vol. 20, no. 4, p.310	BHA	100
RA	Harrington C.A. & Curtis, R.O. (1986m), USDA-FS Res. Pap. PNW-358, p.5	TTA	20
AS	Edminster, Mowrer, and Shepperd (1985), Res. Note RM-453	BHA	80

[1] Equation is based on total tree age (TTA) or breast height age (BHA)

[2] The source equation is in metric units; site index values for MH are assumed to be in meters.

In Region 5 forests, site index values can either be entered directly or based on the Region 5 Site Class Code. See section 3.4.1 for Region 5 Site Class information. If site index is missing or incorrect, the site species is set to white fir with a default site index set to 50. For Region 6 forests and the Warm Springs Reservation, if site index is missing or incorrect, the default site species and site index are determined by plant association codes found in Appendix B. If the plant association code is missing or incorrect, the site species is set to ponderosa pine/Jeffrey pine with a default site index set to 70.

Site indices for species not assigned a site index are determined based on the site index of the site species. If the site species is western juniper, whitebark pine, or quaking aspen, the relative site indices of the other species are computed using equations {3.4.1} and {3.4.2} with the low and high site values in table 3.4.2. If the site species is any other species, site index is assigned based on the site species site index (height at base age) with an adjustment for reference age and base age differences between the site species and the target species.

{3.4.1} $RELSI = (SI_{site} - SITELO_{site}) / (SITEHI_{site} - SITELO_{site})$

{3.4.2} $SI_i = SITELO_i + RELSI*(SITEHI_i - SITELO_i)$

where:

RELSI	is the relative site index of the site species
SI	is species site index
SITELO	is the lower bound of the *SI* range for a species
SITEHI	is the upper bound of the *SI* range for a species
site	is the site species
i	is the species for which site index is to be calculated

Table 3.4.2 *SITELO* and *SITEHI* values for equation {3.4.1} in the SO variant.

Species Code	*SITELO*	*SITEHI*
WP	13	137

Species Code	*SITELO*	*SITEHI*
SP	27	178
DF	21	148
WF	5	195
MH	5	133
IC	5	169
LP	5	140
ES	12	227
SH	10	134
PP	7	176
WJ	5	40
GF	9	173
AF	6	127
SF	4	221
NF	7	210
WB	20	65
WL	60	147
RC	29	152
WH	6	203
PY	5	75
WA	5	100
RA	56	192
BM	108	142
AS	30	66
CW	10	191
CH	10	104
WO	21	85
WI	20	93
GC	5	100
MC	5	75
MB	5	75
OS	5	175
OH	5	125

3.4.1 Region 5 Site Class

In Region 5 forests, the site index values can either be entered directly or based on the Region 5 site class (0-7) as shown in table 3.4.1.1. Site class codes of 0-5 were adapted for Region 5 by Jack Levitan from Duncan Dunning's site index curves (Dunning 1942, Dunning & Reineke 1933).

If a Region 5 site class is entered, it is converted to a site index for each species within the model using a two-step process. First, the Region 5 site class is converted to a 50-year or 100-year site index based on the reference age of the species. For quaking aspen, site index is interpolated between the 50 and 100 year site classes to get an estimated 80 year base age site index. Site index conversions are shown in table 3.4.1.1 (personal communication with Ralph Warbington in March 2008).

Table 3.4.1.1 Region 5 site class values converted into site index in the SO variant.

REGION 5 SITE CLASS	(BREAST HT AGE) 50-YEAR SITE INDEX	(BREAST HT AGE) 100-YEAR SITE INDEX
0	106	140
1	90	121
2	75	102
3	56	81
4	49	67
5	39	54
6	31	44
7	23	36

Second, site index for an individual species is determined by multiplying the site index by a species-specific adjustment factor which is shown in table 3.4.1.2

Table 3.4.1.2 Region 5 adjustment factors for site index values in the SO variant.

Species Code	R5 Adjustment Factor
WP	0.9
SP	0.9
DF	1
WF	1
MH	0.9
IC	0.76
LP	0.82
ES	1
SH	1
PP	1
WJ	0.57
GF	1
AF	1
SF	1
NF	1
WB	0.9
WL	1
RC	1
WH	0.9
PY	0.76
WA	1
RA	0.57

Species Code	R5 Adjustment Factor
BM	0.57
AS	0.57
CW	0.57
CH	1
WO	0.76
WI	0.57
GC	1
MC	1
MB	1
OS	1
OH	0.57

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. Maximum stand density index at the stand level is a weighted average, by basal area, of the individual species SDI maximums.

In Region 5, 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 maximums are assigned from the SDI maximums shown in table 3.5.1.

For Region 5 forests, 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)

For Region 6 forests and the Warm Springs Reservation, the default maximum SDI is set based on a user-specified, or default, plant association code 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, the SDI maximum for the site species is assigned from the SDI maximum associated with the site species for the plant association code shown in Appendix B. SDI maximums were set based on growth basal area (GBA) analysis developed by Hall (1983) or an analysis of Current Vegetation Survey (CVS) plots in USFS Region 6 by Crookston (2008). Once maximum SDI is determined for the site species, maximum SDI for all other species not assigned a value is estimated using a relative adjustment as seen in equation {3.5.2}. Some SDI maximums associated with plant associations are unreasonably large, so SDI maximums are capped at 850.

{3.5.2} $SDIMAX_i = SDIMAX(SSEC) * (SDIMAX(S) / SDIMAX(SS))$

where:

SDIMAX$_i$ is species-specific SDI maximum
SDIMAX(SSEC) is maximum SDI for the plant association from Appendix B
SDIMAX(SS) is R6 maximum SDI for the site species shown in table 3.5.1
SDIMAX(S) is R6 maximum SDI for the target species shown in table 3.5.1

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

Species Code	R5 SDI Maximum	R5 Source*	R5 Mapped to	R6 & Warm Springs SDI Maximum
WP	272	Shaw		447
SP	561	Shaw		447
DF	570	Shaw		767
WF	800	PSW		659
MH	687	Shaw		758
IC	576	Shaw		447
LP	679	Shaw		541
ES	620	Shaw		659
SH	1000	PSW		750
PP	365	PSW		429
WJ	272	Shaw		500
GF	800	PSW		659
AF	602	Shaw		659
SF	790	Shaw		659
NF	1000	PSW		659
WB	621	Shaw		250
WL	423	Shaw		250
RC	762	Shaw		650
WH	682	Shaw		650
PY	576	Shaw	incense-cedar	650
WA	441	Shaw	red alder	200
RA	441	Shaw		300
BM	629	Shaw		300
AS	562	Shaw		250
CW	452	Shaw		250
CH	441	Shaw	red alder	200
WO	440	Shaw		200
WI	447	Shaw	black willow	150

Species Code	R5 SDI Maximum	R5 Source*	R5 Mapped to	R6 & Warm Springs SDI Maximum
GC	785	Shaw	tanoak	250
MC	501	Shaw		100
MB	501	Shaw	curlleaf mountain-mahogany	100
OS	365	PSW	ponderosa pine	447
OH	441	Shaw	red alder	250

*Sources include an unpublished analysis of FIA data by John Shaw (Shaw) and a review of current data/literature by Pacific Southwest Research Station (PSW).

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 SO variant, FVS will dub in missing heights by one of two methods. By default, the SO variant will use the Curtis-Arney functional form as shown in equation {4.1.1} or equation {4.1.2} (Curtis 1967, Arney 1985). If the input data contains at least three measured heights for a species, then FVS can switch to a logistic height-diameter equation {4.1.3} (Wykoff, et.al 1982) that may be calibrated to the input data. In the SO variant, this doesn't happen by default, but can be turned on with the NOHTDREG keyword by entering "1" in field 2.

Coefficients for equation {4.1.1} are shown in table 4.1.1 by location code. Coefficients (B_1 -B_2) for equation {4.1.2} are shown in table 4.1.2 by crown class ratio. For the species western juniper, whitebark pine, and quaking aspen, equation {4.1.2} is always used when dubbing heights because these species don't have Curtis-Arney coefficients.

When height-diameter calibration occurs, noble fir, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany and other hardwoods use equation {4.1.4} instead of equation {4.1.2} when dubbing missing heights for trees with DBH < 5.0". Likewise, western hemlock and Pacific yew use equation {4.1.4} instead of {4.1.2} for trees with DBH < 5.0". Coefficients for equations {4.1.3} and {4.1.4}, and the WC species using these equations are given in table 4.1.3. Small ponderosa pine (10) uses equation {4.1.5} to dub in missing heights when DBH < 3.0".

{4.1.1} Curtis-Arney functional form

$DBH \geq 3.0''$: $HT = 4.5 + P_2 * \exp[-P_3 * DBH \wedge P_4]$
$DBH < 3.0''$: $HT = [(4.5 + P_2 * \exp[-P_3 * 3.0 \wedge P_4] - 4.51) * (DBH - 0.3) / 2.7] + 4.51$

{4.1.2} Wykoff functional form

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

{4.1.3} $DBH < 5.0''$: $HT = H_1 + (H_2 * DBH) + (H_3 * CR) + (H_4 * DBH\wedge 2) + H_5$

{4.1.4} $DBH < 5.0''$: $HT = \exp[H_1 + (H_2 * DBH) + (H_3 * CR) + (H_4 * DBH \wedge 2) + H_5]$

{4.1.5} $HT = 8.31485 + (3.03659 * DBH) - (0.592 * JCR)$

where:

HT is tree height
DBH is tree diameter at breast height

B_1 - B_2	are species-specific coefficients shown in table 4.1.2
P_2 - P_4	are species and location specific coefficients shown in table 4.1.1
H_1 - H_5	are species-specific coefficients shown in table 4.1.3
CR	is tree crown ratio expressed as a percent
JCR	is tree crown class (bounded to $1 \le JCR \le 9$)

Table 4.1.1 Coefficients for Curtis-Arney equation {4.1.1} in the SO variant.

Species Code	Location Code	P_2	P_3	P_4
WP	601 – Deschutes 799 – Warm Springs	582.9947	5.4612	-0.3435
	602 – Freemont	391.7346	5.1102	-0.3602
	620 – Winema	133.7789	6.9968	-0.9072
SP	601 – Deschutes 799 – Warm Springs	128.8697	6.8868	-0.8701
	602 – Freemont	948.8488	6.1388	-0.2877
	620 – Winema	222.7080	6.1735	-0.6122
DF	601 – Deschutes 602 – Freemont 799 – Warm Springs	253.2541	4.7331	-0.4843
	620 – Winema	231.7163	6.7143	-0.6647
WF	601 – Deschutes 799 – Warm Springs	235.3340	5.7931	-0.5972
	602 – Freemont	705.1903	6.0971	-0.3273
	620 – Winema	471.6016	5.7106	-0.4035
MH	601 – Deschutes 799 – Warm Springs	197.4948	6.7218	-0.6528
	602 – Freemont	103.7798	10.6932	-1.0711
	620 – Winema	130.7104	7.7823	-0.8830
IC	601 – Deschutes 799 – Warm Springs	4902.9732	7.5484	-0.1783
	602 – Freemont	76621.919	10.2682	-0.1178
	620 – Winema	4518.2601	8.0469	-0.2090
LP	601 – Deschutes 799 – Warm Springs	777.9043	5.2036	-0.2843
	602 – Freemont	113.7962	4.7726	-0.7601
	620 – Winema	128.7972	4.9833	-0.7463
ES	601 – Deschutes 799 – Warm Springs	290.2790	6.5834	-0.5753
	602 – Freemont	290.2790	6.5834	-0.5753
	620 – Winema	168.9700	13.6848	-1.0635
SH	601 – Deschutes 602 – Freemont	606.3002	6.2936	-0.3860

Species Code	Location Code	P_2	P_3	P_4
	620 – Winema 799 – Warm Springs			
PP	601 – Deschutes 799 – Warm Springs	2700.1370	7.1184	-0.2312
	602 – Freemont	1154.2447	6.6836	-0.2876
	620 – Winema	812.2630	6.4422	-0.3348
WJ	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	0	0	0
GF	601 – Deschutes 799 – Warm Springs	235.3340	5.7931	-0.5972
	602 – Freemont	705.1903	6.0971	-0.3273
	620 – Winema	471.6016	5.7106	-0.4035
AF	601 – Deschutes 799 – Warm Springs	291.4070	5.7543	-0.5013
	602 – Freemont	1056.5434	6.6974	-0.2950
	620 – Winema	299.3002	6.3401	-0.5275
SF	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	171.2219	9.9497	-0.9727
NF	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	247.7348	6.1830	-0.6335
WB	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	0	0	0
WL	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	255.4638	5.5577	-0.6054
RC	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	616.3503	5.7620	-0.3633
WH	601 – Deschutes 602 – Freemont 620 – Winema	317.8257	6.8287	-0.6034

Species Code	Location Code	P_2	P_3	P_4
	799 – Warm Springs			
PY	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	77.2207	3.5181	-0.5894
WA	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	133.7965	6.4050	-0.8329
RA	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	484.4591	4.5713	-0.3643
BM	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	76.5170	2.2107	-0.6365
AS	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	0	0	0
CW	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	178.6441	4.5852	-0.6746
CH	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	73.3348	2.6548	-1.2460
WO	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	40.3812	3.7653	-1.1224
WI	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	149.5861	2.4231	-0.1800
GC	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	10707.390	8.4670	-0.1863

Species Code	Location Code	P_2	P_3	P_4
MC	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	1709.7229	5.8887	-0.2286
MB	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	1709.7229	5.8887	-0.2286
OS	601 – Deschutes 602 – Freemont 799 – Warm Springs	253.2541	4.7331	-0.4843
	620 – Winema	231.7163	6.7143	-0.6647
OH	601 – Deschutes 602 – Freemont 620 – Winema 799 – Warm Springs	1709.7229	5.8887	-0.2286

Table 4.1.2 Coefficients by Crown Ratio Class for the logistic Wykoff equation {4.1.2} in the SO variant. The default B_1 coefficient is listed.

Species Code	Coefficient	Crown Ratio Class								
		1	2	3	4	5	6	7	8	9
WP	B_1	4.8898	4.8898	4.8898	4.8898	4.8898	4.8898	4.7886	4.7886	4.7886
	B_2	-9.1437	-9.1437	-9.1437	-9.1437	-9.1437	-9.1437	-10.2263	-10.2263	-10.2263
SP	B_1	5.0176	5.0176	5.0176	5.0176	5.0176	5.0176	5.0176	5.0176	5.0176
	B_2	-13.3096	-13.3096	-13.3096	-13.3096	-13.3096	-13.3096	-13.3096	-13.3096	-13.3096
DF	B_1	5.0796	5.0796	5.0796	5.1560	5.1560	5.1560	5.0594	5.0594	5.0594
	B_2	-9.9304	-9.9304	-9.9304	-12.7011	-12.7011	-12.7011	-12.0763	-12.0763	-12.0763
WF	B_1	4.7835	4.7835	4.7835	4.9516	4.9516	4.9516	4.9516	4.7776	4.7776
	B_2	-9.6402	-9.6402	-9.6402	-11.4936	-11.4936	-11.4936	-11.4936	-10.8669	-10.8669
MH	B_1	4.8901	4.8901	4.8901	4.8901	4.8901	4.8901	4.8901	4.8901	4.8901
	B_2	-11.7015	-11.7015	-11.7015	-11.7015	-11.7015	-11.7015	-11.7015	-11.7015	-11.7015
IC	B_1	4.5214	4.5214	4.5214	4.7459	4.7459	4.7459	4.7459	4.7459	4.7459
	B_2	-10.4749	-10.4749	-10.4749	-13.1891	-13.1891	-13.1891	-13.1891	-13.1891	-13.1891
LP	B_1	4.6409	4.6409	4.6900	4.6900	4.6900	4.6900	4.6312	4.6312	4.6312

Species Code	Coefficient	Crown Ratio Class 1	2	3	4	5	6	7	8	9
	B_2	-6.9563	-6.9563	-7.6241	-7.6241	-7.6241	-7.6241	-8.7243	-8.7243	-8.7243
ES	B_1	5.2149	5.2149	5.2149	5.2149	5.2149	5.2149	5.2149	5.2149	5.2149
	B_2	-14.2828	-14.2828	-14.2828	-14.2828	-14.2828	-14.2828	-14.2828	-14.2828	-14.2828
SH	B_1	5.2973	5.2973	5.2973	5.2973	5.2973	5.2973	5.2973	5.2973	5.2973
	B_2	-17.204	-17.204	-17.204	-17.204	-17.204	-17.204	-17.204	-17.204	-17.204
PP	B_1	4.6267	4.6267	4.7790	4.7790	4.7790	4.7790	4.5112	4.5112	4.5112
	B_2	-8.4404	-8.4404	-9.9191	-9.9191	-9.9191	-9.9191	-9.9229	-9.9229	-9.9229
WJ	B_1	3.2000	3.2000	3.2000	3.2000	3.2000	3.2000	3.2000	3.2000	3.2000
	B_2	-5.000	-5.000	-5.000	-5.000	-5.000	-5.000	-5.000	-5.000	-5.000
GF	B_1	4.7835	4.7835	4.7835	4.9516	4.9516	4.9516	4.9516	4.7776	4.7776
	B_2	-9.6402	-9.6402	-9.6402	-11.4936	-11.4936	-11.4936	-11.4936	-10.8669	-10.8669
AF	B_1	5.1088	5.1088	5.1088	5.0964	5.0964	5.0964	5.0146	5.0146	5.0146
	B_2	-12.1890	-12.1890	-12.1890	-13.2189	-13.2189	-13.2189	-13.6008	-13.6008	-13.6008
SF	B_1	5.0320	5.0320	5.0320	5.0320	5.0320	5.0320	5.0320	5.0320	5.0320
	B_2	-10.482	-10.482	-10.482	-10.482	-10.482	-10.482	-10.482	-10.482	-10.482
NF	B_1	5.3270	5.3270	5.3270	5.3270	5.3270	5.3270	5.3270	5.3270	5.3270
	B_2	-15.450	-15.450	-15.450	-15.450	-15.450	-15.450	-15.450	-15.450	-15.450
WB	B_1	4.1920	4.1920	4.1920	4.1920	4.1920	4.1920	4.1920	4.1920	4.1920
	B_2	-5.165	-5.165	-5.165	-5.165	-5.165	-5.165	-5.165	-5.165	-5.165
WL	B_1	4.9610	4.9610	4.9610	4.9610	4.9610	4.9610	4.9610	4.9610	4.9610
	B_2	-8.247	-8.247	-8.247	-8.247	-8.247	-8.247	-8.247	-8.247	-8.247
RC	B_1	4.8960	4.8960	4.8960	4.8960	4.8960	4.8960	4.8960	4.8960	4.8960
	B_2	-8.391	-8.391	-8.391	-8.391	-8.391	-8.391	-8.391	-8.391	-8.391
WH	B_1	5.2980	5.2980	5.2980	5.2980	5.2980	5.2980	5.2980	5.2980	5.2980
	B_2	-13.240	-13.240	-13.240	-13.240	-13.240	-13.240	-13.240	-13.240	-13.240
PY	B_1	5.1880	5.1880	5.1880	5.1880	5.1880	5.1880	5.1880	5.1880	5.1880
	B_2	-13.801	-13.801	-13.801	-13.801	-13.801	-13.801	-13.801	-13.801	-13.801
WA	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
RA	B_1	4.8860	4.8860	4.8860	4.8860	4.8860	4.8860	4.8860	4.8860	4.8860

Species Code	Coefficient	Crown Ratio Class								
		1	2	3	4	5	6	7	8	9
	B_2	-8.792	-8.792	-8.792	-8.792	-8.792	-8.792	-8.792	-8.792	-8.792
BM	B_1	4.7000	4.7000	4.7000	4.7000	4.7000	4.7000	4.7000	4.7000	4.7000
	B_2	-6.326	-6.326	-6.326	-6.326	-6.326	-6.326	-6.326	-6.326	-6.326
AS	B_1	4.4421	4.4421	4.4421	4.4421	4.4421	4.4421	4.4421	4.4421	4.4421
	B_2	-6.540	-6.540	-6.540	-6.540	-6.540	-6.540	-6.540	-6.540	-6.540
CW	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
CH	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
WO	B_1	3.8314	3.8314	3.8314	3.8314	3.8314	3.8314	3.8314	3.8314	3.8314
	B_2	-4.822	-4.822	-4.822	-4.822	-4.822	-4.822	-4.822	-4.822	-4.822
WI	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
GC	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
MC	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
MB	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576
OS	B_1	5.0796	5.0796	5.0796	5.1560	5.1560	5.1560	5.0594	5.0594	5.0594
	B_2	-9.9304	-9.9304	-9.9304	-12.7011	-12.7011	-12.7011	-12.0763	-12.0763	-12.0763
OH	B_1	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520	5.1520
	B_2	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576	-13.576

Table 4.1.3 Coefficients for height-diameter equations {4.1.3} and {4.1.4} in the SO variant.

Species Code	H_1	H_2	H_3	H_4	H_5
NF	1.7100	0.2943	0	0	0.1054
WH	1.3608	0.6151	0	0.0442	0.0829
PY	1.5907	0.3040	0	0	0
WA	0.0994	4.9767	0	0	0
RA	0.0994	4.9767	0	0	0

Species Code	H_1	H_2	H_3	H_4	H_5
BM	0.0994	4.9767	0	0	0
CW	0.0994	4.9767	0	0	0
CH	0.0994	4.9767	0	0	0
WI	0.0994	4.9767	0	0	0
GC	0.0994	4.9767	0	0	0
MC	0.0994	4.9767	0	0	0
MB	0.0994	4.9767	0	0	0
OH	0.0994	4.9767	0	0	0

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. In the SO variant, bark ratio values are determined using estimates from DIB equations or by setting a constant value. Equations used in the SO variant are shown in equations {4.2.1} – {4.2.4}. Coefficients (b_1 and b_2) and equation reference for these equations by species are shown in table 4.2.1.

{4.2.1} $DIB = b_1 * DBH\text{^}b2$; $BRATIO = DIB / DBH$

{4.2.2} $DIB = b_1 + (b_2 * DBH)$; $BRATIO = DIB / DBH$

{4.2.3} $BRATIO = b_1$

{4.2.4} $BRATIO = b_1 – b_2 * (1/DBH)$

where:

BRATIO	is species-specific bark ratio (bounded to $0.80 \leq BRATIO \leq 0.99$)
DBH	is tree diameter at breast height
DIB	is tree diameter inside bark at breast height
b_1, b_2	are species-specific coefficients shown in table 4.2.1

Table 4.2.1 Coefficients and equation reference for bark ratio equations {4.2.1} – {4.2.4} in the SO variant.

Species Code	b_1	b_2	Equation Used
WP	0.964	0	{4.2.3}
SP	0.851	0	{4.2.3}
DF	0.867	0	{4.2.3}
WF	0.915	0	{4.2.3}
MH	0.934	0	{4.2.3}
IC	0.950	0	{4.2.3}
LP	0.969	0	{4.2.3}
ES	0.956	0	{4.2.3}
SH	-0.1593	0.8911	{4.2.2}

Species Code	b_1	b_2	Equation Used
PP	0.890	0	{4.2.3}
WJ	0.9002	0.3089	{4.2.4}
GF	0.915	0	{4.2.3}
AF	0.937	0	{4.2.3}
SF	0.903	0	{4.2.3}
NF	0.904973	1.0	{4.2.1}
WB	0.969	0	{4.2.3}
WL	0.851	0	{4.2.3}
RC	0.950	0	{4.2.3}
WH	0.933710	1.0	{4.2.1}
PY	0.933290	1.0	{4.2.1}
WA	0.075256	0.949670	{4.2.2}
RA	0.075256	0.949670	{4.2.2}
BM	0.083600	0.949670	{4.2.2}
AS	0.950	0	{4.2.3}
CW	0.075256	0.949670	{4.2.2}
CH	0.075256	0.949670	{4.2.2}
WO	-0.30722	0.95956	{4.2.2}
WI	0.075256	0.949670	{4.2.2}
GC	0.075256	0.949670	{4.2.2}
MC	0.90	1.0	{4.2.1}
MB	0.90	1.0	{4.2.1}
OS	0.867	0	{4.2.3}
OH	0.90	1.0	{4.2.1}

* *DBH* is bounded between 1.0 and 19.0

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 SO variant, crown ratios missing in the input data are predicted using different equations depending on tree species and size. All live trees less than 1.0" in diameter and dead trees of all sizes use equation {4.3.1.1} and one of the equations listed below, {4.3.1.2} or {4.3.1.3}, to compute crown ratio. Equation number used by species is found in table 4.3.1.1. Equation coefficients are found in table 4.3.1.2.

{4.3.1.1} $X = R_1 + R_2 * DBH + R_3 * HT + R_4 * BA + R_5 * PCCF + R_6 * HT_{Avg} / HT + R_7 * HT_{Avg} + R_8 * BA * PCCF + R_9 * MAI$

{4.3.1.2} $CR = 1 / (1 + \exp(X + N(0,SD))$ where absolute value of $(X + N(0,SD)) < 86$

{4.3.1.3} $CR = ((X – 1) * 10.0 + 1.0) / 100$

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
HT	is tree height
BA	is total stand basal area
PCCF	is crown competition factor on the inventory point where the tree is established
HT_{Avg}	is average height of the 40 largest diameter trees in the stand
MAI	is stand mean annual increment
N(0,SD)	is a random increment from a normal distribution with a mean of 0 and a standard deviation of SD
$R_1 – R_9$	are species-specific coefficients shown in tables 4.3.1.1 and 4.3.1.2

Table 4.3.1.1 *CR* equation used in the SO variant.

Species Code	Equation Number	Species Code	Equation Number	Species Code	Equation Number
WP	{4.3.1.2}	GF	{4.3.1.2}	BM	{4.3.1.3}
SP	{4.3.1.2}	AF	{4.3.1.2}	AS	{4.3.1.2}
DF	{4.3.1.2}	SF	{4.3.1.2}	CW	{4.3.1.3}
WF	{4.3.1.2}	NF	{4.3.1.3}	CH	{4.3.1.3}
MH	{4.3.1.2}	WB	{4.3.1.2}	WO	{4.3.1.3}
IC	{4.3.1.2}	WL	{4.3.1.2}	WI	{4.3.1.3}
LP	{4.3.1.2}	RC	{4.3.1.2}	GC	{4.3.1.3}
ES	{4.3.1.2}	WH	{4.3.1.3}	MC	{4.3.1.3}
SH	{4.3.1.3}	PY	{4.3.1.3}	MB	{4.3.1.3}
PP	{4.3.1.2}	WA	{4.3.1.3}	OS	{4.3.1.2}
WJ	{4.3.1.2}	RA	{4.3.1.3}	OH	{4.3.1.3}

Table 4.3.1.2 Coefficients for the crown ratio equation {4.3.1.1} in the SO variant.

Species Code	Model Coefficients									
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	SD
WP	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.5
SP	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.5
DF	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
WF	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
MH	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
IC	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.931
LP	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.6124
ES	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
SH	8.042774	0	0.007198	-0.016163	0	0	0	0	0	1.3167
PP	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.4942

Species Code	Model Coefficients									
	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	SD
WJ	-2.19723	0	0	0	0	0	0	0	0	0.2
GF	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
AF	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
SF	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
NF	8.042774	0	0.007198	-0.016163	0	0	0	0	0	1.3167
WB	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.5
WL	-1.66949	-0.209765	0	0.003359	0.011032	0	0.017727	-0.000053	0.014098	0.5
RC	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
WH	7.558538	0	-0.015637	-0.009064	0	0	0	0	0	1.9658
PY	6.489813	0	-0.029815	-0.009276	0	0	0	0	0	2.0426
WA	5.0	0	0	0	0	0	0	0	0	0.5
RA	5.0	0	0	0	0	0	0	0	0	0.5
BM	5.0	0	0	0	0	0	0	0	0	0.5
AS	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.931
CW	5.0	0	0	0	0	0	0	0	0	0.5
CH	5.0	0	0	0	0	0	0	0	0	0.5
WO	6.489813	0	-0.029815	-0.009276	0	0	0	0	0	2.0426
WI	5.0	0	0	0	0	0	0	0	0	0.5
GC	5.0	0	0	0	0	0	0	0	0	0.5
MC	5.0	0	0	0	0	0	0	0	0	0.5
MB	5.0	0	0	0	0	0	0	0	0	0.5
OS	-0.426688	-0.093105	0.022409	0.002633	0	-0.045532	0	0.000022	-0.013115	0.6957
OH	5	0	0	0	0	0	0	0	0	0.5

A Weibull-based crown model developed by Dixon (1985) as described in Dixon (2002) is used to predict crown ratio for all live trees 1.0 inch in diameter or larger. To estimate crown ratio using this methodology, the average stand crown ratio is estimated from stand density index using equation {4.3.1.4}. Weibull parameters are then estimated from the average stand crown ratio using equations in equation set {4.3.1.5}. Individual tree crown ratio is then set from the Weibull distribution, equation {4.3.1.6} based on a tree's relative position in the diameter distribution and multiplied by a scale factor, shown in equation {4.3.1.7}, 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 coefficients for each species are shown in table 4.3.1.3.

{4.3.1.4} $ACR = d_0 + d_1 * RELSDI * 100.0$

where: $RELSDI = SDI_{stand} / SDI_{max}$

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

$A = a_0$
$B = b_0 + b_1 * ACR \quad (B \geq 1)$
$C = c_0 + c_1 * ACR \quad (C \geq 2)$

{4.3.1.6} $Y = 1-\exp(-((X-A)/B)^C)$

{4.3.1.7} $SCALE = 1 - (0.00167 * (CCF - 100))$

where:

ACR	is predicted average stand crown ratio for the species
SDI_{stand}	is stand density index of the stand
SDI_{max}	is maximum stand density index
A, *B*, *C*	are parameters of the Weibull crown ratio distribution
X	is a tree's crown ratio expressed as a percent / 10
Y	is a trees rank in the diameter distribution (1 = smallest; ITRN = largest) divided by the total number of trees (ITRN) multiplied by *SCALE*
SCALE	is a density dependent scaling factor (bounded to $0.3 \le SCALE \le 1.0$)
CCF	is stand crown competition factor

a_0, b_{0-1}, c_{0-1}, and d_{0-1} are species-specific coefficients shown in table 4.3.1.3

Table 4.3.1.3 Coefficients for the Weibull parameter equations {4.3.1.4} and {4.3.1.5} in the SO variant.

Species Code	Model Coefficients						
	a_0	b_0	b_1	c_0	c_1	d_0	d_1
WP	2	-2.12713	1.10526	2.77	0	7.16846	-0.02375
SP	2	-2.27296	1.12434	3.34	0	6.597	-0.01954
DF	1	-1.19297	1.12928	3.42	0	5.52653	0
WF	0	0.06593	1.09624	3.71	0	6.61291	-0.02182
MH	1	-0.94138	1.08256	3.47	0	7.45097	-0.02406
IC	1	-1.38636	1.16801	3.02	0	6.17373	-0.01795
LP	0	0.07609	1.10184	3.01	0	5.50719	-0.01833
ES	1	-0.91567	1.06469	3.5	0	6.774	0
SH	0	0.16601	1.0815	0.9142	0.45768	6.14578	-0.02781
PP	0	0.24916	1.04831	4.36	0	6.41166	-0.02041
WJ	0	0.07609	1.10184	3.01	0	7.238	0
GF	0	0.06593	1.09624	3.71	0	6.61291	-0.02182
AF	1	-0.91567	1.06469	3.5	0	6.12779	-0.01269
SF	0	-0.09734	1.14675	2.716	0	4.79981	-0.00653
NF	0	-0.13581	1.14771	3.02	0	5.56886	-0.02129
WB	1	-0.82631	1.06217	3.31429	0	6.19911	-0.02216
WL	0	0.00603	1.12276	2.734	0	4.98675	-0.02466
RC	0	-0.01129	1.11665	3.355	0	5.74915	-0.0109
WH	0	0.49085	1.01414	3.16	0	5.48853	-0.00717
PY	0	0.19605	1.07391	0.35	0.62015	5.41743	-0.01161
WA	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
RA	1	-1.11274	1.12314	2.53	0	4.12048	-0.00636
BM	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
AS	0	-0.08414	1.14765	2.775	0	4.01678	-0.01516
CW	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
CH	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
WO	0	0.06607	1.10705	2.04714	0.1507	6.82187	-0.02247
WI	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
GC	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
MC	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604

Species Code	Model Coefficients						
	a_0	b_0	b_1	c_0	c_1	d_0	d_1
MB	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604
OS	1	-1.19297	1.12928	3.42	0	5.52653	0
OH	0	-0.2383	1.18016	3.04	0	4.62512	-0.01604

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 {4.3.1.4}-{4.3.1.7}, 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} – {4.3.1.3} 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 SO 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 for percent canopy cover (*PCC*) and crown competition factor (*CCF*) calculations in the model.

4.4.1 Region 5 Crown Width

Crown width in region 5 forests is calculated by using equations {4.4.1.1} – {4.4.1.5}. If a tree has a *DBH* greater than or equal to its threshold diameter (given as DBH_T), then it uses equation {4.4.1.1}, {4.4.1.2}, or {4.4.1.3} depending on the species. If a tree has a *DBH* less than its threshold diameter, then it uses equation {4.4.1.4} or {4.4.1.5} depending on the height of the tree. Coefficients, equation reference, and threshold diameter values for these equations are shown in table 4.4.1.1 by species.

{4.4.1.2} $DBH \geq DBHT$: $CW = a1 * DBH^{a2}$

{4.4.1.3} $DBH \geq DBHT$: $CW = a1 + a2 * DBH + a3 * DBH^2$

{4.4.1.4} $HT < 4.5'$ and $DBH < DBHT$: $CW = HT * s1$

{4.4.1.5} $HT \geq 4.5'$ and $DBH < DBHT$: $CW = d1 + d2 * DBH$

where:

CW is maximum tree crown width
DBH is tree diameter at breast height
DBHT is threshold diameter shown in table 4.4.1.1
HT is tree height
s_1, $d_{1\text{-}2}$, and $a_{1\text{-}3}$ are species-specific coefficients shown in table 4.4.1.1

Table 4.4.1.1 Coefficients and equation reference for equations {4.4.1.1} – {4.4.1.5} in the SO variant.

Species Code	Equation Used*	DBH_T	d_1	d_2	a_1	a_2	a_3	s_1
WP	{4.4.1.1}	7.6	3.5	0.329	-0.997	0.92	0	0.7778
SP	{4.4.1.1}	7.4	3.5	0.338	-1.476	1.01	0	0.7778
DF	{4.4.1.1}	5	3.62	1.37	6.81	0.732	0	0.7778
WF	{4.4.1.1}	5	3.26	1.103	5.82	0.591	0	0.7778
MH	{4.4.1.1}	5	3.5	0.852	4.72	0.608	0	0.7778
IC	{4.4.1.1}	5	3.5	1.192	7.11	0.47	0	0.7778
LP	{4.4.1.2}	5	3.5	0.6492	1.91	0.784	0	0.7778
ES	{4.4.1.1}	5	3.5	2.4	6.5	1.8	0	0.7778
SH	{4.4.1.1}	5	3.5	1.063	6.71	0.421	0	0.7778
PP	{4.4.1.2}	5	3.77	0.7756	2.24	0.763	0	0.7778
WJ	{4.4.1.1}	5	3.5	1.1	6	0.6	0	0.7778
GF	{4.4.1.1}	5	3.5	1.548	6.19	1.01	0	0.7778
AF	{4.4.1.1}	5	3.5	1.063	6.71	0.421	0	0.7778
SF	{4.4.1.1}	5	3.26	1.103	5.82	0.591	0	0.7778
NF	{4.4.1.1}	5	3.26	1.103	5.82	0.591	0	0.7778
WB	{4.4.1.2}	5	3.5	0.8496	2.37	0.736	0	0.7778
WL	{4.4.1.1}	5	3.5	0.852	4.72	0.608	0	0.7778
RC	{4.4.1.1}	5	3.5	1.7	4	1.6	0	0.7778
WH	{4.4.1.1}	5	3.5	1.624	4.57	1.41	0	0.7778
PY	{4.4.1.1}	5	3.5	1.56	4.2	1.42	0	0.7778
WA	{4.4.1.1}	5	2.5	2.63	8	1.53	0	0.5556
RA	{4.4.1.1}	5	2.5	2.63	8	1.53	0	0.5556
BM	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556
AS	{4.4.1.1}	5	2.5	1.22	0.5	1.62	0	0.5556
CW	{4.4.1.1}	5	2.5	1.22	0.5	1.62	0	0.5556
CH	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556
WO	{4.4.1.1}	5	2.5	2.036	3.08	1.92	0	0.5556
WI	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556
GC	{4.4.1.3}	5	2.15	1.646	2.98	1.55	-0.014	0.5556
MC	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556
MB	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556
OS	{4.4.1.1}	5	3.5	1.1	6	0.6	0	0.7778

Species Code	Equation Used*	DBH_T	d_1	d_2	a_1	a_2	a_3	s_1
OH	{4.4.1.1}	5	2.5	1.4	2	1.5	0	0.5556

*Equation refers to the species-specific equation used when $DBH \geq DBH_T$

4.4.2 Region 6 and Warm Springs Reservation Crown Width

Crown width for Region 6 forests and the Warm Springs Reservation is calculated using equations {4.4.2.1} – {4.4.2.6}, and coefficients for these equations are shown in table 4.4.2.1. The minimum diameter and bounds for certain data values are given in table 4.4.2.2. Equation numbers in table 4.4.2.1 are given with the first three digits representing the FIA species code, and the last two digits representing the equation source.

{4.4.2.1} Bechtold (2004); Equation 02

$DBH \geq MinD$: $CW = a_1 + (a_2 * DBH) + (a_3 * DBH\text{^}2) + (a_4 * CR\%) + (a_5 * BA) + (a_6 * HI)$

$DBH < MinD$: $CW = [a_1 + (a_2 * MinD) + (a_3 * MinD\text{^}2) + (a_4 * CR\%) + (a_5 * BA) + (a_6 * HI)] * (DBH / MinD)$

{4.4.2.2} Crookston (2003); Equation 03 (used only for Mountain Hemlock)

$HT < 5.0$: $CW = [0.8 * HT * \text{MAX}(0.5, CR * 0.01)] * [1 - (HT - 5) * 0.1] * a_1 * DBH\text{^}a_2 * HT\text{^}a_3 * CL\text{^}a_4 * (HT-5) * 0.1$

$5.0 \leq HT < 15.0$: $CW = 0.8 * HT * \text{MAX}(0.5, CR * 0.01)$

$HT \geq 15.0$: $CW = a_1 * (DBH\text{^}a_2) * (HT\text{^}a_3) * (CL\text{^}a_4)$

{4.4.2.3} Crookston (2003); Equation 03

$DBH \geq MinD$: $CW = a_1 * \exp(a_2 + (a_3 * \ln(CL)) + (a_4 * \ln(DBH)) + (a_5 * \ln(HT)) + (a_6 * \ln(BA)))$

$DBH < MinD$: $CW = (a_1 * \exp (a_2 + (a_3 * \ln(CL)) + (a_4 * \ln(MinD)) + (a_5 * \ln(HT)) + (a_6 * \ln(BA))))* (DBH / MinD)$

{4.4.2.4} Crookston (2005); Equation 04

$DBH \geq MinD$: $CW = a_1 * DBH\text{^}a_2$

$DBH < MinD$: $CW = [a_1 * MinD\text{^}a_2] * (DBH / MinD)$

{4.4.2.5} Crookston (2005); Equation 05

$DBH \geq MinD$: $CW = (a_1 * BF) * DBH\text{^}a_2 * HT\text{^}a_3 * CL\text{^}a_4 * (BA + 1.0)\text{^}a_5 * \exp(EL)\text{^}a_6$

$DBH < MinD$: $CW = [CW = (a_1 * BF) * MinD\text{^}a_2 * HT\text{^}a_3 * CL\text{^}a_4 * (BA + 1.0)\text{^}a_5 * \exp(EL)\text{^}a_6] * (DBH / MinD)$

{4.4.2.6} Donnelly (1996); Equation 06

$DBH \geq MinD$ $CW = a_1 * DBH\text{^}a_2$

$DBH < MinD$ $CW = [a_1 * MinD\text{^}a_2] * (DBH / MinD)$

where:

BF	is a species-specific coefficient based on forest code shown in table 4.4.2.3
CW	is tree maximum crown width

CL	is tree crown length
CR%	is crown ratio expressed as a percent
DBH	is tree diameter at breast height
HT	is tree height
BA	is total stand basal area
EL	is stand elevation in hundreds of feet
MinD	is the minimum diameter
HI	is the Hopkins Index *HI* = (ELEVATION - 5449) / 100) * 1.0 + (LATITUDE - 42.16) * 4.0 + (-116.39 -LONGITUDE) * 1.25
$a_1 – a_6$	are species-specific coefficients shown in table 4.4.2.1

Table 4.4.2.1 Coefficients for crown width equations {4.4.2.1}-{4.4.2.6} in the SO variant.

Species Code	Equation Number*	a_1	a_2	a_3	a_4	a_5	a_6
WP	11905	5.3822	0.57896	-0.19579	0.14875	0	-0.00685
SP	11705	3.593	0.63503	-0.22766	0.17827	0.04267	-0.0029
DF	20205	6.0227	0.54361	-0.20669	0.20395	-0.00644	-0.00378
WF	01505	5.0312	0.5368	-0.18957	0.16199	0.04385	-0.00651
MH	26403	6.90396	0.55645	-0.28509	0.2043	0	0
IC	08105	5.0446	0.47419	-0.13917	0.1423	0.04838	-0.00616
LP	10805	6.6941	0.8198	-0.36992	0.17722	-0.01202	-0.00882
ES	09305	6.7575	0.55048	-0.25204	0.19002	0	-0.00313
SH	02105	2.317	0.4788	-0.06093	0.15482	0.05182	0
PP	12205	4.7762	0.74126	-0.28734	0.17137	-0.00602	-0.00209
WJ	06405	5.1486	0.73636	-0.46927	0.39114	-0.05429	0
GF	01703	1.0303	1.14079	0.20904	0.38787	0	0
AF	01905	5.8827	0.51479	-0.21501	0.17916	0.03277	-0.00828
SF	01105	4.4799	0.45976	-0.10425	0.11866	0.06762	-0.00715
NF	02206	3.0614	0.6276	0	0	0	0
WB	10105	2.2354	0.6668	-0.11658	0.16927	0	0
WL	07303	1.02478	0.99889	0.19422	0.59423	-0.09078	-0.02341
RC	24205	6.2382	0.29517	-0.10673	0.23219	0.05341	-0.00787
WH	26305	6.0384	0.51581	-0.21349	0.17468	0.06143	-0.00571
PY	23104	6.1297	0.45424	0	0	0	0
WA	31206	7.5183	0.4461	0	0	0	0
RA	35106	7.0806	0.4771	0	0	0	0
BM	31206	7.5183	0.4461	0	0	0	0
AS	74605	4.7961	0.64167	-0.18695	0.18581	0	0
CW	74705	4.4327	0.41505	-0.23264	0.41477	0	0
CH	35106	7.0806	0.4771	0	0	0	0
WO	81505	2.4857	0.70862	0	0.10168	0	0
WI	31206	7.5183	0.4461	0	0	0	0

Species Code	Equation Number*	a_1	a_2	a_3	a_4	a_5	a_6
GC	63102	3.115	0.7966	0	0.0745	-0.0053	0.0523
MC	47502	4.0105	0.8611	0	0	0	-0.0431
MB	47502	4.0105	0.8611	0	0	0	-0.0431
OS	12205	4.7762	0.74126	-0.28734	0.17137	-0.00602	-0.00209
OH	31206	7.5183	0.4461	0	0	0	0

*Equation number is a combination of the species FIA code (###) and equation source (##).

Table 4.4.2.2 *MinD* values and data bounds for equations {4.4.2.1} – {4.4.2.6} in the SO variant.

Species Code	Equation Number*	MinD	EL min	*EL* max	*HI* min	*HI* max	*CW* max
WP	11905	1.0	10	75	n/a	n/a	35
SP	11705	1.0	5	75	n/a	n/a	56
DF	20205	1.0	1	75	n/a	n/a	80
WF	01505	1.0	2	75	n/a	n/a	35
MH	26403	n/a	n/a	n/a	n/a	n/a	45
IC	08105	1.0	5	62	n/a	n/a	78
LP	10805	1.0	1	79	n/a	n/a	40
ES	09305	1.0	1	85	n/a	n/a	40
SH	02105	1.0	n/a	n/a	n/a	n/a	65
PP	12205	1.0	13	75	n/a	n/a	50
WJ	06405	1.0	n/a	n/a	n/a	n/a	36
GF	01703	1.0	n/a	n/a	n/a	n/a	40
AF	01905	1.0	10	85	n/a	n/a	30
SF	01105	1.0	4	72	n/a	n/a	33
NF	02206	1.0	n/a	n/a	n/a	n/a	40
WB	10105	1.0	n/a	n/a	n/a	n/a	40
WL	07303	1.0	n/a	n/a	n/a	n/a	40
RC	24205	1.0	1	72	n/a	n/a	45
WH	26305	1.0	1	72	n/a	n/a	54
PY	23104	1.0	n/a	n/a	n/a	n/a	30
WA	31206	1.0	n/a	n/a	n/a	n/a	30
RA	35106	1.0	n/a	n/a	n/a	n/a	35
BM	31206	1.0	n/a	n/a	n/a	n/a	30
AS	74605	1.0	n/a	n/a	n/a	n/a	45
CW	74705	1.0	n/a	n/a	n/a	n/a	56
CH	35106	1.0	n/a	n/a	n/a	n/a	35
WO	81505	1.0	n/a	n/a	n/a	n/a	39
WI	31206	1.0	n/a	n/a	n/a	n/a	30
GC	63102	5.0	n/a	n/a	-55	15	41
MC	47502	5.0	n/a	n/a	-37	27	29
MB	47502	5.0	n/a	n/a	-37	27	29

Species Code	Equation Number*	MinD	EL min	*EL* max	*HI* min	*HI* max	*CW* max
OS	12205	1.0	13	75	n/a	n/a	50
OH	31206	1.0	n/a	n/a	n/a	n/a	30

Table 4.4.2.3 *BF* values for equation {4.4.2.5} in the SO variant.

Species Code	Location Code 601 799	602	620
WP	1.000	1.090	1.090
SP	1.048	1.000	1.048
DF	1.055	1.000	1.184
WF	1.044	1.044	1.095
IC	0.837	1.000	1.000
LP	1.000	1.114	1.050
PP	0.918	0.946	0.951
AF	0.936	1.000	1.000
SF	1.000	1.000	1.000
RC	1.000	1.000	1.000
WH	1.097	1.000	1.000
OS	1.000	1.000	1.000

*Any *BF* values not listed in Table 4.4.2.3 are assumed to be *BF* = 1.0

4.5 Crown Competition Factor

The SO 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 is calculated using equations {4.5.1} – {4.5.5}. All species coefficients are shown in table 4.5.1.Crown competition factor for Shasta red fir (9) and Oregon white oak (27) is calculated using equation {4.5.5} where crown width used in Region 5 forests is the stated equation in Section 4.4.1 and crown width used in Region 6 forests and the Warm Springs Reservation is found in equations {4.5.6} and {4.5.7}.

Equation {4.5.4} is used to calculate CCF_t for trees with *DBH* < 1.0 inch for species taken from the West Cascades (WC) variant. These species include noble fir, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mtn. mahogany, birchleaf mtn. mahogany, other hardwoods. . Any other species except Shasta red fir and Oregon white oak use equations {4.5.2} and {4.5.3}.

All species except Shasta red fir and Oregon white oak use equation {4.5.1} to calculate crown competition factor when $DBH \geq 1.0$ inches.

{4.5.1} $DBH \geq 1.0''$: $CCF_t = R_1 + (R_2 * DBH) + (R_3 * DBH^2)$

{4.5.2} $0.1'' < DBH < 1.0''$: $CCF_t = R_4 * DBH^{R_5}$

{4.5.3} $DBH \leq 0.1''$: $CCF_t = 0.001$

{4.5.4} $DBH < 1.0''$: $CCF_t = (R_1 + R_2 + R_3) * DBH$

{4.5.5} $CCF_t = 0.001803 * CW^2$

{4.5.6} $HT \geq 4.5$: $CW_t = B_1 * DBH^{B_2}$

{4.5.7} $HT < 4.5$: $CW_t = S_1 * HT$

where:

CCF_t	is crown competition factor for an individual tree
CW	is maximum tree crown width
DBH	is tree diameter at breast height
$R_1 - R_5$	are species-specific coefficients shown in table 4.5.1
B_1, B_2, S_1	are species-specific coeffecients shown in table 4.5.2

Table 4.5.1 Coefficients for *CCF* equations {4.5.1} – {4.5.5} in the SO variant.

Species Code	Equations Used	Model Coefficients				
		R_1	R_2	R_3	R_4	R_5
WP	{4.5.1} – {4.5.3}	0.0186	0.0146	0.00288	0.009884	1.6667
SP	{4.5.1} – {4.5.3}	0.0392	0.018	0.00207	0.007244	1.8182
DF	{4.5.1} – {4.5.3}	0.0388	0.0269	0.00466	0.017299	1.5571
WF	{4.5.1} – {4.5.3}	0.069	0.0225	0.00183	0.015248	1.7333
MH	{4.5.1} – {4.5.3}	0.03	0.018	0.00281	0.011109	1.725
IC	{4.5.1} – {4.5.3}	0.0194	0.0142	0.00261	0.008915	1.78
LP	{4.5.1} – {4.5.3}	0.01925	0.01676	0.00365	0.009187	1.76
ES	{4.5.1} – {4.5.3}	0.03	0.0173	0.00259	0.007875	1.736
PP	{4.5.1} – {4.5.3}	0.0219	0.0169	0.00325	0.007813	1.778
WJ	{4.5.1} – {4.5.3}	0.01925	0.01676	0.00365	0.009187	1.76
GF	{4.5.1} – {4.5.3}	0.069	0.0225	0.00183	0.015248	1.7333
AF	{4.5.1} – {4.5.3}	0.0172	0.00877	0.00112	0.011402	1.756
SF	{4.5.1} – {4.5.3}	0.04	0.027	0.00405	0.015248	1.7333
NF	{4.5.1} & {4.5.4}	0.02453	0.01147	0.00134	0	0
WB	{4.5.1} – {4.5.3}	0.01925	0.01676	0.00365	0.009187	1.76
WL	{4.5.1} – {4.5.3}	0.02	0.0148	0.00338	0.007244	1.8182
RC	{4.5.1} – {4.5.3}	0.03	0.0238	0.0049	0.008915	1.78
WH	{4.5.1} & {4.5.4}	0.03758	0.02329	0.00361	0	0
PY	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
WA	{4.5.1} & {4.5.4}	0.03561	0.0273	0.00524	0	0

Species Code	Equations Used	Model Coefficients				
		R_1	R_2	R_3	R_4	R_5
RA	{4.5.1} & {4.5.4}	0.03561	0.0273	0.00524	0	0
BM	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
AS	{4.5.1} – {4.5.3}	0.03	0.0238	0.0049	0.008915	1.78
CW	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
CH	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
WI	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
GC	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
MC	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
MB	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0
OS	{4.5.1} – {4.5.3}	0.0388	0.0269	0.00466	0.017299	1.5571
OH	{4.5.1} & {4.5.4}	0.0204	0.0246	0.0074	0	0

Table 4.5.2 Coefficients for CW equations used in calculating CCF in the SO variant.

Species Code	Model Coefficients		
	B_1	B_2	H_1
SH	3.1146	0.5780	0.345
WO	2.4922	0.8544	0.140

4.6 Small Tree Growth Relationships

Trees are considered "small trees" for FVS modeling purposes when they are smaller than some threshold diameter. The threshold diameter is set to 90.0" for western juniper and 3.0" for all other species in the SO variant. As a result, western juniper trees of all sizes use diameter and height growth equations given in this section.

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 increment model predicts 5-year or 10-year height growth (*HTG*) for small trees, depending on species. Height growth is predicted directly for Shasta red fir, quaking aspen, and Oregon white oak, and is a product of potential height growth and one, or more, modifier functions for all other species.

For western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense cedar, lodgepole pine, Engelmann spruce, ponderosa pine, western juniper, grand fir, subalpine fir, Pacific silver fir, noble fir, whitebark pine, western larch, western redcedar, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods, height growth is estimated using equation {4.6.1.1}. The *PCTRED* modifier, which is an adjustment for stand density, is estimated using equation {4.6.1.2}. The *VIGOR* modifier, which is an adjustment based on a trees' crown ratio, is estimated using equation {4.6.1.3} for all species except western juniper, and equation {4.6.1.4} for western juniper.

{4.6.1.1} $HTG = POTHTG * PCTRED * VIGOR * CON$

{4.6.1.2} $PCTRED = 1.11436 - 0.011493*Z + 0.43012E\text{-}04 * Z^2 - 0.72221E\text{-}07 * Z^3 + 0.5607E\text{-}10 * Z^4 - 0.1641E\text{-}13 * Z^5$

$Z = HT_{Avg} * (CCF / 100)$

{4.6.1.3} $VIGOR = (150 * CR^3 * \exp(-6 * CR)) + 0.3$

{4.6.1.4} $VIGOR = 1 - [(1 - (150 * CR^3 * \exp(-6 * CR))) / 3]$ (for western juniper)

where:

HTG	is estimated 10-year height growth
POTHTG	is estimated 10-year potential height growth
PCTRED	is reduction in height growth due to stand density (bounded to $0.01 \leq PCTRED \leq 1$)
HT_{Avg}	is average height of the 40 largest diameter trees in the stand
CCF	is stand crown competition factor
VIGOR	is reduction in height growth due to tree vigor (bounded to $VIGOR \leq 1.0$)
CR	is a tree's live crown ratio (compacted) expressed as a proportion
CON	is a scalar multiplier

It is expected, in a site index-based height growth model, that the dominant and co-dominant trees in an open-grown stand reach site height at the base age used to develop the equations. After all the parts of the SO variant growth model were assembled, height growth projections for each species were adjusted (if necessary) by applying adjustment factors (*CON*; shown in table 4.6.1.1) to the small-tree height growth increments. These adjustment factors force the dominant and co-dominant trees to reach site height at the base age for a range of site index values.

Potential height growth for western white pine and western redcedar is estimated using equation {4.6.1.5} and coefficients shown in table 4.6.1.1.

{4.6.1.5} $POTHTG = (SI / c_1) * (1.0 - c_2 * \exp(c_3 * X_2))^{c_4} - (SI / c_1) * (SI / c_1) * (1.0 - c_2 * \exp(c_3 * X_1))^{c_4}$

$X_1 = \exp[(1.0 - (c_1 / SI * H)^{(1 / c_4)}) / c_2] / c_3$

$X_2 = X_1 + 10$

where:

POTHTG	is potential 10-year height growth
SI	is species site index
X_1	is estimated tree age at the beginning of the projection cycle
X_2	is estimated tree age at the beginning of the projection cycle plus 10 years
$c_1 - c_4$	are species-specific coefficients shown in table 4.6.1.1

Potential height growth for sugar pine, Douglas-fir, white fir, mountain hemlock, incense cedar, lodgepole pine, Engelmann spruce, ponderosa pine, grand fir, subalpine fir, Pacific silver fir, noble fir, whitebark pine, western larch, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods is estimated using equation {4.6.1.6}.

{4.6.1.6} $POTHTG = [(c_1 + c_2 * SI) / (c_3 – c_4 * SI)] * A$

where:

POTHTG is potential 10-year height growth
SI is species site index
A is the number of years in the growth estimation period (10 in this case)
$c_1 – c_4$ are species-specific coefficients shown in table 4.6.1.1

Potential height growth for western juniper is estimated using equation {4.6.1.7}

{4.6.1.7} $POTHTG = (SI / 5.0) * (SI * 1.5 – HT) / (SI * 1.5)$ where $5.5 \leq SI \leq 75$

where:

POTHTG is potential 10-year height growth
SI is species site index
HT is tree height

Potential height growth for mountain hemlock is estimated using equation {4.6.1.8}.

{4.6.1.8} $POTHTG = [(c_1 + c_2 * SI) / (c_3 – c_4 * SI)] * A * 3.280833$

where:

POTHTG is potential 10-year height growth
SI is species site index bounded by *SITELO* and *SITEHI* (shown in table 4.6.1.2)
A is the number of years in the growth estimation period (10 in this case)
$c_1 – c_4$ are species-specific coefficients shown in table 4.6.1.1

Table 4.6.1.1 Coefficients ($c_1 – c_4$) and equation reference for small-tree height increment equations {4.6.1.1} – {4.6.1.6} in the SO variant.

Species Code	*POTHTG* Equation	Model Coefficients				
		c_1	c_2	c_3	c_4	Adjustment Fact. (CON)
WP	{4.6.1.5}	0.375045	0.92503	-0.020796	2.48811	1.0
SP	{4.6.1.6}	-1.0	0.32857	28.0	0.042857	1.0
DF	{4.6.1.6}	2.0	0.420	28.5	0.05	1.1
WF	{4.6.1.6}	4.2435	0.1510	19.0184	0.0570	1.2
MH	{4.6.1.8}	0.965758	0.082969	55.249612	1.288852	1.6
IC	{4.6.1.6}	4.2435	0.1510	19.0184	0.0570	1.3
LP	{4.6.1.6}	0	0.0200880	1.0	0	1.0
ES	{4.6.1.6}	0.09211	0.208517	43.358	0.168166	1.35
SH	{4.6.1.10}					
PP	{4.6.1.6}	-1.0	0.32857	28.0	0.042857	1.0
WJ	{4.6.1.7}	0	0	0	0	1.0

Species Code	*POTHTG* Equation	Model Coefficients				
		c_1	c_2	c_3	c_4	Adjustment Fact. (CON)
GF	{4.6.1.6}	4.2435	0.1510	19.0184	0.0570	1.2
AF	{4.6.1.6}	6.0	0.14	33.882	0.06588	1.0
SF	{4.6.1.6}	-0.6667	0.4333	28.5	0.05	1.0
NF	{4.6.1.6}	11.26677	0.12027	27.93806	0.02873	1.0
WB	{4.6.1.6}	0	0.0200880	1.0	0	1.6
WL	{4.6.1.6}	-3.9725	0.50995	28.1168	0.05661	1.0
RC	{4.6.1.5}	0.752842	1.0	-0.0174	1.4711	1.0
WH	{4.6.1.6}	-5.74874	0.54576	26.15767	-0.03596	1.0
PY	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
WA	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
RA	{4.6.1.6}	-0.007205	0.056794	1.0	0	1.2
BM	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
AS	{4.6.1.9}					
CW	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
CH	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
WO	{4.6.1.11}					
WI	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
GC	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
MC	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
MB	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0
OS	{4.6.1.6}	2.0	0.420	28.5	0.05	1.1
OH	{4.6.1.6}	1.47043	0.23317	31.56252	0.05586	1.0

Height growth for quaking aspen is estimated using equation {4.6.1.9}.

{4.6.1.9} $HTG = (1.8 * [26.9825 * ((AG + 10) \wedge 1.1752)) – (26.9825 * (AG \wedge 1.1752))] / (2.54 * 12)) * RSIMOD$

and $RSIMOD = 0.5 * (1.0 + (SI - SITELO) / (SITEHI - SITELO))$

where:

HTG is potential 10-year height growth
AG is estimated tree age at the beginning of the projection cycle
SI is species site index bounded so $(SITELO + 0.5) \leq SI \leq SITEHI$
SITELO is the lower limit in the range of site index for this species in this geographic area (shown in table 3.4.2)
SITEHI is the upper limit in the range of site index for this species in this geographic area (shown in table 3.4.2)
$c_1 – c_4$ are species-specific coefficients shown in table 4.6.1.1

Height growth for Shasta red fir is estimated using equation {4.6.1.10}

{4.6.1.10} $HTG = ((5 * (2.2227 + 0.4314 * SI)) / (29 – 0.05 * SI)) * 1.016605 * [1 - \exp(-4.26558 * (CR / 100))] * [\exp(2.54119 * (RELHT \wedge 0.250537 - 1))]$

where:

HTG	is estimated 5-year height growth
SI	is species site index
CR	is a tree's live crown ratio (compacted) expressed as a percent
RELHT	is tree height divided by average height of the 40 largest diameter trees in the stand

Height growth for Oregon white oak is estimated using equation {4.5.1.11}

{4.6.1.11} $HTG = \exp(3.817 – 0.7829 * \ln(BAL)) * (0.8 + 0.004 * (SI - 50))$

where:

HTG	is 5-year height growth
SI	is species site index
BAL	is total basal area in trees larger than the subject tree where $5 \leq BAL$
$c_1 – c_4$	are species-specific coefficients shown in table 4.6.1.1

For all species, a small random error is then added to the height growth estimate. The estimated height growth (*HTG*) is then adjusted to account for cycle length, user defined small-tree height growth adjustments, and adjustments due to small tree height model calibration from the 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 {4.6.1.12}, and applied as shown in equation {4.6.1.13}. The range of diameters for each species is shown in table 4.6.1.3.

{4.6.1.12}

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

{4.6.1.13} 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* where weighting between small and large tree models occurs

X_{min} is the minimum *DBH* where weighting between small and large tree models occurs
STGE is the growth estimate obtained using the small-tree growth model
LTGE is the growth estimate obtained using the large-tree growth model

Table 4.6.1.3 Diameter bounds by species in the SO variant.

Species Code	X_{min}	X_{max}
WP	2.0	3.0
SP	1.0	5.0
DF	2.0	4.0
WF	2.0	4.0
MH	1.0	2.0
IC	2.0	4.0
LP	2.0	4.0
ES	2.0	4.0
SH	2.0	4.0
PP	1.0	5.0
WJ	90.0*	99.0*
GF	2.0	4.0
AF	2.0	4.0
SF	2.0	4.0
NF	2.0	4.0
WB	1.5	3.0
WL	2.0	4.0
RC	2.0	10.0
WH	2.0	4.0
PY	2.0	4.0
WA	2.0	4.0
RA	2.0	4.0
BM	2.0	4.0
AS	2.0	4.0
CW	2.0	4.0
CH	2.0	4.0
WO	2.0	4.0
WI	2.0	4.0
GC	2.0	4.0
MC	2.0	4.0
MB	2.0	4.0
OS	2.0	4.0
OH	2.0	4.0

*There is only one growth relationship that applies to trees of all sizes for this species. These relationships are contained in the "small" tree portion of FVS.

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. In most cases, these two predicted diameters are estimated using the species-specific height-diameter relationships discussed in section 4.1 inverted to predict diameter as a function of height. By definition, diameter growth is zero for trees less than 4.5 feet tall.

In the SO variant, several curve forms are used to predict diameter as a function of height. The equation choice is based on species and whether calibration of the Wykoff form of the height-diameter curve was specified using the NOHTDREG keyword and did occur.

When calibration of the Wykoff form of the height-diameter curve was not specified (the default condition in the SO variant) or does not occur for a species, the Curtis-Arney height-diameter curve, shown in equations {4.6.2.1} and {4.6.2.2}, is used to predict diameter at the beginning and end of the projection cycle for all species except western juniper, whitebark pine, and quaking aspen.

{4.6.2.1} $HT \geq HAT3$: $DBH = \exp(\ln((\ln(HT - 4.5) - \ln(a))/-b) / c)$

{4.6.2.2} $HT < HAT3$: $DBH = (((HT - 4.51) * 2.7) / (4.5 + a * \exp(-b * (3.0 ^\wedge c)) - 4.51)) + 0.3$

where:

HAT3	$= 4.5 + a * \exp(-b * (3.0 ^\wedge c))$
DBH	is tree diameter at breast height
HT	is tree height
a, b, c	are species-specific coefficients shown in table 4.6.2.1

Western juniper uses equation {4.6.2.4}, whitebark pine uses equation {4.6.2.5}, and quaking aspen uses equation {4.6.2.6} with default coefficients.

{4.6.2.3} $DBH = (HT - 4.17085) / 3.03659$

{4.6.2.4} $DBH = 10 * (HT - 4.5) / (SI - 4.5)$

{4.6.2.5} $DBH = CR * (0.001711 + 0.000231 * (HT - 4.5)) - 0.00005 * (HT - 4.5) * TPCCF$
$+ 0.17023 * (HT - 4.5) + 0.3$

{4.6.2.6} $DBH = (B_2 / (\ln(HT - 4.5) - B_1)) - 1.0$

{4.6.2.7} $DBH = 0.1 * HTG$

where:

DBH	is tree diameter at breast height (JU uses diameter at root collar)
HT	is tree height
HTG	is estimated tree height growth
SI	is species site index
CR	is crown ratio expressed as a percent

TPCCF	is crown competition factor based on sample point statistics (bounded to $25 \leq TPCCF \leq 300$)
B_1, B_2	are coefficients from height-diameter relationships (shown in table 4.1.1)

When calibration of the Wykoff form of the height-diameter curve is specified, and occurs for a species, then a different equation selection occurs. Western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense cedar, lodgepole pine, Engelmann spruce, Shasta red fir, grand fir, subalpine fir, Pacific silver fir, western larch, western redcedar, quaking aspen, Oregon white oak, and other softwoods use equation {4.6.2.6} with the calibrated coefficients. Ponderosa pine uses equation {4.6.2.3}, western juniper uses equation {4.6.2.4}, and whitebark pine uses equation {4.6.2.5}, none of which are calibrated. Nobel fir, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, and other hardwoods use equation {4.6.2.7} which is not calibrated.

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 90.0" for western juniper and 3.0" for all other species in the SO variant. As a result, western juniper trees of all sizes use diameter and height growth equations given in section 4.6.

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.

For locations other than Warm Springs (799), the SO variant predicts diameter growth using equation {4.7.1.1} for all species except western juniper, quaking aspen, and red alder. Coefficients for this equation are shown in tables 4.7.1.1 – 4.7.1.4. Diameter growth for quaking aspen and red alder are shown later in this section; western juniper uses equations given in section 4.6 for all sized trees.

For Warm Springs (799), the SO variant predicts diameter growth using equation {4.7.1.1} and coefficients shown in tables 4.7.1.1 – 4.7.1.4 for all species except western white pine, sugar pine, incense cedar, lodgepole pine, western redcedar, other softwoods, western juniper, quaking aspen, and red alder. Diameter growth for western white pine, sugar pine, incense cedar, lodgepole pine, western redcedar, other softwoods, quaking aspen and red alder are shown later in this section; western juniper uses equations given in section 4.6 for all sized trees.

{4.7.1.1} $\ln(DDS) = b_1 + (b_2 * EL) + (b_3 * EL^2) + (b_4 * MAI) + (b_5 * \ln(SI)) + (b_6 * SSI) + SASP + (b_{11} * \ln(DBH)) + (b_{12} * BAL) + (b_{13} * CR) + (b_{14} * CR^2) + (b_{15} * DBH^2) + (b_{16} * BAL / (\ln(DBH$

+ 1.0))) + (b_{17}* *PCCF*) + (b_{18} * ln(*CCF*)) + (b_{19} * *PCCF*^2) + (b_{20} * *RELHT*) + (b_{21} * ln(*BA*)) + (b_{22} * *BA*) + (b_{23}* (*CCF* / 100)) + ((b_{24} * *MAI* * *CCF* / 100) + *DUMMY*

SASP = (b_7 * sin(*ASP*) * *SL*) + (b_8 * cos(*ASP*) * *SL*) + (b_9 * *SL*) + (b_{10} * *SL*^2)

SASP = -0.174404 for Pacific silver fir, and -0.290174 for western larch when stand slope is equal to 0

where:

DDS	is the square of the diameter growth increment
EL	is stand elevation in hundreds of feet (bounded to be $\leq$ 30 for white alder, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, and other hardwoods)
MAI	is stand mean annual increment
SSI	is site index of the site species
SI	is species site index
ASP	is stand aspect in radians ((ASP – 0.7854) is used for whitebark pine
SL	is stand slope
DBH	is tree diameter at breast height
BAL	is total basal area in trees larger than the subject tree ((BAL / 100) is used for whitebark pine)
CR	is crown ratio expressed as a proportion
PCCF	is crown competition factor on the inventory point where the tree is established
RELHT	is tree height divided by average height of the 40 largest diameter trees in the stand (bounded to *RELHT* $\leq$ 1.5)
CCF	is stand crown competition factor
BA	is total stand basal area
DUMMY	is a dummy coefficient where: *DUMMY* = -0.799079 for Pacific silver fir *DUMMY* = 0 for all other species
b_1	is a location-specific coefficient shown in table 4.7.1.2
b_2- b_{24}	are species-specific coefficients shown in table 4.7.1.1

Table 4.7.1.1 Coefficients (b_2 – b_{24}) for equations {4.7.1.1} & {4.7.1.2} in the SO variant.

Coefficient	Species Code									
	WP+	**SP+**	**DF, OS+**	**WF, GF**	**MH**	**IC+**	**LP+**	**ES**	**SH**	**PP**
b_2	0.00279	0.00466	0.01544	0.00362	-0.03036	-0.00637	0.01012	0	0.0248	-0.00331
b_3	-0.00001	0.00001	-0.0001	-0.00006	0.00037	0.00014	-0.0002	0	-0.00033429	0.00006
b_4	0	0.00375	0.00044	0.00114	0	0.00246	0.00778	0	0	0.0036
b_5	0	0	0	0	0	0	0	0.86756	0.492695	0
b_6	0	0	0	0	0	0	0	0	0	0
b_7	-0.19278	0.56358	-0.40153	-0.1713	0.33069	-0.43281	-0.25658	-0.17911	0.13918	-0.14076
b_8	0.12915	0.08831	-0.17389	-0.14234	-0.29385	-0.04156	-0.39893	0.38002	-0.444594	-0.05217

Coefficient	Species Code									
	WP+	SP+	DF, OS+	WF, GF	MH	IC+	LP+	ES	SH	PP
b_9	0.77922	-1.50252	-0.18923	0.02912	-0.59628	-0.90318	0.19253	-0.8178	0	-0.29407
b_{10}	-0.93813	1.21439	-0.49057	-0.29671	1.07549	1.36603	0	0.84368	0	0.16735
b_{11}	0.77889	1.05245	0.3316	0.89887	0.99324	0.72947	0.63249	1.3261	1.186676	0.53028
b_{12}	0.00121	0.0002	0.00479	0.00106	-0.00087	0.00483	0.00169	0	0	0.00325
b_{13}	3.36606	2.89738	4.43317	3.11044	1.73837	1.57139	2.35065	1.2973	2.763519	3.43377
b_{14}	-1.80146	-0.9543	-2.82894	-1.13806	-0.12161	0	-0.63173	0	-0.871061	-1.843
b_{15}*										
b_{16}	-0.00897	-0.00437	-0.01918	-0.00707	-0.00105	-0.01497	-0.00647	-0.00239	-0.003728	-0.01362
b_{17}	0	-0.0006	-0.00041	-0.00027	0	-0.00053	0	-0.00044	0	0
b_{18}	0	0	0	0	0	0	0	0	0	-0.20488
b_{19}**	0	0	0	0	0	0	0	0	0	0.000001
b_{20}	0	0	0	0	0	0	0	0.49649	0	0
b_{21}	0	0	0	0	0	0	0	0	-0.122905	0
b_{22}	0	0	0	0	0	0	0	0	0	0
b_{23}	-0.00016	0.00157	-0.00138	-0.00024	-0.00027	0	0.00109	0	0	0
b_{24}	0.00001	-0.00001	0.00001	0.00001	0.00001	0	-0.00003	0	0	0

*see table 4.7.1.4 for b_{15} values
**set to zero for ponderosa pine when *PCCF* > 400
+for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.1 Coefficients (b_2 - b_{24}) for equations {4.7.1.1} & {4.7.1.2} in the SO variant.

Coefficient	Species Code								
	AF	SF	NF	WB	WL	RC+	WH	PY	WA, CW, CH, WI, GC, MC, MB, OH
b_2	0.02956	-0.015087	-0.069045	0	0.004379	-0.00175	-0.040067	0	-0.075986
b_3	-0.00033	0	0.000608	0	0	-0.000067	0.000395	0	0.001193
b_4	0.00753	0	0	0	0	0	0	0	0
b_5	0	0.323625	0.684939	0	0.351929	0	0.380416	0.252853	0.227307
b_6	0	0	0	0.001766	0	0	0	0	0
b_7	-0.28887	-0.128126	-0.207659	-0.01752	0.258712	0.05534	0	0	-0.86398
b_8	-0.65502	-0.059062	-0.374512	-0.609774	-0.156235	-0.06625	0	0	0.085958
b_9	0.64936	0.240178	0.400223	-2.05706	-0.635704	0.11931	0.421486	0	0
b_{10}	-0.37153	0.131356	0	2.11326	0	0	-0.69361	0	0
b_{11}	0.91259	0.980383	0.904253	0.213947	0.609098	0.58705	0.722462	0.879338	0.889596
b_{12}	0.0038	0	0	-0.358634	0	0	0	0	0
b_{13}	2.44945	1.709846	4.1231012	1.523464	1.158355	1.2936	2.1603479	1.970052	1.732535
b_{14}	-0.72173	0	-2.6893401	0	0	0	-0.834196	0	0
b_{15}*									
b_{16}	-0.0162	-0.000261	-0.006368	0	-0.004253	-0.02284	-0.004065	-0.004215	-0.001265
b_{17}	-0.00064	-0.000643	-0.000471	0	-0.000568	-0.00094	0	0	0

Coefficient	Species Code								
	AF	SF	NF	WB	WL	RC+	WH	PY	WA, CW, CH, WI, GC, MC, MB, OH
b_{18}	0	0	0	0	0	0	0	0	0
b_{19}	0	0	0	0	0	0	0	0	0
b_{20}	0	0	0	0	0	0	-0.000358	0	0
b_{21}	0	0	0	0	0	0	0	0	0
b_{22}	0	0	0	0	0	0	0	-0.000173	-0.000981
b_{23}	0.00201	0	0	-0.199592	0	0	0	0	0
b_{24}	-0.00002	0	0	0	0	0	0	0	0

*see table 4.7.1.4 for b_{15} values

+for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.1 Coefficients (b_2 – b_{24}) for equations {4.7.1.1} & {4.7.1.2} in the SO variant.

Coefficient	Species Code	
	BM	WO
b_2	-0.012111	0.0049
b_3	0	-8.781E-05
b_4	0	0
b_5	1.965888	0.213526
b_6	0	0
b_7	0	0
b_8	0	0
b_9	0	0
b_{10}	0	0
b_{11}	1.024186	1.310111
b_{12}	0	0
b_{13}	0.459387	0.271183
b_{14}	0	0
b_{15}*		
b_{16}	-0.010222	0
b_{17}	-0.000757	-0.000473
b_{18}	0	0
b_{19}	0	0
b_{20}	0	0
b_{21}	0	0
b_{22}	0	0
b_{23}	0	0
b_{24}	0	0

*see table 4.7.1.4 for b_{15} values

Table 4.7.1.2 b_1 values by location class for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Class	Species Code									
	WP[+]	SP[+]	DF, OS[+]	WF, GF	MH	IC[+]	LP[+]	ES	SH	PP
1	-0.23185	-1.09124	0.83941	-0.16674	-0.25368	0.23477	-0.03997	-4.64535	-2.073942	1.48355
2	0	-1.0463	0.97742	-0.04804	0	0	-0.17367	0	0	1.34282
3	0	-0.048564	0.67207	0.02336	0	0	0.80024	0	0	1.46037
4	0	-0.4713	1.17949	0.47563	0	0	0.40611	0	0	1.54377
5	0	0	0.83941	0	0	0	0.17307	0	0	0
6	0	0	0	0	0	0	0.35268	0	0	0

[+]for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.2 (continued) b_1 values by location class for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Class	Species Code								
	AF	SF	NF	WB	WL	RC[+]	WH	PY	WA, CW, CH, WI, GC, MC, MB, OH
1	-1.68772	-0.441408	-1.127977	1.911884	-0.605649	1.49419	-0.147675	-1.3100671	-0.107648
2	-0.9624	0	0	0	0	0	0	0	0
3	-1.38122	0	0	0	0	0	0	0	0
4	-1.0344	0	0	0	0	0	0	0	0
5	-0.76742	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0

[+]for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.2 (continued) b_1 values by location class for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Class	Species Code	
	BM	WO
1	-7.753469	-1.958189
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0

Table 4.7.1.3 Location class by species and location code for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Code	Species Code									
	WP[+]	SP[+]	DF, OS[+]	WF, GF	MH	IC[+]	LP[+]	ES	SH	PP
601 – Deschutes	1	1	1	1	1	1	1	1	1	1

Location Code	Species Code									
	WP+	SP+	DF, OS+	WF, GF	MH	IC+	LP+	ES	SH	PP
799 – Warm Springs Reservation										
602 – Fremont	1	2	1	1	1	1	2	1	1	2
620 – Winema	1	3	2	2	1	1	2	1	1	2
505 – Klamath & Shasta-Trinity	1	4	3	2	1	1	3	1	1	3
506 – Lassen	1	4	4	3	1	1	4	1	1	3
509 – Modoc	1	4	5	3	1	1	5	1	1	4
511 – Plumas	1	4	4	3	1	1	4	1	1	3
701 – Industry Lands	1	1	5	4	1	1	6	1	1	2

+for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.3 (continued) Location class by species and location code for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Code	Species Code								
	AF	SF	NF	WB	WL	RC+	WH	PY	WA, CW, CH, WI, GC, MC, MB, OH
601 – Deschutes 799 – Warm Springs Reservation	1	1	1	1	1	1	1	1	1
602 – Fremont	2	1	1	1	1	1	1	1	1
620 – Winema	2	1	1	1	1	1	1	1	1
505 – Klamath & Shasta-Trinity	3	1	1	1	1	1	1	1	1
506 – Lassen	4	1	1	1	1	1	1	1	1
509 – Modoc	5	1	1	1	1	1	1	1	1
511 – Plumas	4	1	1	1	1	1	1	1	1
701 – Industry Lands	5	1	1	1	1	1	1	1	1

+for the Warm Springs Reservation, see equations below for these species

Table 4.7.1.3 (continued) Location class by species and location code for equations {4.7.1.1} and {4.7.1.2} in the SO variant.

Location Code	Species Code	
	BM	WO
601 – Deschutes 799 – Warm Springs Reservation	1	1
602 – Fremont	1	1
620 – Winema	1	1
505 – Klamath	1	1
506 – Lassen	1	1
509 – Modoc	1	1
511 – Plumas	1	1

701 – Industry Lands	1	1

Table 4.7.1.4 b_{15} values by location code for equation {4.7.1.1} in the SO variant.

Species Code	Location Code 601 799	602	620	505 514	506	509	511	701
WP+	-0.000091	-0.000091	-0.000091	-0.000091	-0.000091	-0.000091	-0.000091	-0.000091
SP+	-0.000295	-0.000295	-0.000295	-0.000295	-0.000295	-0.000295	-0.000295	-0.000295
DF, OS+	-0.000066	-0.000066	-0.000066	-0.000066	-0.000066	-0.000066	-0.000066	-0.000066
WF, GF	-0.000414	-0.000414	-0.000414	-0.000239	-0.000325	-0.000239	-0.000325	-0.000414
MH	-0.000252	-0.000252	-0.000252	-0.000252	-0.000252	-0.000252	-0.000252	-0.000252
IC+	-0.000251	-0.000251	-0.000251	-0.000251	-0.000133	-0.000251	-0.000133	-0.000251
LP+	-0.000099	-0.000099	-0.000099	-0.000099	-0.000099	-0.000099	-0.000099	-0.000099
ES	0	0	0	0	0	0	0	0
SH	-0.0004572	-0.0004572	-0.0004572	-0.0004572	-0.0004572	-0.0004572	-0.0004572	-0.0004572
PP	-0.000324	-0.000356	-0.00012	-0.00012	-0.00012	-0.00012	-0.00012	-0.000324
AF	-0.000468	-0.000468	-0.000468	-0.000468	-0.000468	-0.000468	-0.000468	-0.000468
SF	-0.0002189	-0.0002189	-0.0002189	-0.0002189	-0.0002189	-0.0002189	-0.0002189	-0.0002189
NF	-0.0003996	-0.0003996	-0.0003996	-0.0003996	-0.0003996	-0.0003996	-0.0003996	-0.0003996
WB	-0.0006538	-0.0006538	-0.0006538	-0.0006538	-0.0006538	-0.0006538	-0.0006538	-0.0006538
WL	-0.0001683	-0.0001683	-0.0001683	-0.0001683	-0.0001683	-0.0001683	-0.0001683	-0.0001683
RC+	0	0	0	0	0	0	0	0
WH	-0.0001546	-0.0001546	-0.0001546	-0.0001546	-0.0001546	-0.0001546	-0.0001546	-0.0001546
PY	-0.0001323	-0.0001323	-0.0001323	-0.0001323	-0.0001323	-0.0001323	-0.0001323	-0.0001323
WA, CW, CH, WI, GC, MC, MB, OH	0	0	0	0	0	0	0	0
BM	-0.0001737	-0.0001737	-0.0001737	-0.0001737	-0.0001737	-0.0001737	-0.0001737	-0.0001737
WO	-0.0003048	-0.0003048	-0.0003048	-0.0003048	-0.0003048	-0.0003048	-0.0003048	-0.0003048

+for the Warm Springs Reservation, see equations below for these species

Large-tree diameter growth for quaking aspen is predicted using equation set {4.7.1.2}. Diameter growth is predicted from a potential diameter growth equation that is modified by stand density, average tree size and site. While not shown here, this diameter growth estimate is eventually converted to the *DDS* scale.

{4.7.1.2} Used for quaking aspen

$POTGR = (0.4755 - 0.0000038336 * DBH$^$4.1488) + (0.0451 * CR * DBH$^$ .67266)$
$MOD = 1.0 - \exp(-FOFR * GOFAD * ((310-BA)/310)$^$^{0.5})$
$FOFR = 1.07528 * (1.0 - \exp(-1.89022 * DBH / QMD))$
$GOFAD = 0.21963 * (QMD + 1.0)$^$0.73355$
$PREDGR = POTGR * MOD * (.48630 + 0.01258 * SI)$

where:

POTGR	is potential diameter growth
DBH	is tree diameter at breast height
CR	is crown ratio expressed as a percent divided by 10
MOD	is a modifier based on tree diameter and stand density
FOFR	is the relative density modifier
GOFAD	is the average diameter modifier
BA	is total stand basal area
QMD	is stand quadratic mean diameter
PREDGR	is predicted diameter growth
SI	is species site index

Large-tree diameter growth for red alder is predicted using equation set {4.7.1.3}. Diameter growth is predicted based on tree diameter and stand basal area. While not shown here, this diameter growth estimate is eventually converted to the *DDS* scale.

{4.7.1.3} Used for red alder

$DBH \leq 18.0”: DG = CON – (0.166496 * DBH) + (0.004618 * DBH^2)$
$DBH > 18.0”: DG = CON – (CON / 10) * (DBH – 18)$

where:

$CON = (3.2505 – 0.00303 * BA)$

where:

DG	is potential diameter growth
DBH	is tree diameter at breast height
BA	is stand basal area

For the Warm Springs Reservation, large-tree diameter growth for western white pine, sugar pine, incense cedar, lodgepole pine, western redcedar, and other softwoods is predicted using equation sets {4.7.1.4} - {4.7.1.8}.

{4.7.1.4} Used for western white pine and sugar pine for the Warm Springs Reservation

$ln(DDS) = – 0.58957 – (0.023376 * EL) + (0.40401 * ln(XSITE)) + (0.84469 * ln(DBH)) + (1.59725 * CR) – (0.0000596 * DBH^2) – (0.003726 * BAL / (ln(DBH + 1.0)))– (0.000257 * PCCF)$
for western white pine, $XSITE = 1.96 * SI$
for sugar pine, $XSITE = SI$

{4.7.1.5} Used for incense cedar for the Warm Springs Reservation

$ln(DDS) = –1.310067 + (0.252853 * ln(XSITE)) + (0.879338 * ln(DBH))+ (1.970052 * CR) – (0.0001323 * DBH^2) – (0.004215 * BAL / (ln(DBH + 1.0)))– (0.000173 * BA)$
$XSITE = 25.0 + 1.2 * SI$

{4.7.1.6} Used for lodgepole pine for the Warm Springs Reservation

$$ln(DDS) = -1.084679 - (0.001124 * EL) + (0.458662 * ln(XSITE)) - (0.142328 * \sin(ASP) * SL) - (0.064328 * \cos(ASP) * SL) - (0.097297 * SL) + (0.094464 * SL^2) + (0.554261 * ln(DBH)) + (1.423849 * CR) - (0.004803 * BAL / (\ln(DBH + 1.0))) - (0.000627 * PCCF)$$

$$XSITE = 12.25 + 1.325 * SI$$

{4.7.1.7} Used for western redcedar for the Warm Springs Reservation

$$ln(DDS) = 0.645645 - (0.050081 * EL) + (0.00066 * EL^2) + (0.139734 * ln(XSITE)) + (0.843013 * ln(DBH)) + (2.878032 * CR) - (1.631418 * CR^2) - (0.0000644 * DBH^2) - (0.003923 * BAL / (\ln(DBH + 1.0))) - (0.000552 * PCCF)$$

$$XSITE = SI$$

{4.7.1.8} Used for other softwoods species group, which represents yellow cedar, for the Warm Springs Reservation

$$ln(DDS) = -1.277664 + (0.244694 * ln(XSITE)) + (0.679903 * \sin(ASP) * SL) - (0.023186 * \cos(ASP) * SL) + (0.81688 * ln(DBH)) + (2.471226 * CR) - (0.0002536 * DBH^2) - (0.00595 * BAL / (\ln(DBH + 1.0))) - (0.000147 * BA)$$

$$XSITE = 3.5 + 1.45 * SI$$

where:

DDS	is the square of the diameter growth increment
EL	is stand elevation in hundreds of feet
SI	is species site index using the SO variant site index reference curves
XSITE	is species site index transformed to the reference curve for which the equation was fit
ASP	is stand aspect in radians
SL	is stand slope
DBH	is tree diameter at breast height
BAL	is total basal area in trees larger than the subject tree
CR	is crown ratio expressed as a proportion
PCCF	is crown competition factor on the inventory point where the tree is established
BA	is total stand basal area

4.7.2 Large Tree Height Growth

Large tree height growth equations in the SO variant are based on site index curves. Species differences in height growth are accounted for by entering the appropriate curve with the species specific site index value (see section 3.4). Height growth for western juniper trees of all sizes is calculated using the small tree height growth equations shown in section 4.6.1.

Using a species site index and tree height at the beginning of the projection cycle, an estimated tree age is computed using the site index curves. Also, maximum species heights and ages for the species site index curve are assigned using values shown in table 4.7.2.1.

Table 4.7.2.1 Maximum tree height and age for the species site index curve in the SO variant.

Species Code	Maximum Height	Maximum Age
WP	165	500

Species Code	Maximum Height	Maximum Age
SP	160	400
DF	180	900
WF	180	450
MH	150	650
IC	150	650
LP	130	350
ES	165	400
SH	180	500
PP	175	900
WJ	n/a	n/a
GF	165	350
AF	120	350
SF	165	400
NF	165	400
WB	85	400
WL	175	400
RC	165	550
WH	165	550
PY	50	350
WA	50	350
RA	100	100
BM	100	100
AS	75	100
CW	125	100
CH	30	50
WO	75	250
WI	30	50
GC	30	75
MC	20	50
MB	25	50
OS	165	400
OH	100	100

For western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense-cedar, lodgepole pine, Engelmann spruce, grand fir, subalpine fir, Pacific silver fir, noble fir, whitebark pine, western larch, western redcedar, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, quaking aspen, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods, if tree height at the beginning of the projection cycle is greater than or equal to the maximum species height, then height growth is computed using equation {4.7.2.1} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.1} $HTG = 0.1$

where:

HTG is estimated 10-year tree height growth

For western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense-cedar, lodgepole pine, Engelmann spruce, grand fir, subalpine fir, Pacific silver fir, noble fir, whitebark pine, western larch, western redcedar, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, quaking aspen, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods, when tree height at the beginning of the projection cycle is less than the maximum species height, and for Shasta red fir and Oregon white oak, if estimated tree age at the beginning of the projection cycle is greater than the species maximum age, height growth is calculated using equation {4.7.2.2} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.2} $HTG = 0.1 * HTGMOD$

where:

HTG is estimated 10-year tree height growth
HTGMOD is the weighted height growth multiplier shown in section 4.7.2.3

For ponderosa pine, if estimated tree age at the beginning of the projection cycle is greater than the species maximum age, height growth is calculated using equation {4.7.2.3} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.3} $HTG = \mathrm{POTHTG} * HTGMOD$

where:

HTG is estimated 10-year tree height growth
POTHTG is estimated potential height growth calculated as $POTHTG = -1.31 + 0.05 * SINDX$ and bounded ($POTHTG \geq 0.1$)
SINDX is ponderosa pine site index
HTGMOD is the weighted height growth multiplier shown in section 4.7.2.3

For western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense-cedar, lodgepole pine, Engelmann spruce, Shasta red fir, grand fir, subalpine fir, Pacific silver fir, noble fir, western larch, western redcedar, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, Oregon white oak, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods, when estimated tree age at the beginning of the projection cycle is less than or equal to the species maximum age and tree height at the beginning of the projection cycle is less than the species maximum height, then potential height growth is obtained by subtracting estimated current height from an estimated future height. For ponderosa pine, when estimated tree age at the beginning of the projection cycle is less than or equal to the species maximum age, then potential height growth is obtained by subtracting estimated current height from an estimated future height. For all these species, potential height growth is then adjusted according to the tree's crown ratio and height relative to other trees in the stand.

Estimated current height (ECH) and estimated future height (H10) are both obtained using the equations shown below with the following exception. Shasta red fir and Oregon white oak located in Region 5 forests use the Dunning/Levitan curves shown in section 4.7.2.1. Estimated current height is obtained using estimated tree age at the start of the projection cycle and site index. Estimated future height is obtained using estimated tree age at the start of the projection cycle plus 10-years and site index.

{4.7.2.4} western white pine

$H = SI / (b_0 * (1.0 - b_1 * \exp(b_2 * A))\text{^}b_3)$

{4.7.2.5} Douglas-fir and other softwoods

$H = 4.5 + \exp(b_1 + b_2 * \ln(A) + b_3 * (\ln(A)) \text{^} 4) + (b_4 + (SI - 4.5)) * (b_5 + b_6 * (1 - \exp(b_7 * A))\text{^}b_8)$

{4.7.2.6} white fir, incense-cedar, grand fir, and Pacific silver fir

$H = \exp[b_0 + b_1 * \ln(A) + b_2 * (\ln(A))\text{^}4 + b_3 * (\ln(A))\text{^}9 + b_4 * (\ln(A))\text{^}11 + b_5 * (\ln(A))\text{^}18] + b_{12} * \exp[b_6 + b_7 * \ln(A) + b_8 * (\ln(A))\text{^}2 + b_9 * (\ln(A))\text{^}7 + b_{10} * (\ln(A))\text{^}16 + b_{11} * (\ln(A))\text{^}24] + (SI - 4.5) * \exp[b_6 + b_7 * \ln(A) + b_8 * (\ln(A))\text{^}2 + b_9 * (\ln(A))\text{^}7 + b_{10} * (\ln(A))\text{^}16 + b_{11} * (\ln(A))\text{^}24] + 4.5$

{4.7.2.7} mountain hemlock

$H = [(b_0 + b_1 * SI) * (1 - \exp(b_2 * SI \text{^}0.5 * A))\text{^}(b_4 + b_5/SI) + 1.37] * 3.281$

{4.7.2.8} lodgepole pine

$H = SI * [b_0 + (b_1 * A) + (b_2 * A\text{^}2)]$

{4.7.2.9} Engelmann spruce

$H = 4.5 + [(b_0 * SI\text{^}b_1) * (1 - \exp(-b_2 * A)) \text{^} (b_3 * SI\text{^}b_4)]$

{4.7.2.10} Shasta red fir

$H = [(SI - 4.5) * (1 - \exp(-X * A\text{^}b_1))] / [1 - \exp(-Y * 50\text{^}b_1)] + 4.5$
$X = (SI * TERM) + (b_4 * TERM\text{^}2) + b_5$
$TERM = A * b_2 * \exp(A * b_3)$
$Y = (SI * TERM2) + (b_4 * TERM2\text{^}2) + b_5$
$TERM2 = 50 * b_2 * \exp(50 * b_3)$

{4.7.2.11} ponderosa pine and sugar pine

$H = [b_0 * (1 - \exp(b_1 * A))\text{^}b_2] - [(b_3 + b_4 * (1 - \exp(b_5 * A))\text{^}b_6) * b_7] + [(b_3 + b_4 * (1 - \exp(b_5 * A))\text{^}b_6) * (SI - 4.5)] + 4.5$

{4.7.2.12} subalpine fir

$H = SI * [b_0 + (b_1 * A) + (b_2 * A\text{^}2)]$

{4.7.2.13} noble fir

$H = 4.5 + [(SI - 4.5) / (X1 * (1 / A)\text{^}2 + X2 * (1 / A) + 1 - (X1 * 0.0001) - (X2 * 0.01))]$
$X1 = b_0 + (b_1 * (SI - 4.5)) - (b_2 * (SI - 4.5)\text{^}2)$
$X2 = b_3 + (b_4 / (SI - 4.5)) + (b_5 / (SI - 4.5)\text{^}2)$

{4.7.2.14} western larch

$H = 4.5 + (b_1 * A) + (b_2 * A^2) + (b_3 * A^3) + (b_4 * A^4) + (SI – 4.5) * [b_5 + (b_6 * A) + (b_7 * A^2) + (b_8 * A^3)] – b_9 * [b_{10} + (b_{11} * A) + (b_{12} * A^2) + (b_{13} * A^3)]$

{4.7.2.15} red cedar

$H = b_1 * SI * [(1 – \exp(b_2 * A))^{b_3}]$

{4.7.2.16} western hemlock

$H = [A^2 / (b_0 + (b_1 * Z) + ((b_2 + (b_3 * Z)) * A) + ((b_4 + (b_5 * Z)) * A^2))] + 4.5$

$Z = 2500 / (SI – 4.5)$

{4.7.2.17} Pacific yew, white alder, bigleaf maple, black cottonwood, bitter cherry, willow, giant chinquapin, curl-leaf mtn. mahogany, birch-leaf mtn. mahogany, and other hardwoods

$H = [(SI – 4.5) / [b_0 + (b_1 / (SI – 4.5))] + [A^{-1.4} * (b_2 + (b_3 / (SI – 4.5)))]] + 4.5$

{4.7.2.18} red alder

$H = SI + [(b_0 + b_1 * SI) * (1 – \exp((b_2 + b_3 * SI) * A))^{b_4}] – [(b_0 + b_1 * SI) * (1 – \exp((b_2 + b_3 * SI) * 20))^{b_4}]$

{4.7.2.19} Oregon white oak

$H = SI * [1 + b_1 * (A^{0.5} – 7.07107)] – [b_0 * (A^{0.5} – 7.07107)]$

where:

H	is estimated height of the tree
SI	is species site index
A	is estimated age of the tree
$b_0 – b_{13}$	are species-specific coefficients shown in Table 4.7.2.2

Table 4.7.2.2 Coefficients ($b_0 – b_{13}$) for height-growth equations in the SO variant.

	Species Index								
Coefficient	**WP**	**DF, OS**	**WF, IC, GF, SF**	**MH**	**LP**	**ES**	**SH**	**SP, PP**	**AF**
b_0	0.375045	0	-0.30935	22.8741	-0.0968	2.7578	0	128.8952	-0.07831
b_1	0.92503	-0.37496	1.2383	0.950234	0.02679	0.83312	1.51744	-0.01696	0.0149
b_2	-0.0208	1.36164	0.001762	-0.00206	-9.3E-05	0.015701	1.42E-06	1.23114	-4.08E-05
b_3	-2.48811	-0.00243	-5.40E-06	0	0	22.71944	-0.04409	-0.7864	0
b_4	0	-79.97	2.05E-07	1.365566	0	-0.63557	-3.05E06	2.49717	0
b_5	0	-0.2828	-4.04E-13	2.045963	0	0	5.72E-04	-0.0045	0
b_6	0	1.87947	-6.2056	0	0	0	0	0.33022	0
b_7	0	-0.0224	2.097	0	0	0	0	100.43	0
b_8	0	0.966998	-0.09411	0	0	0	0	0	0
b_9	0	0	-4.4E-05	0	0	0	0	0	0
b_{10}	0	0	2.01E-11	0	0	0	0	0	0

b_{11}	0	0	-2.05E-17	0	0	0	0	0	0
b_{12}	0	0	-84.93	0	0	0	0	0	0
b_{13}	0	0	0	0	0	0	0	0	0

Table 4.7.2.2 (continued) Coefficients (b_0 – b_{13}) for height-growth equations in the SO variant.

	Species Index						
Coefficient	**NF**	**WL**	**RC**	**WH**	**PY, WA, BM, CW, CH, WI, GC, MC, MB, OH**	**RA**	**WO**
b_0	-564.38	0	0	-1.7307	0.6192	59.5864	6.413
b_1	22.25	1.46897	1.3283	0.1394	-5.3394	0.7953	0.322
b_2	0.04995	0.009247	-0.0174	-0.0616	240.29	0.00194	0
b_3	6.8	-0.00024	1.4711	0.0137	3368.9	-0.00074	0
b_4	2843.21	1.11E-06	0	0.00192	0	0.9198	0
b_5	34735.54	-0.12528	0	0.00007	0	0	0
b_6	0	0.039636	0	0	0	0	0
b_7	0	-0.00043	0	0	0	0	0
b_8	0	1.70E-06	0	0	0	0	0
b_9	0	73.57	0	0	0	0	0
b_{10}	0	-0.12528	0	0	0	0	0
b_{11}	0	0.039636	0	0	0	0	0
b_{12}	0	-0.00043	0	0	0	0	0
b_{13}	0	1.70E-06	0	0	0	0	0

Potential height growth is estimated using equation {4.7.2.20}. Height increment is computed using equation {4.7.2.21} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.20} $POTHTG = H10 – ECH$

{4.7.2.21} $HTG = POTHTG * HTGMOD$

where:

POTHTG	is potential height growth
H10	is estimated height of the tree in ten years
ECH	is estimated height of the tree at the beginning of the cycle
HTG	is estimated 10-year tree height growth (bounded $0.1 \leq HTG$)
HTGMOD	is the weighted height growth multiplier shown in section 4.7.2.3

4.7.2.1 Dunning/Levitan Site Curves

For Shasta red fir and Oregon white oak in Region 5 forests, estimated current height (ECH) and estimated future height (H10) are both obtained using the use the Dunning/Levitan site curve equations {4.7.2.1.1 – 4.7.2.2.2}. Estimated current height is obtained using estimated tree age at the start of the projection cycle and site index. Estimated future height is obtained using estimated tree age at the start of the projection cycle plus 10-years and site index. Potential height growth is estimated using equation {4.7.2.20}. Height increment is computed using equation {4.7.2.21} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.1.1} $H = d_1 + d_2 * \ln(A)$ for $A > 40$

{4.7.2.1.2} $H = d_3 * A$ for $A \leq 40$:

where:

H is estimated height of the tree
A is estimated age of the tree
d_1, d_2, d_3 are coefficients based on Region 5 site class shown in table 4.7.2.2.1

Table 4.7.2.2.1 Coefficients for the Dunning/Levitan site curves, nominal site index by site class in the SO variant.

Region 5 Site Class	Nominal Site Index	Site Index Range	d_1	d_2	d_3
0	106	99+	-88.9	49.7067	2.375
1	90	83 - 98	-82.2	44.1147	2.025
2	75	66 - 82	-78.3	39.1441	1.65
3	56	53 - 65	-82.1	35.416	1.225
4	49	45 - 52	-56	26.7173	1.075
5-7	39	0 - 44	-33.8	18.64	0.875

4.7.2.2 Whitebark Pine and Quaking Aspen

Whitebark pine and quaking aspen use Johnson's SBB (1949) method (Schreuder and Hafley, 1977). Height increment, using this method, is obtained by subtracting current height from the estimated future height. If tree diameter is greater than ($C_1 + 0.1$), or tree height is greater than ($C_2 + 4.5$), where C_1 and C_2 are shown in table 4.7.2.2.1, parameters of the SBB distribution cannot be calculated and height growth is set to 0.1. Otherwise, the SBB distribution "*Z*" parameter is estimated using equation {4.7.2.2.1}.

{4.7.2.2.1} Species Index 18 (whitebark pine and quaking aspen)

$Z = \{[C_4 + C_6 * FBY2 – C_7 * (C_3 + C_5 * FBY1)] * (1 – C_7\text{^}2)\text{^}{-0.5}\} + ZBIAS$
$FBY1 = \ln[Y1/(1 - Y1)]$
$FBY2 = \ln[Y2/(1 - Y2)]$
$Y1 = (DBH – 0.1) / C_1$
$Y2 = (HT – 4.5) / C_2$

where:

HT is tree height
DBH is tree diameter at breast height
$C_1 – C_9$ are coefficients based on species and crown ratio class shown in table 4.7.2.2.1
ZBIAS is known bias (see equation 4.7.2.2.2)

Known bias is calculated using equation {4.7.2.2.2}.

{4.7.2.2.2} Known bias:

For quaking aspen: ZBIAS = $(0.1 - 0.10273 * Z + 0.00273 * Z^2)$ bounded ZBIAS ≥ 0
For whitebark pine: ZBIAS = 0

If the Z value is 2.0 or less, it is adjusted for all younger aged trees using equation {4.7.2.2.3}. This adjustment is done for trees with an estimated age between 11 and 39 years and a diameter less than 9.0 inches. After this calculation, the value of Z is bounded to be 2.0 or less for trees meeting these criteria.

{4.7.2.2.3} $Z = Z * (0.3564 * DG) * \text{CLOSUR} * K$

if $CCF \geq 100$: $CLOSUR = PCT / 100$
if $CCF < 100$: $CLOSUR = 1$
if $CR \geq 75\%$: $K = 1.1$
if $CR < 75\%$: $K = 1.0$

where:

DG	is diameter growth for the cycle
PCT	is the subject tree's percentile in the basal area distribution of the stand
CCF	is stand crown competition factor

Estimated height 10 years later is calculated using equation {4.7.2.2.4}, and finally, 10-year height growth is calculated by subtraction using equation {4.7.2.2.5} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.2.4}

$H10 = [(PSI / (1 + PSI)) * C_2] + 4.5$
$PSI = C_8 * [(D10 - 0.095) / (0.095 + C_1 - D10)]^{\wedge}C_9 * [\exp(K)]$
$K = Z * [(1 - C_7{}^{\wedge}2)^{\wedge}(0.5 / C6)]$

{4.7.2.2.5}

$POTHTG = H10 - HT$ for $H10 > HT$
$POTHTG = 0.1$ for $H10 \leq HT$

where:

H10	is estimated height of the tree in ten years
HT	is height of the tree at the beginning of the cycle
D10	is estimated diameter at breast height of the tree in ten years
POTHTG	is potential height growth
$C_1 - C_9$	are regression coefficients based on species and crown ratio class

Table 4.7.2.2.1 Coefficients in the large tree height growth model, by crown ratio, for species using the Johnson's SBB height distribution in the SO variant.

Coefficient*	WB	AS
C_1 ($CR \leq 24$)	37.0	30.0
C_1 ($25 \leq CR \leq 74$)	45.0	30.0

Coefficient*	WB	AS
C_1 ($75 \le CR \le 100$)	45.0	35.0
C_2 ($CR \le 24$)	85.0	85.0
C_2 ($25 \le CR \le 74$)	100.0	85.0
C_2 ($75 \le CR \le 100$)	90.0	85.0
C_3 ($CR \le 24$)	1.77836	2.00995
C_3 ($25 \le CR \le 74$)	1.66674	2.00995
C_3 ($75 \le CR \le 100$)	1.64770	1.80388
C_4 ($CR \le 24$)	-0.51147	0.03288
C_4 ($25 \le CR \le 74$)	0.25626	0.03288
C_4 ($75 \le CR \le 100$)	0.30546	-0.07682
C_5 ($CR \le 24$)	1.88795	1.81059
C_5 ($25 \le CR \le 74$)	1.45477	1.81059
C_5 ($75 \le CR \le 100$)	1.35015	1.70032
C_6 ($CR \le 24$)	1.20654	1.28612
C_6 ($25 \le CR \le 74$)	1.11251	1.28612
C_6 ($75 \le CR \le 100$)	0.94823	1.29148
C_7 ($CR \le 24$)	0.57697	0.72051
C_7 ($25 \le CR \le 74$)	0.67375	0.72051
C_7 ($75 \le CR \le 100$)	0.70453	0.72343
C_8 ($CR \le 24$)	3.57635	3.00551
C_8 ($25 \le CR \le 74$)	2.17942	3.00551
C_8 ($75 \le CR \le 100$)	2.46480	2.91519
C_9 ($CR \le 24$)	0.90283	1.01433
C_9 ($25 \le CR \le 74$)	0.88103	1.01433
C_9 ($75 \le CR \le 100$)	1.00316	0.95244

**CR* represents percent crown ratio

4.7.2.3 Large Tree Height Growth Modifiers

For western white pine, sugar pine, Douglas-fir, white fir, mountain hemlock, incense-cedar, lodgepole pine, Engelmann spruce, ponderosa pine, grand fir, subalpine fir, Pacific silver fir, noble fir, western larch, western redcedar, western hemlock, Pacific yew, white alder, red alder, bigleaf maple, black cottonwood, bitter cherry, willow species, giant chinquapin, curl-leaf mountain mahogany, birchleaf mountain mahogany, other softwoods, and other hardwoods, modifiers are applied to the height growth based upon a tree's crown ratio (using equation {4.7.2.3.1}), and relative height and shade tolerance (using equation {4.7.2.3.2}). Equation {4.7.2.3.3} uses the Generalized Chapman – Richard's function (Donnelly et. al, 1992) to calculate a height-growth modifier. Height growth is calculated using equations {4.7.2.2}, {4.7.2.3}, or {4.7.2.21} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.3.1} $HGMDCR = (100 * (CR / 100)^3) * \exp(-5 * (CR / 100))$ bounded $HGMDCR \le 1.0$

{4.7.2.3.2} $HGMDRH = [1 + ((1 / b_1)^{(b_2 - 1)} - 1) * \exp((-1 * (b_3 / (1 - b_4)) * RELHT^{(1 - b_4)})]^{(-1 / (b_2 - 1))}$

{4.7.2.3.3} $HTGMOD = (0.25 * HGMDCR) + (0.75 * HGMDRH)$ bounded $0.0 \le HTGMOD \le 2.0$

*if $HTGMOD \le 0.0$, then $HTGMOD = 0.1$

{4.7.2.3.4} $HTG = POTHTG * HTGMOD$

where:

POTHTG	is potential height growth
HGMDCR	is a height growth modifier based on crown ratio
HGMDRH	is a height growth modifier based on relative height and shade tolerance
HTGMOD	is a weighted height growth modifier
CR	is crown ratio expressed as a percent
RELHT	is tree height divided by average height of the 40 largest diameter trees in the stand
$b_1 - b_4$	are species-specific coefficients shown in table 4.7.2.3

Table 4.7.2.3.1 Coefficients for the modifiers for the height growth equations by species for the SO variant.

Species	Model Coefficients			
Code	b_1	b_2	b_3	b_4
WP	0.10	1.10	15	-1.45
SP	0.10	1.10	15	-1.45
DF	0.10	1.10	15	-1.45
WF	0.20	1.10	20	-1.10
MH	0.20	1.10	20	-1.10
IC	0.20	1.10	20	-1.10
LP	0.01	1.10	12	-1.60
ES	0.15	1.10	16	-1.20
SH	0.15	1.10	16	-1.20
PP	0.05	1.10	13	-1.60
WJ	n/a	n/a	n/a	n/a
GF	0.20	1.10	13	-1.10
AF	0.05	1.10	20	-1.20
SF	0.10	1.10	20	-1.10
NF	0.10	1.10	15	-1.45
WB	0.10	1.10	15	-1.60
WL	0.10	1.10	12	-1.60
RC	0.10	1.10	20	-1.10
WH	0.20	1.10	20	-1.10
PY	0.20	1.10	20	-1.10
WA	0.05	1.10	13	-1.60
RA	0.05	1.10	13	-1.60
BM	0.20	1.10	20	-1.10
AS	0.10	1.10	15	-1.45
CW	0.01	1.10	12	-1.60
CH	0.05	1.10	13	-1.60
WO	0.10	1.10	15	-1.45

Species Code	Model Coefficients			
	b_1	b_2	b_3	b_4
WI	0.01	1.10	12	-1.60
GC	0.10	1.10	15	-1.45
MC	0.10	1.10	15	-1.45
MB	0.10	1.10	15	-1.45
OS	0.10	1.10	15	-1.45
OH	0.10	1.10	15	-1.45

For Shasta red fir and Oregon white oak, the height growth modifier is calculated as shown above when the estimated tree age at the start of the projection cycle is greater than the maximum age for the site index curve. When estimated tree age at the start of the projection cycle is less than the maximum age for the site index curve, the height growth modifier is calculated using equation {4.7.2.3.5}. Height growth is calculated using equations {4.7.2.2} or {4.7.2.21} and adjusted for cycle length and user supplied growth multipliers.

{4.7.2.3.5} $HTGMOD = 1.016605 * [1 - \exp(-4.26558 * CR)] * [\exp(2.54119 * ((RELHT \wedge 0.250537) - 1))]$

where:

HTGMOD is the height growth modifier
CR is crown ratio expressed as a proportion
RELHT is tree height divided by average height of the 40 largest diameter trees in the stand (bounded $RELHT \leq 1$, and set equal to 1 when $PCCF < 100$)
PCCF is the crown competition factor for the inventory point on which the tree is located

These height growth modifiers are not applied to quaking aspen or whitebark pine, and are not applicable to western juniper.

5.0 Mortality Model

The SO 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 SO variant.

Species Code	p_0	p_1
WP	6.5112	-0.0052485
SP	6.5112	-0.0052485
DF	7.2985	-0.0129121
WF	5.1677	-0.0077681
MH	9.6943	-0.0127328
IC	5.1677	-0.0077681
LP	5.9617	-0.03401328
ES	9.6943	-0.01273328
SH	5.1677	-0.0077681
PP	5.5877	-0.005348
WJ	5.1677	-0.0077681
GF	5.1677	-0.0077681
AF	5.1677	-0.0077681
SF	5.1677	-0.0077681

Species Code	p_0	p_1
NF	5.1677	-0.0077681
WB	6.5112	-0.0052485
WL	5.9617	-0.0340128
RC	5.1677	-0.0077681
WH	7.2985	-0.0129121
PY	5.5877	-0.005348
WA	5.9617	-0.03401328
RA	5.9617	-0.03401328
BM	5.5877	-0.005348
AS	5.1677	-0.0077681
CW	5.5877	-0.005348
CH	5.9617	-0.03401328
WO	5.9617	-0.03401328
WI	5.9617	-0.03401328
GC	5.5877	-0.005348
MC	5.9617	-0.03401328
MB	5.9617	-0.03401328
OS	7.2985	-0.0129121
OH	5.9617	-0.03401328

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 percentile in the basal area distribution (*PCT*) using equation {5.0.3}. This value is then adjusted by a species-specific mortality modifier (representing the species' tolerance) to obtain a final mortality rate as 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} $MR = 0.84525 - (0.01074 * PCT) + (0.0000002 * PCT^3)$

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

where:

MR	is the proportion of the tree record attributed to mortality (bounded: $0.01 \le MR \le 1$)
PCT	is the subject tree's percentile in the basal area distribution of the stand
MORT	is the final mortality rate of the tree record

MWT is a mortality weight value based on a species' tolerance shown in table 5.0.2

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

Species Code	*MWT*
WP	0.7
SP	0.75
DF	1
WF	0.55
MH	0.5
IC	0.65
LP	0.9
ES	0.6
SH	0.6
PP	0.85
WJ	1.1
GF	0.55
AF	0.55
SF	0.5
NF	0.7
WB	0.8
WL	1

Species Code	*MWT*
RC	0.5
WH	0.5
PY	0.5
WA	1
RA	0.9
BM	0.7
AS	1.3
CW	0.85
CH	1.1
WO	1
WI	1.3
GC	0.8
MC	1.1
MB	1.1
OS	0.7
OH	1

6.0 Regeneration

The SO 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 SO variant.

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
WP	No	0.4	1	23
SP	No	0.4	1	27
DF	No	0.3	1.5	21
WF	No	0.3	1.5	21
MH	No	0.2	0.5	22
IC	No	0.2	0.5	20
LP	No	0.4	1.5	20
ES	No	0.3	0.5	18
SH	No	0.2	0.8	20
PP	No	0.5	1.3	17
WJ	No	0.3	0.5	6
GF	No	0.3	1.5	21
AF	No	0.3	0.8	20
SF	No	0.3	0.5	21
NF	No	0.3	1	20
WB	No	0.4	1	23
WL	No	0.3	1	27
RC	No	0.2	0.5	22
WH	No	0.2	1	20
PY	Yes	0.2	1	20
WA	Yes	0.2	1	20
RA	Yes	0.3	1	50
BM	Yes	0.2	1	20
AS	Yes	0.2	6	16
CW	Yes	0.2	1	20
CH	Yes	0.2	1	20
WO	Yes	0.2	1.5	20
WI	Yes	0.2	1	20
GC	Yes	0.2	1	20

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
MC	No	0.2	1	20
MB	Yes	0.2	1	20
OS	No	0.3	1.5	21
OH	No	0.2	1	20

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

{6.0.5} $PS = ((99.9 - 3.8462 * DSTMP_i) / 100)$

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 SO variant.

Species Code	Sprouting Probability	Number of Sprout Records	Source
PY	0.4	1	Minore 1996 Ag. Handbook 654
WA	{6.0.5}	1	See red alder (RA)
RA	{6.0.5}	1	Harrington 1984 Uchytil 1989
BM	0.9	{6.0.2}	Roy 1955 Tappenier et al. 1996 Ag. Handbook 654
AS	{6.0.4}	2	Keyser 2001
CW	0.9	{6.0.2}	Gom and Rood 2000 Steinberg 2001
CH	0.9	{6.0.2}	Mueggler 1965 Leedge and Hickey 1971 Morgan and Neuenschwander 1988
WO	0.9	{6.0.1}	Roy 1955 Gucker 2007
WI	0.9	1	Ag. Handbook 654
GC	0.9	{6.0.2}	Harrington et al. 1992 Meyer 2012
MB	0.7	1	Gucker 2006

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

In the SO variant, volume is calculated for three merchantability standards: total stem cubic feet, merchantable stem cubic feet, and merchantable stem board feet (Scribner Decimal C (R5) and Scribner (R6)). 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 volume merchantability standards and equation numbers for the SO variant are shown in tables 7.0.1-7.0.3.

Table 7.0.1 Volume merchantability standards for the SO variant.

Merchantable Cubic Foot Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
Region 5	9.0 / 6.0 inches	9.0 / 6.0 inches
Region 6 and Warm Springs Reservation	9.0 / 4.5 inches	9.0 / 4.5 inches
Stump Height	1.0 foot	1.0 foot
Merchantable Board Foot Volume Specifications:		
Minimum DBH / Top Diameter	Hardwoods	Softwoods
Region 5	9.0 / 6.0 inches	9.0 / 6.0 inches
Region 6 and Warm Springs Reservation	9.0 / 4.5 inches	9.0 / 4.5 inches
Stump Height	1.0 foot	1.0 foot

Table 7.0.2 Volume equation defaults for each species, at specific location codes, with model name.

Common Name	Location Code	Equation Number	Reference
western white pine	505, 506, 509, 511, 701	500WO2W117	Wensel and Olsen Profile Model
western white pine	601, 602, 620, 799	616BEHW119	Behre's Hyperbola
sugar pine	505, 506, 509, 511, 701	500WO2W117	Wensel and Olsen Profile Model
sugar pine	601, 602, 620, 799	616BEHW117	Behre's Hyperbola
Douglas-fir	505, 506, 509, 511, 701	500WO2W202	Wensel and Olsen Profile Model
Douglas-fir	601, 799	I11FW2W202	Flewelling's INGY 2-Point Profile Model
Douglas-fir	602, 620	I00FW2W017	Flewelling's INGY 2-Point Profile Model
white fir	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
white fir	601, 799	I00FW2W017	Flewelling's INGY 2-Point Profile Model
white fir	602, 620	I11FW2W017	Flewelling's INGY 2-Point Profile Model

Common Name	Location Code	Equation Number	Reference
mountain hemlock	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
mountain hemlock	601, 602, 620, 799	616BEHW264	Behre's Hyperbola
incense-cedar	505, 506, 509, 511, 701	500WO2W081	Wensel and Olsen Profile Model
incense-cedar	601, 799	I11FW2W242	Flewelling's INGY 2-Point Profile Model
incense-cedar	602, 620	I00FW2W202	Flewelling's INGY 2-Point Profile Model
lodgepole pine	505, 506, 509, 511, 701	500WO2W108	Wensel and Olsen Profile Model
lodgepole pine	601, 799	I11FW2W108	Flewelling's INGY 2-Point Profile Model
lodgepole pine	602, 620	I00FW2W108	Flewelling's INGY 2-Point Profile Model
Engelmann spruce	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
Engelmann spruce	601, 602, 620, 799	616BEHW093	Behre's Hyperbola
Shasta red fir	505, 506, 509, 511, 701	500WO2W020	Wensel and Olsen Profile Model
Shasta red fir	601, 799	I00FW2W017	Flewelling's INGY 2-Point Profile Model
Shasta red fir	602, 620	616BEHW021	Behre's Hyperbola
ponderosa pine/Jeffrey pine	505, 506, 509, 511, 701	500WO2W122	Wensel and Olsen Profile Model
ponderosa pine/Jeffrey pine	601, 799	I11FW2W122	Flewelling's INGY 2-Point Profile Model
ponderosa pine/Jeffrey pine	602, 620	I00FW2W122	Flewelling's INGY 2-Point Profile Model
western juniper	505, 506, 509, 511, 701	500DVEW060	Wensel and Olsen Profile Model
western juniper	601, 602, 620, 799	616BEHW064	Behre's Hyperbola
grand fir	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
grand fir	601, 799	I00FW2W017	Flewelling's INGY 2-Point Profile Model
grand fir	602, 620	I11FW2W017	Flewelling's INGY 2-Point Profile Model
subalpine fir	505, 506, 509, 511, 701	500WO2W020	Wensel and Olsen Profile Model
subalpine fir	601, 602, 620, 799	616BEHW019	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
Pacific silver fir	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
Pacific silver fir	601, 799	I00FW2W017	Flewelling's INGY 2-Point Profile Model
Pacific silver fir	602, 620	616BEHW011	Flewelling's INGY 2-Point Profile Model
noble fir	505, 506, 509, 511, 701	500WO2W020	Wensel and Olsen Profile Model
noble fir	601, 602, 620, 799	616BEHW022	Behre's Hyperbola
whitebark pine	505, 506, 509, 511, 701	500WO2W108	Wensel and Olsen Profile Model
whitebark pine	601, 602, 620, 799	616BEHW101	Behre's Hyperbola
western larch	505, 506, 509, 511, 701	500WO2W202	Wensel and Olsen Profile Model
western larch	601, 799	I11FW2W073	Flewelling's INGY 2-Point Profile Model
western larch	602, 620	616BEHW073	Flewelling's INGY 2-Point Profile Model
western redcedar	505, 506, 509, 511, 701	500WO2W081	Wensel and Olsen Profile Model
western redcedar	601, 602, 620, 799	616BEHW242	Behre's Hyperbola
western hemlock	505, 506, 509, 511, 701	500WO2W015	Wensel and Olsen Profile Model
western hemlock	601, 602, 620, 799	616BEHW263	Behre's Hyperbola
Pacific yew	505, 506, 509, 511, 701	500WO2W108	Wensel and Olsen Profile Model
Pacific yew	601, 602, 620, 799	616BEHW231	Behre's Hyperbola
white alder	505, 506, 509, 511, 701	500DVEW351	Pillsbury and Kirkley Equations
white alder	601, 602, 620, 799	616BEHW352	Behre's Hyperbola
red alder	505, 506, 509, 511, 701	500DVEW351	Pillsbury and Kirkley Equations
red alder	601, 602, 620, 799	616BEHW351	Behre's Hyperbola
bigleaf maple	505, 506, 509, 511, 701	500DVEW312	Pillsbury and Kirkley Equations
bigleaf maple	601, 602, 620, 799	616BEHW312	Behre's Hyperbola
quaking aspen	505, 506, 509, 511, 701	500DVEW818	Pillsbury and Kirkley Equations
quaking aspen	601, 602, 620, 799	616BEHW746	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
black cottonwood	505, 506, 509, 511, 701	500DVEW818	Pillsbury and Kirkley Equations
black cottonwood	601, 602, 620, 799	616BEHW747	Behre's Hyperbola
bitter cherry	505, 506, 509, 511, 701	500DVEW801	Pillsbury and Kirkley Equations
bitter cherry	601, 602, 620, 799	616BEHW768	Behre's Hyperbola
Oregon white oak	505, 506, 509, 511, 701	500DVEW815	Pillsbury and Kirkley Equations
Oregon white oak	601, 602, 620, 799	616BEHW815	Behre's Hyperbola
willow species	505, 506, 509, 511, 701	500DVEW807	Pillsbury and Kirkley Equations
willow species	601, 602, 620, 799	616BEHW920	Behre's Hyperbola
giant chiquapin	505, 506, 509, 511, 701	500DVEW431	Pillsbury and Kirkley Equations
giant chiquapin	601, 602, 620, 799	616BEHW431	Behre's Hyperbola
curl-leaf mtn. mahogany	505, 506, 509, 511, 701	500DVEW801	Pillsbury and Kirkley Equations
curl-leaf mtn. mahogany	601, 602, 620, 799	616BEHW475	Behre's Hyperbola
birchleaf mtn. mahogany	505, 506, 509, 511, 701	500DVEW801	Pillsbury and Kirkley Equations
birchleaf mtn. mahogany	601, 602, 620, 799	616BEHW478	Behre's Hyperbola
other softwoods	505, 506, 509, 511, 701	500WO2W108	Wensel and Olsen Profile Model
other softwoods	601, 602, 620, 799	616BEHW298	Behre's Hyperbola
other hardwoods	505, 506, 509, 511, 701	500DVEW981	Pillsbury and Kirkley Equations
other hardwoods	601, 602, 620, 799	616BEHW998	Behre's Hyperbola

Table 7.0.3 Citations by Volume Model

Model Name	Citation
Behre's Hyperbola	USFS-R6 Sale Preparation and Valuation Section of Diameter and Volume Procedures - R6 Timber Cruise System. 1978.
Flewelling's INGY 2-Point Profile Model	Unpublished. Based on work presented by Flewelling and Raynes. 1993. Variable-shape stem-profile predictions for western hemlock. Canadian Journal of Forest Research Vol 23. Part I and Part II.
Pillsbury and Kirkley Equations	Norman H Pillsbury and Michael L Kirkley 1984 Equations for Total, Wood, and saw-Log Volume for Thirteen California Hardwoods. Pacific Northwest Forest and Range Experiment Station Research Note PNW-414.

Wensel and Olsen Profile Model	Wensel, L. C. and C. M. Olson. 1993. Tree Taper Models for Major Commercial California Conifers. Research Note No. 33. Northern Calif. Forest Yield Cooperative. Dept. of Forstry and Mgmt., Univ. of Calif., Berkeley. 28 pp.

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 SO variant, refer to the updated FFE-FVS model documentation (Rebain, comp. 2010) available on the FVS website. The Warm Springs Reservation uses FFE-FVS model settings for the Deschutes National Forest.

9.0 Insect and Disease Extensions

FVS Insect and Pathogen models for dwarf mistletoe and western root disease have been developed for the SO variant through the participation and contribution of various organizations led by Forest Health Protection. These models are currently maintained by the Forest Management Service Center and regional Forest Health Protection specialists. Additional details regarding each model may be found in chapter 8 of the Essential FVS Users Guide (Dixon 2002).

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11.0 Appendices

11.1 Appendix A. Distribution of Data Samples

Data used to develop equations for the original 11 species in the SO variant came from the following sources:

- Deschutes forest inventory
- Fremont forest inventory
- Winema forest inventory
- Klamath forest inventory
- Lassen forest inventory
- Modoc forest inventory
- Hat Creek Rim thinning (Lassen NF)
- Forest Inventory and Analysis samples from state and private lands
- True fir release study (Ken Seidel, Deschutes NF)
- PSW Goosenest RD. thinning (Klamath NF)
- Washington Mountain thinning (PSW, Modoc NF)
- Sugar Hill thinning (PSW, Modoc NF)
- Jelly Pass thinning (PSW)
- Weyerhauser Spaulding Butte thinning (Modoc NF)
- Diamond International Bend thinning (Bob Wheeler)
- Center Peak thinning (Fremont NF)
- Fremont-Winema evaluation plantations
- Deschutes benchmark plantations
- Island thinning (Lassen NF)
- Adin Pass thinning (PSW, Modoc NF)
- Lookout Mountain fir study (PNW, Ken Seidel)
- Sheridan Mountain thinning (PSW, Deschutes NF)
- D25/D56 ponderosa pine study (PNW, Barrett)
- D66 red fir spacing study (PNW)

- D72 mixed conifer spacing study (PNW, Deschutes NF)

Table 11.1.1 contains distribution information of data used to fit species relationships in this variant's geographic region (information from original variant overview).

Table 11.1.1 The distribution of growth sample trees by species and type of study (landowner).

Species	Deschutes Forest	Winema Forest	Fremon t Forest	Klamath Forest	Modoc Forest	Lassen Forest	Special Studies	Private Land	Total Number of Observations
Western White Pine	20	27	15	0	28	9	0	0	260
Sugar Pine	1	42	16	0	1	37	2	0	326
Douglas-fir	29	55	0	1	0	12	1	1	717
White Fir	6	29	28	1	16	18	1	1	5797
Mountain Hemlock	86	11	1	0	3	0	0	0	783
Incense Cedar	4	13	35	0	12	34	0	1	511
Lodgepole Pine	46	23	24	0	4	3	0	0	3416
Engelmann Spruce	81	19	0	0	0	0	0	0	31
Shasta Red Fir	10	61	1	1	21	5	0	0	1216
Ponderosa Pine	15	14	22	1	11	10	26	1	10038
Other	0	2	48	0	35	0	0	15	48

11.2 Appendix B: Plant Association Codes

Table 11.2.1 Region 5 Plant association codes recognized in the SO variant.

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
1 = 2TE/BEOC2 Conifer/water birch	43014	501 – Manning & Padgett
2 =2TE/ROWO Conifer/wood's rose	43015	501 – Manning & Padget
3 = 2TE/2FORB Conifer/tall forb	43016	501 – Manning & Padgett
4 = 2TE/2FORB Conifer/mesic forb	43017	501 – Manning & Padget
5 = PICO/CASC12 Lodgepole pine/mountain sedge	43031	501 – Manning & Padgett
6 = POTR5/BEOC2 Quaking aspen/water birch	43061	501 – Manning & Padget
7 = POTR5/COSE16 Quaking aspen/redosier dogwood	43062	501 – Manning & Padgett
8 = POTR5/SALIX Quaking aspen/willow	43063	501 – Manning & Padget

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
9 = POTR5/ROWO Quaking aspen/woods' rose	43064	501 – Manning & Padgett
10 = POTR5/BRCA5 Quaking aspen/California brome	43065	501 – Manning & Padget
11 = POTR5/POPR Quaking aspen/Kentucky bluegrass	43066	501 – Manning & Padgett
12 = POTR5/2FORB Quaking aspen/mesic forb	43067	501 – Manning & Padget
13 = POPUL/BEOC2 Cottonwood/water birch	43071	501 – Manning & Padgett
14 = POPUL/COSE16 Cottonwood/redosier dogwood	43072	501 – Manning & Padget
15 = POPUL/SALIX Cottonwood/willow	43073	501 – Manning & Padgett
16 = POPUL/ROWO Cottonwood/woods' rose	43074	501 – Manning & Padget
17 = POPUL/RHAR4 Cottonwood/fragrant sumac	43075	501 – Manning & Padgett
18 = POPUL Cottonwood (stream bar)	43076	501 – Manning & Padget
19 = ALIN2 Gray alder (bench)	43106	501 – Manning & Padgett
20 = BEOC2/2GRAM Water birch/mesic graminoid	43153	501 – Manning & Padget
21 = BEOC2/EQAR Water birch/field horsetail	43154	501 – Manning & Padgett
22 = BEOC2 Water birch (bench)	43156	501 – Manning & Padget
23 = SAEX/ROWO Narrowleaf willow/woods' rose	43246	501 – Manning & Padgett
24 = SAEX Narrowleaf willow (bench)	43267	501 – Manning & Padget
25 = SALE/CASC12 Lemmons willow/mountain sedge	43261	501 – Manning & Padgett
26 = SALE/2GRAM Lemmons willow/mesic graminoid	43262	501 – Manning & Padget
27 = SALE/2FORB Lemmons willow/mesic forb	43263	501 – Manning & Padgett
28 = SALE/2FORB Lemons willow/tall forb	43264	501 – Manning & Padget

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
29 = SALE Lemmons willow (seep)	43265	501 – Manning & Padgett
30 = SALE Lemmons willow (bench)	43266	501 – Manning & Padget
31 = SALU2/2GRAM Yellow willow/ mesic graminoid	43272	501 – Manning & Padgett
32 = SALU2/2FORB Yellow willow/mesic forb	43273	501 – Manning & Padget
33 = SALU2/ROWO Yellow willow/woods' rose	43274	501 – Manning & Padgett
34 = SALU2/POPR Yellow willow/Kentucky bluegrass	43275	501 – Manning & Padget
35 = SALU2 Yellow willow (bench)	43276	501 – Manning & Padgett
36 = SADR Drummond's willow	43282	501 – Manning & Padget
37 = SALUL/2FORB Pacific willow/mesic forb	43284	501 – Manning & Padgett
38 = SALUL Pacific willow (bench)	43285	501 – Manning & Padget
39 = SALA6/ROWO Arroyo willow/woods' rose	43287	501 – Manning & Padgett
40 = SALA6 Arroyo willow (bench)	43288	501 – Manning & Padget
41 = SALIX/CARO6 Willow/beaked sedge	43289	501 – Manning & Padgett
42 = SALIX/2GRAM Willow/mesic graminoid	43290	501 – Manning & Padget
43 = SALIX/2FORB Willow/mesic forb	43291	501 – Manning & Padgett
44 = SALIX/2FORB Willow/tall forb	43292	501 – Manning & Padget
45 = SALIX/ROWO Willow/woods' rose	43293	501 – Manning & Padgett
46 = SALIX/POPR Willow/Kentucky bluegrass	43294	501 – Manning & Padget
47 = SAWO/CASC12 Wolf's willow/mountain sedge	43304	501 – Manning & Padgett
48 = SAPL2/CASC12 Diamondleaf willow/mountain sedge	43325	501 – Manning & Padget

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
49 = SAEA/CASC12 Mountain willow/mountain sedge	43327	501 – Manning & Padgett
50 = SAOR/2FORB Sierra willow/tall forb	43328	501 – Manning & Padget
51 = SALIX/2FORB Willow/mesic forb	43329	501 – Manning & Padgett
52 = COSE16 Redosier dogwood	43351	501 – Manning & Padget
53 = COSE16/SALIX Redosier dogwood-willow	43352	501 – Manning & Padgett
54 = PRVI/ROWO Chokecherry/woods' rose	43451	501 – Manning & Padget
55 = ROWO Woods' rose	43500	501 – Manning & Padgett
56 = DAFL3/LIGR Shrubby cinquefoil/gray's licorice-root	43554	501 – Manning & Padget
57 = ARCA13/2GRAM Silver sagebrush/graminoid (dry)	43605	501 – Manning & Padgett
58 = ARCA13/2GRAM Silver sagebrush/graminoid (mesic)	43606	501 – Manning & Padget
59 = ARTRT/ROWO Basin big sagebrush/woods' rose	43651	501 – Manning & Padgett
60 = CADO2 Douglas' sedge	43803	501 – Manning & Padget
61 = CASC12 Mountain sedge	43811	501 – Manning & Padgett
62 = DECA18-CANE2 Tufted hairgrass-Nebraska sedge	43872	501 – Manning & Padget
63 = POSE Sandberg bluegrass	43883	501 – Manning & Padgett
64 = DOJE Sierra shootingstar	43905	501 – Manning & Padget
65 = LUPO2-SETR Bigleaf lupine-arrowleaf ragwort	43911	501 – Manning & Padgett
66 = IRMI/2GRAM Western iris/dry graminoid	43915	501 – Manning & Padget
67 = IRMI/2GRAM Western iris/ mesic graminoid	43916	501 – Manning & Padgett
68 = AGST2 Creping bentgrass	43991	501 – Manning & Padget

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
69 = HOBR2 Meadow barley	43995	501 – Manning & Padgett
70 = CHLA Port Orford cedar	CCOCCO00	510 – Jimerson, 1994
71 = Port Orford cedar/salal (1)	CCOCCO11	510 – Jimerson, 1994
72 = Port Orford cedar/pacific rhododendron-salal(1)	CCOCCO12	510 – Jimerson, 1994
73 = Port Orford cedar/western azalea (1)	CCOCCO13	510 – Jimerson, 1994
74 = Port Orford cedar-western white pine/huckleberry oak (1)	CCOCCO14	510 – Jimerson, 1994
75 = CHLA-ABCO Port Orford cedar-white fir	CCOCFW00	510 – Jimerson, 1994
76 = CHLA-ABCO/QUVA Port Orford cedar-white fir/huckleberry oak	CCOCFW11	510 – Jimerson, 1994
77 = CHLA-ABCO-PIMO3/QUVA Port Orford cedar-white fir-western white pine/huckleberry oak	CCOCFW12	510 – Jimerson, 1994
78 = CHLA-ABCO/RHOB Port Orford cedar-white fir/western azalea	CCOCFW13	510 – Jimerson, 1994
79 = CHLA-ABCO/2FORB Port Orford cedar-white fir/forbs	CCOCFW14	510 – Jimerson, 1994
80 = CHLA-ABCO/QUSA2 Port Orford cedar-white fir/deer oak	CCOCFW15	510 – Jimerson, 1994
81 = CHLA-ABSH/QUSA2-VAME Port Orford cedar-Shasta red fir/deer oak-thinleaf huckleberry	CCOCFW16	510 – Jimerson, 1994
82 = CHLA-PSME/QUVA Port Orford cedar-Douglas-fir/huckleberry oak	CCOCFW17	510 – Jimerson, 1994
83 = CHLA-CADE27-ALRH2 Port Orford cedar-incense cedar-white alder	CCOCFW18	510 – Jimerson, 1994
84 = PSME Douglas-fir	CD000000	513 – Jimerson et al, 1996
85 = PSME-CADE27 Douglas-fir-incense cedar	CD0CCI00	513 – Jimerson et al, 1996
86 = PSME-CADE27/FECA Douglas-fir-incense cedar/California fescue	CD0CCI11	513 – Jimerson et al, 1996
87 = PSME-PIJE Douglas-fir-Jeffrey Pine	CD0CPJ00	513 – Jimerson et al, 1996
88 = PSME-PIJE/FECA Douglas-fir-Jeffrey pine/California fescue	CD0CPJ11	513 – Jimerson et al, 1996

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
89 = PSME-ALRU2 Douglas-fir-red alder	CD0HAR00	513 – Jimerson et al, 1996
90 = PSME-ALRU2/ACCI/CLSIS Douglas-fir-red alder/vine maple/Siberian springbeauty	CD0HAR11	513 – Jimerson et al, 1996
91 = PSME-UMCA Douglas-fir-California laurel	CD0HBC00	513 – Jimerson et al, 1996
92 = PSME-UMCA/TODI Douglas-fir-California laurel/Pacific poison oak	CD0HBC11	513 – Jimerson et al, 1996
93 = PSME-UMCA/HODI Douglas-fir-California laurel/ocean spray	CD0HBC12	513 – Jimerson et al, 1996
94 = PSME-CHCHC4 Douglas-fir-giant chinquapin	CD0HGC00	513 – Jimerson et al, 1996
95 = PSME-CHCHC4-LIDE3 Douglas-fir-giant chinquapin-tanoak	CD0HGC11	513 – Jimerson et al, 1996
96 = PSME-CHCHC4/XETE Douglas-fir-giant chinquapin/common beargrass	CD0HGC12	513 – Jimerson et al, 1996
97 = PSME-CHCHC4/RHMA3-GASH Douglas-fir-giant chinquapin/Pacific rhododendron-salal	CD0HGC13	513 – Jimerson et al, 1996
98 = PSME-CHCHC4/RHMA3-MANE2 Douglas-fir-giant chinquapin/pacific rhododendron-Cascade barberry	CD0HGC14	513 – Jimerson et al, 1996
99 = PSME-CHCHC4/RHMA3-QUSA2/XETE Douglas-fir-giant chinquapin/pacific rhododendron-deer oak/common beargrass	CD0HGC15	513 – Jimerson et al, 1996
100 = PSME-CHCHC4-LIDE3/MANE2 Douglas-fir-giant chinquapin-tanoak/cascade barberry	CD0HGC16	513 – Jimerson et al, 1996
101 = PSME-CHCHC4/RHA3-QUSA-GASH Douglas-fir-giant chinquapin/pacific rhododendron-deer oak-salal	CD0HGC17	513 – Jimerson et al, 1996
102 = PSME-ACER Douglas-fir-maple	CD0HMA00	513 – Jimerson et al, 1996
103 = PSME-ACMA3/POMU Douglas-fir-bigleaf maple/western swordfern	CD0HMA11	513 – Jimerson et al, 1996
104 = PSME-ACMA3/PHLE4 Douglas-fir-bigleaf maple/Lewis' mock orange	CD0HMA12	513 – Jimerson et al, 1996
105 = PSME/ACCI-MARE11 Douglas-fir/vine maple-Cascade barberry	CD0HMA13	513 – Jimerson et al, 1996
106 = PSME-QUKE Douglas-fir-California black oak	CD0HOB00	513 – Jimerson et al, 1996
107 = PSME-QUKE Douglas-fir-California black oak (metamorphic)	CD0HOB11	513 – Jimerson et al, 1996

FVS Sequence Number = Plant Association **Species Type**	**Alpha Code**	**Reference**
108 = PSME-QUKE Douglas-fir-California black oak (sandstone)	CD0HOB12	513 – Jimerson et al, 1996
109 = PSME-QUKE-QUGA4/2GRAM Douglas-fir-California black oak-Oregon white oak/grass	CD0HOB13	513 – Jimerson et al, 1996
110 = PSME-QUCH2 Douglas-fir-canyon live oak	CD0HOL00	513 – Jimerson et al, 1996
111 = PSME-QUCH2 Douglas-fir-canyon live oak (rockpile)	CD0HOL11	513 – Jimerson et al, 1996
112 = PSME-QUCH2-ARME/TODI Douglas-fir-canyon live oak-Pacific madrone/pacific poison oak	CD0HOL12	513 – Jimerson et al, 1996
113 = PSME-QUCH2-LIDE3 Douglas-fir-canyon live oak-tanoak	CD0HOL13	513 – Jimerson et al, 1996
114 = PSME-QUGA4 Douglas-fir-Oregon white oak	CD0HOO00	513 – Jimerson et al, 1996
115 = PSME-QUGA4/2GRAM Douglas-fir-Oregon white oak/grass	CD0HOO11	513 – Jimerson et al, 1996
116 = PSME-QUGA4/HODI Douglas-fir-Oregon white oak/oceanspray	CD0HOO12	513 – Jimerson et al, 1996
117 = PSME-LIDE3 Douglas-fir-tanoak	CD0HT000	513 – Jimerson et al, 1996
118 = PSME-LIDE3/WHMO Douglas-fir-tanoak/common whipplea	CD0HT011	513 – Jimerson et al, 1996
119 = PSME-LIDE3/QUVA-HODI Douglas-fir-tanoak/huckleberry oak-oceanspray	CD0HT012	513 – Jimerson et al, 1996
120 = PSME/2SHRUB Douglas-fir/shrub (moist)	CD0SM000	513 – Jimerson et al, 1996
121 = PSME/COCOC Douglas-fir/California hazelnut	CD0SM011	513 – Jimerson et al, 1996
122 = PSME/QUVA Douglas-fir/huckleberry oak	CD0SOH00	513 – Jimerson et al, 1996
123 = PSME/QUVA/LIDEE Douglas-fir/huckleberry oak-tanoak	CD0SOH12	513 – Jimerson et al, 1996
124 = PSME/QUVA-RHMA3 Douglas-fir/huckleberry oak-Pacific rhododendron	CD0SOH13	513 – Jimerson et al, 1996
125 = PIJE Jeffrey pine	CPJ00000	512 – Jimerson et al, 1995
126 = PIJE-CADE27 Jeffrey Pine – Incense cedar	CPJCCI00	512 – Jimerson et al, 1995
127 = PIJE-CADE27-ABCO/QUVA Jeffrey Pine-Incense cedar-white fir/huckleberry oak	CPJCCI11	512 – Jimerson et al, 1995

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
128 = PIJE-CADE27/QUVA/XETE Jeffrey Pine-Incense cedar/huckleberry oak/common beargrass	CPJCCI12	512 – Jimerson et al, 1995
129 = PIJE-CADE27/CEPU Jeffrey Pine-incense cedar/dwarf ceanothus	CPJCCI13	512 – Jimerson et al, 1995
130 = PIJE-CADE27/CECU Jeffrey Pine-incense cedar/buckbrush	CPJCCI14	512 – Jimerson et al, 1995
131 = PIJE-ABCO/IRIS Jeffrey Pine-white fir/iris	CPJCFW11	512 – Jimerson et al, 1995
132 = PIJE-ABCO/QUSA2/XETE Jeffrey pine-white fir/deer oak/common beargrass	CPJCFW12	512 – Jimerson et al, 1995
133 = PIJE/FEID Jeffrey pine/Idaho fescue	CPJGFI00	512 – Jimerson et al, 1995
134 = PIJE/FEID Jeffrey pine/Idaho fescue	CPJGFI11	512 – Jimerson et al, 1995
135 = PIJE/QUVA-ARNE/FEID Jeffrey pine/huckleberry oak-pinemat manzanita/Idaho fescue	CPJGFI12	512 – Jimerson et al, 1995
136 = PIJE/QUSA2-ARNE/FEID Jeffrey pine/deer oak-pinemat manzanita/Idaho fescue	CPJSOD11	512 – Jimerson et al, 1995
137 = PICO Lodgepole pine	CPL00000	512 – Jimerson et al, 1995
138 = PICO/QUVA Lodgepole pine/huckleberry oak	CPLSOH00	512 – Jimerson et al, 1995
139 = PICO/QUVA-FRCAO4 Lodgepole pine/huckleberry oak-California buckthorn	CPLSOH11	512 – Jimerson et al, 1995
140 = PICO/QUVA/LIDE3 Lodgepole pine/huckleberry oak-tanoak	CPLSOH12	512 – Jimerson et al, 1995
141 = PICO/LIDE3 Lodgepole pine/shrub tanoak	CPLST000	512 – Jimerson et al, 1995
142 = PICO/LIDE3-RHMA3 Lodgepole pine/tanoak-Pacific rhododendron	CPLST011	512 – Jimerson et al, 1995
143 = PILA Sugar pine	CPS00000	512 – Jimerson et al, 1995
144 = PILA-PICO Sugar pine-lodgepole pine	CPSCPL00	512 – Jimerson et al, 1995
145 = PILA-PICO/QUVA-LIDEE Sugar pine-lodgepole pine/huckleberry oak-tanoak	CPSCPL11	512 – Jimerson et al, 1995
146 = PILA-PICO/LIDEE-RHMA3 Sugar pine-lodgepole pine/tanoak-Pacific rhododendron	CPSCPL12	512 – Jimerson et al, 1995
147 = PILA-PIMO3 Sugar pine-western white pine	CPSCPW00	512 – Jimerson et al, 1995

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
148 = PILA-PIMO3/QUVA-GABU2 Sugar pine-western white pine/huckleberry oak-dwarf silktassel	CPSCPW11	512 – Jimerson et al, 1995
149 = PILA-CHCHC4 Sugar pine-giant chinquapin	CPSHGC00	512 – Jimerson et al, 1995
150 = PILA-CHCHC4/Quva-QUSA2 Sugar pine-giant chinquapin/huckleberry oak-deer oak	CPSHGC11	512 – Jimerson et al, 1995
151 = PIMO3 Western white pine	CPW00000	512 – Jimerson et al, 1995
152 = PIMO3-PSME Western white pine-Douglas-fir	CPWCD000	512 – Jimerson et al, 1995
153 = PIMO3-PSME/QUVA-LIDEE Western white pine-Douglas-fir/huckleberry oak-tanoak	CPWCD011	512 – Jimerson et al, 1995
154 = PIMO3/PIMO3 Western white pine/white pine	CPWCFW00	512 – Jimerson et al, 1995
155 = PIMO3-ABCO/QUVA/ANEMO Western white pine-white fir/huckleberry oak/western anemone	CPWCFW11	512 – Jimerson et al, 1995
156 = PIMO3-PICO Western white pine-lodgepole pine	CPWCPL00	512 – Jimerson et al, 1995
157 = PIMO3-PICO/LIDEE-RHMA3 Western white pine-lodglepole pine/tanoak-Pacific rhododendron	CPWCPL11	512 – Jimerson et al, 1995
158 = PIMO3-PILA Western white pine-sugar pine	CPWCPS00	512 – Jimerson et al, 1995
159 = PIMO3-PILA/QUVA-LIDEE Western white pine-sugar pine/huckleberry oak-tanoak	CPWCPS11	512 – Jimerson et al, 1995
160 = LIDE3 Tanoak	HT000000	513 – Jimerson et al, 1996
161 = LIDE3/CADE27 Tanoak-incense cedar	HT0CCI00	513 – Jimerson et al, 1996
162 = LIDE3-CADE27/FECA Tanoak-incense cedar/California fescue	HT0CCI11	513 – Jimerson et al, 1996
163 = LIDE3-CHLA Tanoak-Port Orford cedar	HT0CCO00	513 – Jimerson et al, 1996
164 = LIDE3-CHLA-UMCA/VAOV2 Tanoak-Port Orford cedar-California laurel/California huckleberry	HT0CCO11	513 – Jimerson et al, 1996
165 = LIDE3-CHLA/VAOV2-RHOC Tanoak-Port Orford cedar/California huckleberry-western azalea	HT0CCO12	513 – Jimerson et al, 1996
166 = LIDE3-CHLA/VAOV2 Tanoak-Port Orford cedar/California huckleberry	HT0CCO13	513 – Jimerson et al, 1996
167 = LIDE3-CHLA/MANE2/LIBOL2 Tanoak-Port Orford cedar/Cascade barberry/longtube twinflower	HT0CCO14	513 – Jimerson et al, 1996

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
168 = LIDE3-CHLA-ALRH2 Tanoak-Port Orford cedar-white alder (riparian)	HT0CCO15	513 – Jimerson et al, 1996
169 = LIDE3-CHLA/ACCI Tanoak-Port Orford cedar/vine maple	HT0CCO16	513 – Jimerson et al, 1996
170 = LIDE3-CHLA/VAPA Tanoak-Port Orford cedar/red huckleberry	HT0CCO17	513 – Jimerson et al, 1996
171 = LIDE3-CHLA/GASH Tanoak-Port Orford cedar/salal	HT0CCO18	513 – Jimerson et al, 1996
172 = LIDE3-CHLA-TSHE/VAOV2 Tanoak-Port Orford cedar-western hemlock/California huckleberry	HT0CCO19	513 – Jimerson et al, 1996
173 = LIDE3-UMCA Tanoak-California laurel	HT0HBC00	513 – Jimerson et al, 1996
174 = LIDE3-UMCA/TODI Tanoak-California laurel/Pacific poison oak	HT0HBC11	513 – Jimerson et al, 1996
175 = LIDE3-UMCA/VAOV2 Tanoak-California laurel/California huckleberry	HT0HBC12	513 – Jimerson et al, 1996
176 = LIDE3-CHCHC4 Tanoak-giant chinquapin	HT0HGC00	513 – Jimerson et al, 1996
177 = LIDE3-CHCHC4/GASH Tanoak-giant chinquapin/salal	HT0HGC11	513 – Jimerson et al, 1996
178 = LIDE3-CHCHC4/GASH-RHMA3 Tanoak-giant chinquapin/salal-Pacific rhododendron	HT0HGC12	513 – Jimerson et al, 1996
179 = LIDE3-CHCHC4/RHMA3/XETE Tanoak-giant chinquapin/Pacific rhododendron/common beargrass	HT0HGC13	513 – Jimerson et al, 1996
180 = LIDE3-CHCHC4/PTAQL Tanoak-giant chinquapin/western brackenfern	HT0HGC14	513 – Jimerson et al, 1996
181 = LIDE3-CHCHC4/MANE2 Tanoak-giant chinquapin/Cascade barberry	HT0HGC15	513 – Jimerson et al, 1996
182 = LIDE3CHCHC4/VAOV2-GASH Tanoak-giant chinquapin/California huckleberry-salal	HT0HGC16	513 – Jimerson et al, 1996
183 = LIDE3/ACER Tanoak-maple	HT0HM000	513 – Jimerson et al, 1996
184 = LIDE3-ACMA3/POMU Tanoak-bigleaf maple/swordfern	HT0HM011	513 – Jimerson et al, 1996
185 = LIDE3/ACCI-GASH Tanoak/vine maple-salal	HT0HM012	513 – Jimerson et al, 1996
186 = LIDE3/ACCI Tanoak/vine maple	HT0HM013	513 – Jimerson et al, 1996

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
187 = LIDE3/QUKE Tanoak-California black oak	HT0HOB00	513 – Jimerson et al, 1996
188 = LIDE3/QUKE Tanoak-California black oak	HT0HOB11	513 – Jimerson et al, 1996
189 = LIDE3-QUCH2 Tanoak-canyon live oak	HT0HOL00	513 – Jimerson et al, 1996
190 = LIDE3-QUCH2 Tanoak-canyon live oak (rockpile)	HT0HOL11	513 – Jimerson et al, 1996
191 = LIDE3-QUCH2/VAOV2 Tanoak-canyon live oak/California huckleberry	HT0HOL12	513 – Jimerson et al, 1996
192 = LIDE3-QUCH2/GASH-MANE2 Tanoak-canyon live oak/salal-Cascade barberry	HT0HOL13	513 – Jimerson et al, 1996
193 = LIDE-QUCH2-QUKE/TODI Tanoak-canyon live oak-California black oak/Pacific poison oak	HT0HOL14	513 – Jimerson et al, 1996
194 = LIDE3-QUCH2/TODI Tanoak-canyon live oak/Pacific poison oak	HT0HOL15	513 – Jimerson et al, 1996
195 = LIDE3-QUCH2/MANE2 Tanoak-canyon live oak/Cascade barberry	HT0HOL16	513 – Jimerson et al, 1996
196 = LIDE3/2SHRUB Tanoak/shrub (dry)	HT0SD000	513 – Jimerson et al, 1996
197 = LIDE3/TODI/LOHIV Tanoak/Pacific poison oak/pink honeysuckle	HT0SD011	513 – Jimerson et al, 1996
198 = LIDE3/MANE2 Tanoak/Cascade barberry	HT0SD012	513 – Jimerson et al, 1996
199 = LIDE3/VAOV2-GASH Tanoak/California huckleberry-salal	HT0SEH12	513 – Jimerson et al, 1996
200 = LIDE3/VAOV2-RHMA3 Tanoak/California huckleberry-Pacific rhododendron	HT0SEH13	513 – Jimerson et al, 1996
201 = LIDE3/2SHRUB Tanoak/shrub (moist0	HT0SM000	513 – Jimerson et al, 1996
202 = LIDE2/COCOC Tanoak/California hazelnut	HT0SM011	513 – Jimerson et al, 1996
203 = LIDE3/QUVA Tanoak/huckleberry oak	HT0SOH00	513 – Jimerson et al, 1996
204 = LIDE3/QUVA-RHMA3 Tanoak/huckleberry oak-Pacific rhododendron	HT0SOH11	513 – Jimerson et al, 1996
205 = LIDE3/GASH-RHMA3 Tanoak/salal-Pacific rhododendron	HT0SSG12	513 – Jimerson et al, 1996
206 = LIDE3/GASH-MANE2 Tanoak/salal-Cascade barberry	HT0SSG13	513 – Jimerson et al, 1996

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
207 = LIDE3/VAOV2 Tanoak/California huckleberry	HT0SEH00	513 – Jimerson et al, 1996
208 = LIDE3/VAOV2 Tanoak/California huckleberry	HT0SEH11	513 – Jimerson et al, 1996
209 = LIDE3/GASH Tanoak/salal	HT0SSG00	513 – Jimerson et al, 1996
210 = LIDE3/GASH Tanoak/salal	HT0SSG11	513 – Jimerson et al, 1996
211 = CADE27-PIPO-PSME/CHFO Incense cedar-ponderosa pine-Douglas-fir/mountain misery	CC0311	502 – Benson (1988)
212 = PIJE-ABCO/POA Jeffrey pine-white fir/bluegrass (granite)	CPJGBW11	502 – Benson (1988)
213 = PIPO-PIJE-ABCO/ACOCO Ponderosa pine-Jeffrey pine-white fir/western needlegrass (ash)	CPJGNG11	502 – Benson (1988)
214 = PIPO-PIJE-QUKE/AMPA2 Ponderosa pine-Jeffrey pine-California black oak/pale serviceberry	CPJSAM11	502 – Benson (1988)
215 = PIPO-PIJE-ABCO/AMPA2-MARE11 Ponderosa pine-Jeffrey pine-white fir/pale serviceberry-creeping barberry	CPJSAM12	502 – Benson (1988)
216 = PIJE-QUKE/RHTRQ Jeffrey pine-California black oak/skunkbush sumac	CPJSBB11	502 – Benson (1988)
217 = PIJE/PUTR2-CELE3/ACOCO Jeffrey pine/antelope bitterbrush-curl-leaf mountain mahogany/western needlegrass	CPJSBB12	502 – Benson (1988)
218 = PIJE/PUTR2-SYORU/POA Jeffrey pine/antelope bitterbrush-Utah snowberry/bluegrass	CPJSBB13	502 – Benson (1988)
219 = PIJE/PUTR2/WYMO Jeffrey pine/antelope bitterbrush/woolly mule-ears	CPJSBB14	502 – Benson (1988)
220 = PIPO-PIJE-PSME/PUTR2/WYMO Ponderosa pine-Jeffrey pine-Douglas-fir/antelope bitterbrush/woolly mule-ears	CPJSBB15	502 – Benson (1988)
221 = PIPO-PIJE-QUKE/POA Ponderosa pine-Jeffrey pine-California black oak/bluegrass (granite)	CPJSBB16	502 – Benson (1988)
222 = PIPO-PIJE/ARTRV-PUTR2 Ponderosa pine-Jeffrey pine/mountain big sagebrush-antelope bitterbrush	CPJSBB17	502 – Benson (1988)
223 = PIPO-PIJE/PUTR2/FEID Ponderosa pine-Jeffrey pine/antelope bitterbrush/Idaho fescue	CPJSBB18	502 – Benson (1988)

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
224 = PIPO-PIJE/PUTR2/FEID Ponderosa pine-Jeffrey pine/antelope bitterbrush/Idaho fescue (granite)	CPJSBB19	502 – Benson (1988)
225 = PIPO-PIJE/PUTR2/SEINM Ponderosa pine-Jeffrey pine/antelope bitterbrush/lambstongue ragwort (granite)	CPJSBB20	502 – Benson (1988)
226 = PIPO-PIJE/FRRUM/POSE Ponderosa pine-Jeffrey pine/Modoc buckthorn/Sandberg bluegrass	CPJSBB21	502 – Benson (1988)
227 = PIPO-PIJE-ABCO/QUW12 Ponderosa pine-Jeffrey pine-white fir/interior live oak	CPJSBB23	502 – Benson (1988)
228 = PIJE/CELE3 Jeffrey pine/curl-leaf mountain mahogany	CPJSMC11	502 – Benson (1988)
229 = PIPO-PIJE/CELE3/PSSPS Ponderosa pine-Jeffrey pine/curl-leaf mountain mahogany/ bluebunch balsamroot	CPJSMC12	502 – Benson (1988)
230 = PIPO-PIJE/CELE3/BASA3 Ponderosa pine-Jeffrey pine/curl-leaf mountain mahogany/ arrowleaf balsamroot	CPJSMC13	502 – Benson (1988)
231 = PIPO-PIJE-ABCO/QUVA/WYMO Ponderosa pine-Jeffrey pine-white fir/huckleberry oak/woolly mule-ears	CPJSOH11	502 – Benson (1988)
232 = PIJE/ARTRV/FEID Jeffrey pine/mountain big sagebrush/Idaho fescue	CPJSSB11	502 – Benson (1988)
233 = PIPO-PIJE-ABCO/SYAC/WYMO Ponderosa pine-Jeffrey pine-white fir/sharpleaf snowberry/ woolly mule-ears	CPJSSS12	502 – Benson (1988)
234 = PIJE-ABCO/SYORU/PONE2 Jeffrey pine-white fur/Utah snowberry/Wheeler bluegrass	CPJSSY11	502 – Benson (1988)
235 = PIWA/ARNE Washoe pine/pinemat manzanita	CPOSMP11	502 – Benson (1988)
236 = PIWA-ABCO/SYORU/PSJA2 Washoe pine-white fir/Utah snowberry/tuber starwort	CPOSSY11	502 – Benson (1988)
237 = PIPO/AMPA2-MARE11/ARCO9 Ponderosa pine/pale serviceberry-creeping barberry/ heartleaf arnica	CPPSAM11	502 – Benson (1988)
238 = PIPO/AMPA2-PRUNU Ponderosa pine/pale serviceberry-prunus	CPPSAM12	502 – Benson (1988)
239 = PIPO-ABCO-PICO/AMPA2 Ponderosa pine-white fir-lodgepole pine/pale serviceberry	CPPSAM13	502 – Benson (1988)

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
240 = PIPO-ABCO-QUVA/AMPA2 Ponderosa pine-white fir-black oak/pale serviceberry	CPPSAM14	502 – Benson (1988)
241 = PIPO-ABCO/AMPA2-MARE11 Ponderosa pine-white fir/pale serviceberry-creeping barberry	CPPSAM15	502 – Benson (1988)
242 = PIPO-ABCO/AMPA2-CEVE/BROR2 Ponderosa pine-white fir/pale serviceberry-snowbrush ceonothus/Orcutt's brome	CPPSAM16	502 – Benson (1988)
243 = PIPO-CADE27/PUTR2/BASA3 Ponderosa pine-incense cedar/antelope bitterbrush/ arrowleaf balsamroot	CPPSBB11	502 – Benson (1988)
244 = PIPO-QUKE/PUTR2/ACOCO Ponderosa pine-California black oak/antelope bitterbrush/ western needlegrass	CPPSBB12	502 – Benson (1988)
245 = PIPO/CELE3-PUTR2/FEID Ponderosa pine/curl-leaf mountain mahogany-antelope bitterbrush/Idaho fescue	CPPSBB13	502 – Benson (1988)
246 = PIPO/PURT2-CEVE-ARPA6/BROR2 Ponderosa pine/antelope bitterbrush-snowbrush ceanothus-greenleaf manzanita/Orcutt's brome	CPPSBB14	502 – Benson (1988)
247 = PIPO/PURT2-PRUNU/BROR2 Ponderosa pine/antelope bitterbrush-prunus/Orcutt's brome	CPPSBB15	502 – Benson (1988)
248 = PIPO/PUTR2-PRUNU/PSSPS Ponderosa pine/antelope bitterbrush-prunus/bluebunch wheatgrass	CPPSBB16	502 – Benson (1988)
249 = PIPO/PUTR2-RICE/BROR2 Ponderosa pine/antelope bitterbrush-wax current/Orcutt's brome	CPPSBB17	502 – Benson (1988)
250 = PIPO/PUTR2/BASA3 Ponderosa pine/antelope bitterbrush/arrowleaf balsamroot	CPPSBB18	502 – Benson (1988)
251 = PIPO/PUTR2/FEID Ponderosa pine/antelope bitterbrush/Idaho fescue	CPPSBB19	502 – Benson (1988)
252 = PIPO/PUTR2/ACOCO Ponderosa pine/antelope bitterbrush/western needlegrass (pumice)	CPPSBB20	502 – Benson (1988)
253 = PIPO-ABCO/CEVE/ACOCO Ponderosa pine-white fir/snowbrush ceonothus/western needlegrass	CPPSBB21	502 – Benson (1988)
254 = PIPO-ABCO/PUTR2-ARPA6/ACOCO Ponderosa pine-white fir/antelope bitterbrush-greenleaf manzanita/western needlegrass	CPPSBB22	502 – Benson (1988)

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
255 = PIPO/ARTRV/FEID Ponderosa pine/mountain big sagebrush/Idaho fescue	CPPSSB11	502 – Benson (1988)
256 = PSME-PIPO/TODI Douglas-fir-ponderosa pine/Pacific poison oak	DC0811	502 – Benson (1988)
257 = PSME-PIPO/CHFO/POCOC Douglas-fir-ponderosa pine/mountain misery/Sierra milk wort	DC0812	502 – Benson (1988)
258 = PSME-PINUS-QUCH2/CEIN3 Douglas-fir-pine-canyon live oak/deerbrush	DC0813	502 – Benson (1988)
259 = PSME-ABCO-LIDE3/PTAQL Douglas-fir-white fir-tanoak/western brackenfern	DC0911	502 – Benson (1988)
260 = PSME-CONU2-LIDE3/COCOC/GAAP2 Douglas-fir-mountain dogwood-tanoak/California hazelnut/ stickywilly	DH0711	502 – Benson (1988)
261 = PIPO-ABCO/CEVE3-CEPR Ponderosa pine-white fir/tobaccobrush-squawcarpet	PC0611	502 – Benson (1988)
262 = PILE-PIMO3/QUVA-ARNE2 Sugar pine-western white pine/huckleberry oak-pinemat manzanita	QS0111	502 – Benson (1988)
263 = ABCO-PSME-LIDE3/COCOC White fir-Douglas-fir-tanoak/California hazelnut	WC0911	502 – Benson (1988)
264 = ABCO-PSME/????/???? White fir-Douglas-fir-mountain dogwood/bush chinquapin	WC0912	502 – Benson (1988)
265 = ABCO-PSME/SYACC-????/???? White fir-Douglas-fir/sharpleaf snowberry/thimbleberry	WC0913	502 – Benson (1988)
266 = ABCO-PILA/SYAC/CARO5 White-fir-sugar pine/sharpleaf snowberry/Ross' sedge	WC0914	502 – Benson (1988)
267 = ABCO-PSME/CHME2 White fir-Douglas-fir/prince's pine	WC0915	502 – Benson (1988)
268 = ABCO-PSME-CADE27/AMPA2 White fir-Douglas-fir-incense cedar/pallid serviceberry	WC0916	502 – Benson (1988)
269 = ABCO-PSME-PIJE/???? White fir-Douglas-fir-Jeffrey pine/rosy everlasting	WC0917	502 – Benson (1988)
270 = PSME-PINUS-CADE27/ASDE6 Douglas-fir-pine-incense cedar/Indian dream	CC0411	
271 = PSME-PILA/LIDEE/PTAQL Douglas-fir-sugar pine/tanoak/western brackenfern	DC1011	
272 = PSME-PILA/LIDEE/TRIEN Douglas-fir-sugar pine/tanoak/broadleaf starflower	DC1012	
273 = PSME-PIPO/FRCAO4/PTAQL Douglas-fir-ponderosa pine/California buckthorn/western brackenfern	DC1013	

FVS Sequence Number = Plant Association **Species Type**	**Alpha Code**	**Reference**
274 = PSME-PIPO/CEIN3/COHE2 Douglas-fir-ponderosa pine/deerbrush/variableleaf collomia	DC1014	
275 = PSME-PIPO/FECA Douglas-fir-ponderosa pine/California fescue	DC1015	
276 = PSME-PIPO/QUVA/POMU Douglas-fir-ponderosa pine/huckleberry oak/western swordfern	DC1016	
277 = PSME-PINUS-CADE27/TRBR3 Douglas-fir-pine-incense cedar/forest clover	DC1017	
278 = PSME-PINUS-CADE27/CECU/TRBR3-FECA Douglas-fir-pine-incense cedar/buckbrush/forest clover-California fescue	DC1018	
279 = PSME-PINUS-CADE27/XETE Douglas-fir-pine-incense cedar/common beargrass	DC1019	
280 = PSME/COCOC/POMU Douglas-fir/California hazelnut/western swordfern	DS0911	
281 = PIJE-CADE27/CECU/HECAS2 Jeffrey pine-incense cedar/buckbrush/Shasta heliathella	PG0611	
282 = PIJE-CADE27/MAAQ2/FEID Jeffrey pine-incense cedar/hollyleaved barberry/Idaho fescue	PG0612	
283 = PIJE/CELE3/PSSPS Jeffrey pine/curl-leaf mountain mahogany/bluebench wheatgrass	PG0613	
284 = PIJE/ERPAA2/PHDI3 Jeffrey pine/Parry's rabbitbrush/spreading phlox	PG0614	
285 = PIJE-CADE27/QUVA/ASDE6 Jeffrey pine-incense cedar/huckleberry oak/Indian's dream	PS0911	
286 = ABCO-PSME-PILA/CONU4 White fir-Douglas-fir-sugar pine/Pacific dogwood	WC1011	
287 = PSME-ABCO/RHOC Douglas-fir-white fir/western azalea	WC1012	
288 = PSME-ABCO-PIPO/ARNE/CHUMO2 Douglas-fir-white fir-ponderosa pine/pinemat manzanita/ pipsisseqa	WC1013	
289 = 2TE Mixed conifer series	CX000000	
290 = Mixed conifer dry group	CX0D0000	
291 = Ponderosa pine-mixed conifer/Bolander's bedstraw-milkwort	CX0FBB11	
292 = White fir-mixed conifer/false Solomon's seal-Hooker's fairybells	CX0FFS11	

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
293 = Ponderosa pine-mixed conifer/rosy everlasting-naked stemmed	CX0FRE11	
294 = White fir-mixed conifer/troul plant	CX0FTP11	
295 = Douglas-fir-mixed conifer/starflower	CX0FWS11	
296 = White fir-mixed conifer/Ross' sedge	CX0GCR11	
297 = Douglas-fir-mixed conifer-white alder/Indian rhubarb	CX0HAW11	
298 = Mountain dogwood group	CX0HDP00	
299 = Douglas-fir-mixed conifer-mountain dogwood/California hazel buckwheat	CX0HDP13	
300 = Douglas-fir-mixed conifer-mountain dogwood/trail plant	CX0HDP14	
301 = Douglas-fir-mixed conifer-bigleaf maple/trail plant	CX0HMB12	
302 = QUCH2 Canyon live oak	CX0H0L00	
303 = Ponderosa pine-mixed conifer-canyon live oak/bearclover	CX0H0L15	
304 = Ponderosa pine-mixed conifer/Bolander's bedstraw	CX0H0L16	
305 = Douglas-fir-mixed conifer-canyon live oak/sword fern	CX0H0L17	
306 = LIDE3 Tanoak	CX0HT000	
307 = PSME-2TE-LIDE3/CONU4 Douglas-fir-mixed conifer-tanoak/Pacific dogwood	CX0HT012	
308 = PSME-2TE-LIDE3/CHFO Douglas-fir-mixed conifer-tanoak/mountain misery	CX0HT013	
309 = PSME-2TE-LIDE3/COCOC Douglas-fir-mixed conifer-tanoak/California hazelnut	CX0HT011	
310 = PSME-2TE-LIDE3/IRIS Douglas-fir-mixed conifer-tanoak/iris	CX0HT014	
311 = Mixed conifer moderate group	CX0M0000	
312 = Mixed conifer riparian group	CX0R0000	

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
313 = Douglas-fir-mixed conifer/serviceberry	CX0SAM12	
314 = Evergreen shrub group	CX0SE000	
315 = White fir-mixed conifer/vine maple-bush chinquapin	CX0SE011	
316 = White fir-mixed conifer/bush chinquapin	CX0SE012	
317 = Ponderosa pine-mixed conifer/shrub canyon live oak, huckleberry oak	CX0SE013	
318 = Ponderosa pine-mixed conifer/huckleberry oak (serpentine)	CX0SE014	
319 = Douglas-fir-mixed conifer/California hazelnut	CX0SHN12	
320 = Douglas-fir-mixed conifer/Sierra laurel	CX0SLS11	
321 = White fir-mixed conifer/mountain alder/sedge	CX0SMA11	
322 = White fir-mixed conifer/mountain alder/monkshood	CX0SMA12	
323 = Bearclover group	CX0SMM00	
324 = Ponderosa pine-mixed conifer/manzanita bearclover	CX0SMM11	
325 = Ponderosa pine-mixed conifer/bearclover/Bolander's bedstraw	CX0SMM12	
326 = White fir-mixed conifer/creeping snowberry/kelloggia	CX0SSS13	
327 = Mixed conifer moist group	CX0W0000	
328 = Douglas-fir-mixed conifer/American dogwood	CX0SDA11	
329 = ABMAS/RHMA Red fir/Pacific rhododendron	RS0511	
330 = ABCO-PILA-ABMAS/PTAQL White fir-sugar pine-red fir/bracken	WC0413	
331 = JUOC/WYMO Western juniper/woolly mule-ears	JC0111	
332 = JUOC Western juniper	JC0112	

FVS Sequence Number = Plant Association **Species Type**	**Alpha Code**	**Reference**
333 = TSME Mountain hemlock (steep)	MC0211	
334 = PIJE/QUVA Jeffrey pine/huckleberry oak	PS0811	
335 = PIJE/ARPA6-CEVE Jeffrey pine/greenleaf manzanita-snowbrush ceonothus	PS0812	
336 = PIJE/CECO-ARTR2 Jeffrey pine/whitethorn ceanothus-big sagebrush	PS0813	
337 = POTR5 Quaking aspen (flats)	QC0211	
338 = POTR5 Quaking aspen (uplands)	QC0212	
339 = ABMA California red fir	RC0011	
340 = ABMA/ABCO California red fir/white fir	RC0331	
341 = ABMA-TSME California red fir-mountain hemlock	RC0421	
342 = PIMO3/ARNE Western white pine/pinemat manzanita	RC0511	
343 = PIMO3-PICO Western white pine-lodgepole pine	RC0512	
344 = PIMO3 Western white pine	RC0513	
345 = PICO/HIAL2 Lodgepole pine/white hawkweed	RC0611	
346 = PICO/LIGR Lodgepole pine/Gray's licorice-root	RC0612	
347 = PICO Lodgepole pine	RC0613	
348 = ABMA/ASBO2 California red fir/Bolander's locoweed	RF0411	
349 = ABMA/WYMO California red fir/wooly mule-ears	RF0412	
350 = ABMA/ARNE California red fir/pinemat manzanita	RS0114	
351 = ABCO-PIJE White fir-Jeffrey pine	WC0711	
352 = ABCO-ABMA White fir-California red fir (mixed conifer)	WC0712	

FVS Sequence Number = Plant Association Species Type	**Alpha Code**	**Reference**
353 = PSME/QUVA Douglas-fir/huckleberry oak	CD0SOH11	507-513 – Jimerson et al, 1996
354 = SESE3 Redwood	CN00000	507-514 – Borchert, Segotta, & Purser
355 = SESE3 Redwood (Gamboa-Sur)	CN00011	507-514 – Borchert, Segotta, & Purser
356 = SESE3/PTAQ-WOFI Redwood/western brackenfern-giant chainfern (steamsides)	CNF0111	507-514 – Borchert, Segotta, & Purser
357 = SESE3/POMU-TROV2 Redwood/western swordfern-Pacific trillium (Gamboa-Sur)	CNF0211	507-514 – Borchert, Segotta, & Purser
358 = SESE3/MAFA3-VISAN2 Redwood/California manroot-garden vetch (Gamboa-Sur)	CNF0311	507-514 – Borchert, Segotta, & Purser
359 = SESE3-ACMA3/POCA12 Redwood-bigleaf maple/California polypody (Gamboa)	CNHB011	507-514 – Borchert, Segotta, & Purser
360 = SESE3-LIDE3/CAGL7-IRDO Redwood-tanoak/roundfruit sedge-Douglas iris (Gamboa)	CNHT011	507-504 – Smith
361 = PIPO-ABCO/SYAC Ponderosa pine-white fir/sharpleaf snowberry	CPPSSS11	507-515 – Borchert, Cunha, Krosse, & Lawrence
362 = QUDO Blue oak	HOD00000	507-515 – Borchert, Cunha, Krosse, & Lawrence
363 = QUDO/2GRAM Blue oak/annual grass	HODGA000	507-515 – Borchert, Cunha, Krosse, & Lawrence
364 = QUDO/HOMUL-VIPE3 Blue oak/leporinum barley-Johnny-jump-up	HODGA011	507-515 – Borchert, Cunha, Krosse, & Lawrence
365 = QUDO/LOWR2-NAPU4 Blue oak/Chilean bird's foot trefoil-purple tussockgrass	HODGA012	507-515 – Borchert, Cunha, Krosse, & Lawrence
366 = QUDO/EUSP-PETR7 Blue oak/warty spurge-goldback fern	HODGA013	507-515 – Borchert, Cunha, Krosse, & Lawrence
367 = QUDO/GAAN-LUCO Blue oak/phloxleaf bedstraw-scarlet lupine	HODGA014	507-515 – Borchert, Cunha, Krosse, & Lawrence
368 = QUDO/ERMO7-HOMUL Blue oak/musky stork's bill-leporinum barley	HODGA015	507-515 – Borchert, Cunha, Krosse, & Lawrence
369 = QUDO/DEPA2-PHIM Blue oak/San Bernardino larkspur-imbricate phacelia	HODGA016	507-515 – Borchert, Cunha, Krosse, & Lawrence

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
370 = QUDO/LUCO-MEAL12 Blue oak/scarlet lupine-foothill clover	HODGA017	507-515 – Borchert, Cunha, Krosse, & Lawrence
371 = QUDO/AMME12-PLNO Blue oak/common fiddleneck-rusty popcornflower	HODGA018	507-515 – Borchert, Cunha, Krosse, & Lawrence
372 = QUDO/EREL6/LOWR2-PLER3 Blue oak/longstem buckwheat/Chilean bird's-foot trefoil-dotseed plantain	HODGA019	507-515 – Borchert, Cunha, Krosse, & Lawrence
373 = QUDO/COSP-RILE2 Blue oak/spinster's blue eyed Mary-wireweed	HODGA020	507-515 – Borchert, Cunha, Krosse, & Lawrence
374 = QUDO/CEMOG/BOIN3-LIAF Blue oak/birchleaf mountain mahogany/hoary bowlesia-San Francisco woodland-star	HODGA021	507-515 – Borchert, Cunha, Krosse, & Lawrence
375 = QUDO/RICA/BRDI3 Blue oak/hillside gooseberry/ripgut brome	HODGA022	507-515 – Borchert, Cunha, Krosse, & Lawrence
376 = QUDO-QUWI2/2GRAM Blue oak-interior live oak/grass	HODHOI00	507-515 – Borchert, Cunha, Krosse, & Lawrence
377 = QUDO-QUWI2/LICY3 Blue oak-interior live oak/mission woodland-star	HODHOI11	507-515 – Borchert, Cunha, Krosse, & Lawrence
378 = ADFA Chamise	SA000000	511 – Gordon & White, 1994
379 = ADFA/ERFA2-SAAP2 Chamise/Eastern Mojave buckwheat-white sage	SA0SB000	511 – Gordon & White, 1994
380 = ADFA/SAME3 Chamise/black sage	SA0SBS00	511 – Gordon & White, 1994
381 = ADFA-CEGRP Chamise-desert ceanothus	SA0SCC00	511 – Gordon & White, 1994
382 = ADFA-CECR Chamise-hoaryleam ceanothus	SA0SCH00	511 – Gordon & White, 1994
383 = ADFA-CETO-CYBI Chamise-woolyleaf ceanothus-mission manzanita	SA0SCT00	511 – Gordon & White, 1994
384 = ADFA-CECU Chamise-buckbrush	SA0SCW00	511 – Gordon & White, 1994
385 = ADFA-ARGL4 Chamise-bigberry manzanita	SA0SMB00	511 – Gordon & White, 1994
386 = ADFA-ARGL3 Chamise-Eastwood's manzanita	SA0SME00	511 – Gordon & White, 1994
387 = ERFA2-SAAP2 Eastern Majove buckwheat-white sage	SB0SSW00	511 – Gordon & White, 1994
388 = CEMOG Birchleaf mountain mahogany	SBM00000	511 – Gordon & White, 1994

FVS Sequence Number = Plant Association Species Type	Alpha Code	Reference
389 = CECR Hoaryleaf ceanothus	SCH00000	511 – Gordon & White, 1994
390 = ARGL4 Bigberry manzanita	SMB00000	511 – Gordon & White, 1994
391 = ARGL3 Eastwood's manzanita	SME00000	511 – Gordon & White, 1994
392 = QUCH2 Canyon live oak	SOC00000	511 – Gordon & White, 1994
393 = QUW12 Interior live oak	SOI00000	511 – Gordon & White, 1994
394 = QUW12-CELE2 Interior live oak-chaparral whitethorn	SOISCL00	511 – Gordon & White, 1994
395 = QUW12-QUCH2 Interior live oak-canyon live oak	SOISOC00	511 – Gordon & White, 1994
396 = QUW12-QUBE5 Interior live oak-scrub oak	SOISOS00	511 – Gordon & White, 1994
397 = QUBE5 Scrub oak	SOS00000	511 – Gordon & White, 1994
398 = QUBE5-ADFA Scrub oak-chamise	SOSSA000	511 – Gordon & White, 1994
399 = QUBE5-CEMOG Scrub oak-birchleaf mountain mahogany	SOSSBM00	511 – Gordon & White, 1994
400 = QUBE5-CEOL-HEAR5 Scrub oak-hairy ceanothus-toyon	SOSSCH00	511 – Gordon & White, 1994
401 = QUBE5-CELE2 Scrub oak-chaparral whitethorn	SOSSCL00	511 – Gordon & White, 1994
402 = ADSP Redshank	SR000000	511 – Gordon & White, 1994
403 = ADSP-ADFA Redshank-chamise	SR0SA000	511 – Gordon & White, 1994
404 = ARCA11 Coastal sagebrush	SSC00000	511 – Gordon & White, 1994
405 = ARCA11-ERFA2 Coastal sagebrush-Eastern Majave buchwheat	SSCSB000	511 – Gordon & White, 1994
406 = ARCA11-SAME3 Coastal sagebrush-black sage	SSCSSB00	511 – Gordon & White, 1994

Table 11.2.2 Region 6 plant association codes recognized in the SO variant. Also used for the Warm Springs Reservation.

FVS Sequence Number = Plant Association Species Type	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
407 = PSME ABCO/SYAL/FORB Mixed conifer/snowberry/twinflower	CDS612	DF	85	755	C	p. 78 R6 E 104-85
408 = PSME-ABCO/SYAL/FORB Mixed conifer/snowberry/forb	CDS613	WF	90	810	C	p. 77 R6 E 104-85
409 = PSME-ABCO/SYAL/CARU Mixed conifer/snowberry/pinegrass	CDS614	DF	78	615	C	p. 76 R6 E 104-85
410 = PIEN/CAEU Mixed conifer/snowberry/pinegrass	CEM111	ES	80	635	H	p. 55 R6 E TP-279-87
411 = PIEN/EQAR-STRO Engelmann spruce/common horsetail-twistedstalk	CEM221	ES	90	712	H	p. 57 R6 E TP-279-87
412 = PIEN/CLUN Engelmann spruce/queencup beadlily	CEM222	ES	105	842	H	p. 49 R6 E TP-279-87
413 = PIEN/VAOC2-FORB Engelmann spruce/bog blueberry/forb	CEM331	ES	85	643	H	p. 51 R6 E TP-279-87
414 = PIEN/VAOC2/CAEU Engelmann spruce/bog blueberry/widefruit sedge	CEM312	ES	76	444	H	p. 53 R6 E TP-279-87
415 = PICO-PIAL/PELA Lodgepole pine-Whitebark pine/Gay penstemon	CLC111	LP	30	625	C	p. 19 R6 E 79-004
416 = PICO-PIAL/ARCO2 Lodgepole pine-Whitebark pine-W white pine/sandwort	CLC112	LP	25	690	C	p. 20 R6 E 79-004
417 = PICO/FORB Lodgepole pine/forb	CLF111	LP	43	365	C	p. 11 R6 E 79-005
418 = PICO/STOC-BASIN Lodgepole pine/needlegrass basins	CLG311	LP	38	480	C	p. 42 R6 E 104-85
419 = PICO/STOC-LUCA-LINU Lodgepole pine/needlegrass-lupine-linanthastrum	CLG313	LP	45	395	C	p. 49 R6 E 104-85
420 = PICO/STOC-LUCA Lodgepole pine/needlegrass-lupine	CLG314	LP	52	660	C	p. 48 R6 E 104-85
421 = PICO/FRVI-FEID Lodgepole pine/strawberry-fescue	CLG315	LP	44	510	C	p. 21 R6 E 79-004
422 = PICO/CAPE-LUCA Lodgepole pine/sedge-lupine	CLG411	LP	49	680	C	p. 46 R6 E 104-85
423 = PICO/CAPE-LUCA-PEEU Lodgepole pine/sedge-lupine-penstemon	CLG412	LP	50	635	C	p. 47 R6 E 104-85
424 = PICO/CAPE-STOC-BASIN Lodgepole pine/sedge-needlegrass basins	CLG413	LP	37	590	C	p. 43 R6 E 104-85
425 = PICO/SIHY-CAPE Lodgepole pine/squirreltail-long-stolon sedge	CLG415	LP	40	540	C	p. 22 R6 E 79-004
426 = PICO/POTR/FRVI Lodgepole pine/quaking aspen/strawberry	CLH111	LP	48	345	C	p. 23 R6 E 79-004
427 = PICO/CANE-ELGL-WET Lodgepole pine/sedge-grass wetland	CLM111	LP	51	540	C	p. 32 R6 E 104-85
428 = PICO/POPR Lodgepole pine/Kentucky bluegrass	CLM112	LP	55	538	H	p. 29 R6 E TP-279-87
429 = PICO/CAEU Lodgepole pine/widefruit sedge	CLM113	LP	57	491	H	p. 41 R6 E TP-279-87
430 = PICO/CAAQ Lodgepole pine/aquatic sedge	CLM114	LP	45	549	H	p. 43 R6 E TP-279-87
431 = PICO/ARUV Lodgepole pine/bearberry	CLM211	LP	48	585	C	p. 31 R6 E TP-279-87
432 = PICO/VAOC2/FORB Lodgepole pine/blueberry/forb	CLM311	LP	47	570	C	p.37R6 E TP-279-87 p.33R6 E 104-85

FVS Sequence Number = Plant Association Species Type	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
433 = PICO/VAOC2/CAEU Lodgepole pine/bog blueberry/widefruit sedge	CLM312	LP	54	466	H	p. 39 R6 E TP-279-87
434 = PICO/SPDO/FORB Lodgepole pine/Douglas spiraea/forb	CLM313	LP	51	558	H	p. 33 R6 E TP-279-87
435 = PICO/SPDO/CAEU Lodgepole pine/Douglas spiraea/widefruit sedge	CLM314	LP	59	519	H	p. 35 R6 E TP-279-87
436 = PICO/XETE Lodgepole pine/beargrass	CLM411	LP	56	535	H	p. 52 R6 E 104-85
437 = PICO/PIEN/ELPA2 Lodgepole pine-Engel spruce/few-flowered spikerush	CLM911	LP	35	495	C	p. 45 R6 E TP-279-87
438 = PICO/ARTR-RHYO Lodgepole pine/sagebrush (rhyolite)	CLS112	LP	41	180	C	p. 36 R6 E 104-85
439 = PICO/PUTR/STOC Lodgepole pine/bitterbrush/needlegrass	CLS211	LP	46	405	C	p. 40 R6 E 104-85
440 = PICO/PUTR/CAPE Lodgepole pine/bitterbrush/sedge	CLS212	LP	52	405	C	p. 44 R6 E 104-85
441 = PICO/PUTR/FORB Lodgepole pine/bitterbrush/forb	CLS213	LP	43	400	C	p. 35 R6 E 104-85
442 = PICO/PUTR/FEID Lodgepole pine/bitterbrush/fescue	CLS214	LP	45	400	C	p. 39 R6 E 104-85
443 = PICO/RICE-PUTR/STOC Lodgepole pine/current-bitterbrush/needlegrass	CLS215	LP	41	370	C	p. 41 R6 E 104-85
444 = PICO/PUTR-RHYO Lodgepole pine/bitterbrush (rhyolite pumice)	CLS216	LP	36	345	C	p. 38 R6 E 104-85
445 = PICO/ARNE Lodgepole pine/pinemat manzanita	CLS311	LP	31	575	C	p. 50 R6 E 104-85
446 = PICO/VASC Lodgepole pine/grouse huckleberry	CLS412	LP	45	865	C	p. 51 R6 E 104-85
447 = PICO/VASC-FORB Lodgepole pine/grouse huckleberry/forb	CLS413	LP	55	444	H	p. 12 R6 E 79-005
448 = PICO/VASC/CAPE Lodgepole pine/grouse huckleberry/long-stolon sedge	CLS414	LP	43	290	H	p. 13 R6 E 79-005
449 = PICO/CEVE-ARPA Lodgepole pine/snowbrush-manzanita	CLS911	LP	44	575	C	p. 45 R6 E 104-85
450 = TSME/VASC-DES Mountain hemlock/grouse huckleberry, Deschutes	CMS111	MH	30	895	C	p. 24 R6 E 79-005 p. 80 R6 E 104-85
451 = PIPO-JUOC/CELE/FEID Ponderosa-juniper/mahogany-bitterb-big sage/fescue	CPC211	PP	82	345	C	p. 24 R6 E 79-004
452 = PIPO/WYMO Ponderosa pine/wooly wyethia	CPF111	PP	84	510	C	p. 27 R6 E 79-004
453 = PIPO/CAPE-FEID-LALA2 Ponderosa pine/sedge-fescue-peavine	CPG212	PP	97	575	C	p. 66 R6 E 104-85
454 = PIPO-POTR/PONE Ponderosa pine/quaking aspen/bluegrass	CPH311	PP	84	485	C	p. 28 R6 E 79-004
455 = PIPO/PUTR-ARTR/FEID Ponderosa pine/bitterbrush sagebrush/fescue	CPS111	PP	70	285	C	p. 56 R6 E 104-85
456 = PIPO/PUTR-ARTR/SIHY Ponderosa pine/bitterbrush-sage/squirreltail (Rhyo)	CPS112	PP	75	335	C	p. 55 R6 E 104-85
457 = PIPO/ARTR/PONE Ponderosa pine/mtn big sagebrush/bluegrass	CPS121	PP	82	450	C	p. 29 R6 E 79-004
458 = PIPO/PUTR/FEID Ponderosa pine/bitterbrush/fescue	CPS211	PP	81	460	C	p. 57 R6 E 104-85

FVS Sequence Number = Plant Association Species Type	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
459 = PIPO/PUTR/STOC Ponderosa pine/bitterbrush/needlegrass	CPS212	PP	85	440	C	p. 60b R6 E 104-85
460 = PIPO/PUTR-ARPA/STOC Ponderosa pine/bitterbrush-manzanita/needlegrass	CPS213	PP	81	345	C	p. 61 R6 E 104-85
461 = PIPO/PUTR-ARPA/CAPE Ponderosa pine/bitterbrush-manzanita/sedge	CPS214	PP	88	450	C	p. 64 R6 E 104-85
462 = PIPO/PUTR/CAPE Ponderosa pine/bitterbrush/sedge	CPS215	PP	89	425	C	p. 63 R6 E 104-85
463 = PIPO/PUTR/FEID-AGSP Ponderosa pine/bitterbrush/bunchgrass	CPS216	PP	77	225	C	p. 53 R6 E 104-85
464 = PIPO/PUTR-ARPA/FEID Ponderosa pine/bitterbrush-manzanita/fescue	CPS217	PP	76	425	C	p. 58 R6 E 104-85
465 = PIPO/PUTR/SIHY-RHYO Ponderosa pine/bitterbrush/squirreltail (rhyolite)	CPS218	PP	80	385	C	p. 54 R6 E 104-85
466 = PIPO/PUTR-CEVE/STOC Ponderosa pine/bitterbrush-snowbrush/needlegrass	CPS311	PP	85	550	C	p. 62 R6 E 104-85
467 = PIPO/PUTR-CEVE/CAPE Ponderosa pine/bitterbrush-snowbrush/sedge	CPS312	PP	89	345	C	p. 65 R6 E 104-85
468 = PIPO/PUTR-CEVE/FEID Ponderosa pine/bitterbrush-snowbrush/fescue	CPS314	PP	90	365	C	p. 59 R6 E 104-85
469 = PIPO/SYAL-FLOOD Ponderosa pine/common snowberry-floodplain	CPS511	PP	101	516	H	p. 27 R6 E TP-279-87
470 = ABMAS/CAPE Shasta red fir/long-stolon sedge	CRG111	RF	120	745	C	p. 22 R6 E 79-005
471 = ABMAS/ARNE Mixed conifer/manzanita	CRS111	RF	79	725	C	p. 72 R6 E 104-85
472 = ABMAS-TSME/ARNE/CAPE Shasta red fir-Mtn hemlock/pinemat manzanita/sedge	CRS112	RF	99	910	C	p. 23 R6 E 79-005
473 = ABMAS-ABCO/CACH-CHUM/CAPE Shasta red fir-white fir/chink-prince's pine/sedge	CRS311	RF	114	775	C	p. 21 R6 E 79-005
474 = ABCO-PIPO-CADE/AMAL White fir-ponderosa pine-incense cedar/serviceberry	CWC111	WF	58	665	C	p. 34 R6 E 79-004
475 = ABCO/CEVE-CACH/PTAQ Mixed conifer/snowbrush-chinkquapin/brackenfern	CWC211	PP	96	675	C	p. 75 R6 E 104-85
476 = ABCO/CEVE-CACH/CARU Mixed conifer/snowbrush-chinkquapin/pinegrass	CWC212	PP	95	630	C	p. 74 R6 E 104-85
477 = ABCO/CEVE/CAPE-PTAQ Mixed conifer/snowbrush/sedge-bracken	CWC213	PP	87	645	C	p. 69 R6 E 104-85
478 = ABCO-PSME/CEVE-ARUV Mixed conifer/snowbrush-bearberry	CWC215	WF	78	671	H	p. 17 R6 E 79-005
479 = ABCO-PICO/CAPE5-STOC White fir-lodgepole pine/long-stolon sedge-needlegr	CWC311	WF	54	770	C	p. 30 R6 E 79-004
480 = ABCO-PIPO-PILA/RIVI White fir-ponderosa pine-white pine/sticky currant	CWC411	WF	56	910	C	p. 35 R6 E 79-004
481 = ABCO-PIPO-PILA/ARPA White fir-ponderosa pine-sugar pine/manzanita	CWC412	WF	68	510	C	p. 33 R6 E 79-004
482 = PIEN-BOTTOMS Engelmann spruce bottomlands	CWC911	ES	86	682	H	p. 79 R6 E 104-85
483 = ABCO/CLUN White fir/queencup beadlily	CWF431	WF	81	872	H	p. 47 R6 E TP-279-87
484 = ABCO/CEVE-CACH Mixed conifer/snowbrush-chinquapin	CWH111	PP	91	675	C	p. 73 R6 E 104-85

FVS Sequence Number = Plant Association Species Type	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
485 = ABCO/CACH-PAMY-CHUM White fir/chinquapin-boxwood-prince's pine	CWH112	WF	84	750	C	p. 20 R6 E 79-005
486 = ABCO-PIPO-POTR/CAPE White fir-ponderosa pine-aspen/long-stolon sedge	CWH211	PP	84	270	C	p. 36 R6 E 79-004
487 = ABCO/ALTE White fir-alder/shrub meadow	CWM111	WF	81	607	H	p. 16 R6 E 79-005
488 = ABCO/CEVE-ARPA Mixed conifer/snowbrush-manzanita	CWS112	PP	85	660	C	p. 70 R6 E 104-85
489 = ABCO/CEVE-ARPA/CAPE-PEEU M conifer/manzanita-snowbrush/sedge-penstemon	CWS113	PP	88	660	C	p. 71 R6 E 104-85
490 = ABCO/CEVE Mixed conifer/snowbrush	CWS114	PP	86	725	C	p. 67 R6 E 104-85
491 = ABCO/CEVE/CAPE Mixed conifer/snowbrush/sedge	CWS115	PP	88	790	C	p. 68 R6 E 104-85
492 = ABCO/CEVE-CEPR/FRVI Mixed conifer/snowbrush-squawcarpet/strawberry	CWS116	WF	65	560	C	p. 18 R6 E 79-005
493 = ABCO-PIPO/ARPA-BERE White fir-ponderosa pine/manzanita-Oregon grape	CWS117	PP	86	570	C	p. 32 R6 E 79-004
494 = ABCO/SYAL/FRVI White fir/snowberry/strawberry	CWS312	WF	69	485	C	p. 19 R6 E 79-005
495 = ABCO-PIPO/SYAL/STJA White fir-ponderosa pine/snowberry/starwort	CWS313	WF	63	810	C	p. 31 R6 E 79-004
496 = POTR/ELGL Quaking aspen/blue wildrye	HQM121	LP	55	464	H	p. 61 R6 E TP-279-87
497 = POTR-PICO/SPDO/CAEU Quak. aspen-lodgepole pine/Doug spiraea/widefruit sedge	HQM411	LP	59	640	H	p. 63 R6 E TP-279-87
498 = POTR/SYAL/ELGL Quaking aspen/common snowberry/blue wildrye	HQS221	PP	101	596	H	p. 59 R6 E TP-279-87

*Site index estimates are from GBA analysis. SDI maximums are set by GBA analysis (Source=H) or CVS plot analysis (Source=C).

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