ORGANON Southwest (OC) Variant Overview of the Forest Vegetation Simulator

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Onion Mountain Look Out, Rogue River-Siskiyou National Forest
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The FVS staff has maintained model documentation for this variant in the form of a variant overview since its release in July 2015.

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Quick Guide to Default Settings

Parameter or Attribute	**Default Setting**	
Number of Projection Cycles	1 (10 if using FVS GUI)	
Projection Cycle Length	5 years	
Location Code (National Forest)	711 – BLM Medford -Lakeview	
Plant Association Code (Region 5 /Region 6)	0 (Unknown) / 46 (CWC221 ABCO-PSME)	
Slope	5 percent	
Aspect	0 (no meaningful aspect)	
Elevation	35 (3500 feet)	
Latitude / Longitude	Latitude	Longitude
All location codes	42	124
Site Species (Region 5 / Region 6 and BLM)	DF / Plant Association Code Specific	
Site Index (Region 5 / Region 6 and BLM)	80 feet / Plant Association Code Specific	
Maximum Stand Density Index (R5 /R6 and BLM)	Species specific / Plant Association Code specific	
Volume Equations	National Volume Estimator Library	
Merchantable Cubic Foot Volume Specifications:		
Minimum DBH / Top Diameter	KP	All Other Species
Region 6 and BLM	6.0 / 4.5 inches	7.0 / 4.5 inches
Stump Height	1.0 foot	1.0 foot
Merchantable Board Foot Volume Specifications:		
Minimum DBH / Top Diameter	KP	All Other Species
Region 6	6.0 / 4.5 inches	7.0 / 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 OC variant uses the ORGANON Southwest Oregon growth equations embedded into the existing CA variant code framework. The ORGANON model was developed by David Hann PhD, his graduate students and cooperators at Oregon State University. Like FVS, ORGANON is also an individual tree distance independent model.

Using the CA variant framework allows for extensions which are part of the CA variant to be available in the OC variant. These include the Fire and Fuels, regeneration establishment, event monitor, climate, and dwarf mistletoe extensions.

The OC variant is limited to a maximum of 2000 individual tree records.

For background on the development of the ORGANON model users should consult the ORGANON web site:

- http://www.cof.orst.edu/cof/fr/research/organon/

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.

1.1 FVS-Organon

ORGANON recognizes less species codes than FVS and has minimum size restrictions. FVS can accommodate trees of any size including seedlings. So an FVS simulation file representing a stand may contain tree records that cannot be directly handled within the ORGANON code.

The Southwest Oregon (SWO) version of ORGANON recognizes 19 species found in southwestern Oregon. Trees must be greater than 4.5feet tall and 0.09” in diameter-at-breast-height. Tree records with parameters meeting these species and size requirements will be referred to as valid ORGANON tree records in the remainder of this document; all others will be referred to as non-valid ORGANON tree records. Valid ORGANON tree records get their growth and mortality estimates using ORGANON equations; non-valid ORGANON tree records get their growth and mortality estimates using FVS CA variant equations.

Of the 19 species recognized in SWO, six species are designated as “the big 6”. These are white fir, grand fir, incense cedar, sugar pine, ponderosa pine, and Douglas-fir. At least one of these species must be in the stand for the ORGANON growth routines to run. In FVS, if one of these species is not present, then all tree records are designated as non-valid ORGANON tree records and will get their growth and mortality estimates from FVS CA variant equations.

The OC variant recognizes 50 individual species or species groups (see section 3.2 and table 3.2.1). When the ORGANON growth routines are being called, all tree records get passed into the ORGANON growth routines so stand density measures are correct in the ORGANON growth and mortality equations. This is done by making sure all non-valid ORGANON tree records have temporarily assigned to them a valid ORGANON species code and the tree diameter and height meet the minimum ORGANON requirements. This species mapping is shown in table 1.1.1. If tree height is less than or equal to 4.5’ it is temporarily set to 4.6’; if tree diameter is less than or equal to 0.09” it is temporarily set to 0.1”.

Table 1.1.1 Species code mapping used in the OC variant when calling ORGANON growth routines.

Valid SWO ORGANON Species Code	OC Variant FVS Alpha Code*	OC Variant FVS Alpha Codes* mapped to the valid ORGANON Species Code
015	not in OC variant	FVS maps WF to GF in the OC variant
017	GF	GF, BR
081	IC	IC
117	SP	SP
122	PP	PP, WB, KP, LP, CP, LM, JP, WP, MP, GP, GS, RW
202	DF	DF, RF, SH
231	PY	PY, WJ, OS
242	RC	RC, PC
263	WH	WH, MH
312	BM	BM, BU, FL, WN, SY, AS, CW
351	RA	RA
361	MA	MA
431	GC	GC
492	DG	DG, CN, CL, OH
631	TO	TO
805	CY	CY, LO, BL, EO, VO, IO
815	WO	WO
818	BO	BO

920	WI	WI

*See table 3.2.1 for alpha code definitions

The intent of this variant is to give users access to the ORGANON growth model growth prediction equations and the functionality of FVS. ORGANON model code is called from two places within the FVS code and performs two different tasks just as it does when running ORGANON separately.

The first call is to edit the input data, estimate missing values such as tree height and crown ratio, and calibrate growth equations to the input data. This only happens at most one time when a tree input file is provided which contains valid ORGANON tree records (discussed in the next paragraph). In cases such as a bare ground plant management scenario, or when the tree input file does not contain valid ORGANON tree records, or when the provided tree input file has already been through the ORGANON edit process (i.e. an existing ORGANON .INP file), it won't happen at all. Any errors in the input data will be noted in the main FVS output file so users can correct them and rerun the simulation at their discretion.

The second call is made to the ORGANON model code to estimate tree growth and mortality. This happens every growth projection cycle when there are valid ORGANON tree records in the run. Estimates include large tree diameter growth, height growth, and crown ratio change, and tree mortality.

2.0 Geographic Range

The ORGANON Southwest Oregon version was built with data from even and un-even aged stands collected from 529 stands as part of the southwestern Oregon Forestry Intensified Research (FIRS) Growth and Yield Project. The CA was built with data that was collected on the Klamath, Lassen, Mendocino, Plumas, and Shasta-Trinity National Forests in California, the Illinois Valley (east) Ranger District of the Siskiyou National Forest in Oregon, and the Applegate and Ashland (west) Ranger Districts of the Rogue River National Forest in Oregon. Since the OC variant is a combination of ORGANON and FVS-CA, the suggested use is limited to southwest Oregon.

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

3.0 Control Variables

FVS users need to specify certain variables used by the OC 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 OC variant, a default forest code of 711 (BLM Medford-Lakeview ADU) will be used. Location codes recognized in the OC variant are shown in tables 3.1.1 and 3.1.2.

Table 3.1.1 Location codes used in the OC variant.

Location Code	Location
505	Klamath National Forest
506	Lassen National Forest
508	Mendocino National Forest
511	Plumas National Forest
514	Shasta-Trinity National Forest
610	Rogue River National Forest
611	Siskiyou National Forest
518	Trinity National Forest (mapped to 514)
710	BLM Roseburg ADU
711	BLM Medford ADU
712	BLM Coos Bay ADU

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

Location Code	Location
7801	Berry Creek Off-Reservation Trust Land (mapped to 511)
7803	Cold Springs Rancheria (mapped to 511)
7804	Colusa Rancheria (mapped to 508)
7805	Cortina Indian Rancheria (mapped to 508)
7809	Grindstone Indian Rancheria (mapped to 508)
7811	Jackson Rancheria (mapped to 511)
7812	Chicken Ranch Off-Reservation Trust Land (mapped to 511)
7818	Picayune Off-Reservation Trust Land (mapped to 511)
7822	Rumsey Indian Rancheria (mapped to 508)
7823	Shingle Springs Rancheria (mapped to 511)

Location Code	Location
7826	Table Mountain Rancheria (mapped to 511)
7827	Tule River Reservation (mapped to 511)
7829	Mooretown Off-Reservation Trust Land (mapped to 511)
7837	Pit River Trust Land (mapped to 506)
7842	Quartz Valley Reservation (mapped to 505)
7846	Karuk Off-Reservation Trust Land (mapped to 505)
7864	Santa Rosa Rancheria (mapped to 511)
8104	Cow Creek Reservation (mapped to 611)

3.2 Species Codes

The OC variant recognizes 48 species, plus two other composite species categories. You may use FVS species codes, Forest Inventory and Analysis (FIA) species codes, or USDA Natural Resources Conservation Service PLANTS symbols to represent these species in FVS input data. Any valid western species code identifying species not recognized by the variant will be mapped to a similar species in the variant. The species mapping crosswalk is available on the FVS website variant documentation webpage. Any non-valid species code will default to the “other hardwood” category.

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

When entering tree data, users should substitute diameter at root collar (DRC) for diameter at breast height (DBH) for woodland species (western juniper).

Table 3.2.1 Species codes used in the OC variant.

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
1	PC	041	CHLA	*Chamaecyparis lawsoniana*	Port Orford cedar
2	IC	081	CADE27	*Calocedrus decurrens*	incense cedar
3	RC	242	THPL	*Thuja plicata*	western redcedar
4	GF	017	ABGR	*Abies grandis*	grand fir
5	RF	020	ABMA	*Abies magnifica*	California red fir
6	SH	021	ABSH	*Abies shastensis*	Shasta red fir
7	DF	202	PSME	*Pseudotsuga menziesii*	Douglas-fir
8	WH	263	TSHE	*Tsuga heterophylla*	western hemlock
9	MH	264	TSME	*Tsuga mertensiana*	mountain hemlock
10	WB	101	PIAL	*Pinus albicaulis*	whitebark pine
11	KP	103	PIAT	*Pinus attenuata*	knobcone pine
12	LP	108	PICO	*Pinus contorta*	lodgepole pine

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
13	CP	109	PICO3	*Pinus coulteri*	Coulter pine
14	LM	113	PIFL2	*Pinus flexilis*	limber pine
15	JP	116	PIJE	*Pinus jeffreyi*	Jeffrey pine
16	SP	117	PILA	*Pinus lambertiana*	sugar pine
17	WP	119	PIMO3	*Pinus monticola*	western white pine
18	PP	122	PIPO	*Pinus ponderosa*	ponderosa pine
19	MP	124	PIRA2	*Pinus radiata*	Monterey pine
20	GP	127	PISA2	*Pinus sabiniana*	California foothill pine
21	WJ	064	JUOC	*Juniperus occidentalis*	western juniper
22	BR	092	PIBR	*Picea breweriana*	Brewer spruce
23	GS	212	SEGI2	*Sequoiadendron giganteum*	giant sequoia
24	PY	231	TABR2	*Taxus brevifolia*	Pacific yew
25	OS	299	2TN		other softwood[2]
26	LO	801	QUAG	*Quercus agrifolia*	California live oak
27	CY	805	QUCH2	*Quercus chrysolepsis*	canyon live oak
28	BL	807	QUDO	*Quercus douglasii*	blue oak
29	EO	811	QUEN	*Quercus engelmanni*	Engelmann oak
30	WO	815	QUGA4	*Quercus garryana*	Oregon white oak
31	BO	818	QUKE	*Quercus kelloggii*	California black oak
32	VO	821	QULO	*Quercus lobata*	valley oak
33	IO	839	QUWI2	*Quercus wislizenii*	interior live oak
34	BM	312	ACMA3	*Acer macrophyllum*	bigleaf maple
35	BU	333	AECA	*Aesculus californica*	California buckeye
36	RA	351	ALRU2	*Alnus rubra*	red alder
37	MA	361	ARME	*Arbutus menziesii*	Pacific madrone
38	GC	431	CHCHC4	*Chrysolepis chrysophylla* var. *chrysophylla*	giant chinquapin
39	DG	492	CONU4	*Cornus nuttallii*	Pacific dogwood
40	FL	542	FRLA	*Fraxinus latifolia*	Oregon ash
41	WN	600	JUGLA	*Juglans spp.*	walnut
42	TO	631	LIDE3	*Lithocarpus densiflorus*	tanoak
43	SY	730	PLRA	*Platanus racemosa*	California sycamore
44	AS	746	POTR5	*Populus tremuloides*	quaking aspen
45	CW	747	POBAT	*Populus balsamifera* ssp. *trichocarpa*	black cottonwood
46	WI	920	SALIX	*Salix*	willow
47	CN	251	TOCA	*Torreya californica*	California nutmeg
48	CL	981	UMCA	*Umbellularia californica*	California laurel

Species Number	Species Code	FIA Code	PLANTS Symbol	Scientific Name[1]	Common Name[1]
49	OH	998	2TB		other hardwood[2]
50	RW	211	SESE3	*Sequioa sempervirens*	redwood

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

3.3 Habitat Type, Plant Association, and Ecological Unit Codes

Plant association codes recognized in the OC variant are shown in Appendix A. If an incorrect plant association code is entered or no code is entered, FVS will use the default plant association code, which is 46 (CWC221 ABCO-PSME). The plant association codes are used in the Fire and Fuels Extension (FFE) to set fuel loading in cases where there are no live trees 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 OC variant. Users should always use the same site curves that FVS uses as shown in table 3.4.1.

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

Reference Number	Reference	BHA or TTA*	Base Age
1	Hann & Scrivani (1987)	BHA	50
2	Dolph (1987)	BHA	50
3	Dahms (1964)	TTA	50
4	Powers (1972)	BHA	50
5	Porter & Wiant (1965)	TTA	50
6	Krumland and Eng (2005)***	BHA	50

* Equation is based on total tree age (TTA) or breast height age (BHA)
** Height at BHA50 should be entered even though the original site curve was a TTA curve
*** Equation form is presented on page 34 and coefficients are provided on page 68

Table 3.4.2 Reference numbers for site index reference curves in Region 6 by species.

Species Code	R6 Reference Number	Species Code	R6 Reference Number
PC	1	LO	5
IC	1	CY	5
RC	1	BL	5
GF	1	EO	5
RF	2	WO	4

Species Code	R6 Reference Number
SH	2
DF	1
WH	1
MH	2
WB	3
KP	3
LP	3
CP	3
LM	3
JP	1
SP	1
WP	1
PP	1
MP	1
GP	1
WJ	3
BR	1
GS	6
PY	4
OS	1

Species Code	R6 Reference Number
BO	4
VO	4
IO	5
BM	5
BU	4
RA	5
MA	5
GC	5
DG	4
FL	4
WN	5
TO	5
SY	5
AS	5
CW	5
WI	5
CN	5
CL	5
OH	5
RW	6

For Region 6 Forests and BLM, the default site species is set from Plant Association. In the OC variant, if site index is provided for Douglas-fir but not for ponderosa pine, then ponderosa pine site index is estimated from the Douglas-fir site index using equation {3.4.1}; if site index is provided for ponderosa pine but not for Douglas-fir, then Douglas-fir site index is estimated from ponderosa pine site index using equation {3.4.2}.

{3.4.1} $PPSI = 0.940792 * DFSI$

{3.4.2} $DFSI = 1.062934 * PPSI$

where:

PPSI	is site index for ponderosa pine
DFSI	is site index for Douglas-fir

For other species not assigned a site index, site index is determined by first converting the site species site index to a Hann-Scrivani DF site index equivalent. This is done by dividing the site species site index by the site species adjustment factor located in table 3.4.4. Next, the species site index is determined by multiplying the converted site species site index by the species adjustment factor located in table 3.4.4.

Table 3.4.4 Region 6 adjustment factors for 50-year site index values in the OC variant.

Species Code	R6 Adjustment Factor	Species Code	R6 Adjustment Factor
PC	0.90	LO	0.28
IC	0.70	CY	0.42
RC	0.80	BL	0.34
GF	1	EO	0.28
RF	1	WO	0.40
SH	1	BO	0.56
DF	1	VO	0.76
WH	0.95	IO	0.28
MH	0.90	BM	0.76
WB	0.90	BU	0.56
KP	0.90	RA	0.76
LP	0.90	MA	0.76
CP	0.90	GC	0.76
LM	0.90	DG	0.40
JP	0.94	FL	0.70
SP	1	WN	0.40
WP	0.94	TO	0.76
PP	0.94	SY	0.76
MP	0.90	AS	0.40
GP	0.90	CW	0.76
WJ	0.76	WI	0.25
BR	0.76	CN	0.25
GS	1	CL	0.25
PY	0.4	OH	0.56
OS	0.76	RW	1

3.5 Maximum Density

Maximum stand density index can be set for each species using the SDIMAX or SETSITE keywords. If not set by the user, a default value is assigned as discussed below.

The default maximum SDI is set based on a user-specified, or default, plant association code. The SDI maximum for all species is assigned from the SDI maximum associated with the site species for the plant association code shown in Appendix A. 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). Some SDI maximums associated with plant associations are unreasonably large, so SDI maximums are capped at 850. Maximum stand density index at the stand level is a weighted average, by basal area, of the individual species SDI maximums.

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 OC variant, FVS will dub in heights by one of two methods. By default, non-valid ORGANON records will use the Curtis-Arney functional form as shown in equation {4.1.1} (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 {4.1.2} (Wykoff, et.al 1982) that may be calibrated to the input data. FVS will not automatically use equation {4.1.2} even if you have enough height values in the input data. To override this default, the user must use the NOHTDREG keyword to turn calibration on. Coefficients for equations {4.1.1} and {4.1.2} are given in Table 4.1.1.

In the OC variant, the default Curtis-Arney equation used depends on the “spline DBH” (given as *Z*). Values for “spline DBH” are given as *Z* in table 4.1.1.

{4.1.1} Curtis-Arney functional form

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

{4.1.2} Wykoff functional form

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

All valid ORGANON tree records use equation {4.1.3}. If equation {4.1.2} is being used for non-valid ORGANON tree records then heights estimated for valid ORGANON tree records are used along with measure tree heights in calibrating equation {4.1.2} to better align equation {4.1.2} with the equation ORGANON is using.

{4.1.3} ORGANON

$HT = 4.5+\exp(X_1+X_2*DBH**X_3)$

where:

HT	is tree height
Z	is the “spline DBH” shown in table 4.1.1
DBH	is tree diameter at breast height
B_1 - B_2	are species-specific coefficients shown in table 4.1.1
P_2 - P_4	are species-specific coefficients shown in table 4.1.1
X_1 - X_3	are species-specific coefficients shown in table 4.1.1

Data were available to fit Curtis-Arney and Wykoff height-diameter coefficients for incense cedar, white fir, California red fir, Shasta red fir, Douglas-fir, knobcone pine, lodgepole pine, Jeffrey pine, sugar pine, western white pine, ponderosa pine, California foothill pine, Oregon white oak, California black oak, and Pacific madrone, and redwood. Curtis-Arney coefficients for the other species were fit from inventory data from other forests in Region 6.

Table 4.1.1 Coefficients and "spline DBH" for equations {4.1.1} – {4.1.3} in the OC variant.

Species Code	Curtis-Arney Coefficients				Wykoff Coefficients		Organon Coefficients		
	P_2	P_3	P_4	Z	Default B_1	B_2	X_1	X_2	X_3
PC	8532.903	8.0343	-0.1831	3	4.7874	-7.317			
IC	695.4196	7.5021	-0.3852	6	5.2052	-20.1443	8.776627	-7.43837	-0.16906
RC	487.5415	5.4444	-0.3801	3	4.7874	-7.317	6.148174	-5.40093	-0.38922
GF	467.307	6.1195	-0.4325	3	5.218	-14.8682	6.638004	-5.44399	-0.33929
RF	606.3002	6.2936	-0.386	3	5.2973	-17.2042			
SH	606.3002	6.2936	-0.386	3	5.2973	-17.2042			
DF	408.7614	5.4044	-0.4426	3	5.3076	-14.474	7.153156	-5.36901	-0.25833
WH	263.1274	6.9356	-0.6619	3	4.7874	-7.317	6.58804	-5.35325	-0.31898
MH	233.6987	6.9059	-0.6166	3	4.7874	-7.317			
WB	89.5535	4.2281	-0.6438	3	4.7874	-7.317			
KP	101.517	4.7066	-0.954	2	4.6843	-6.5516			
LP	99.1568	12.13	-1.3272	5	4.8358	-9.2077			
CP	514.1013	5.5983	-0.2734	3	4.7874	-7.317			
LM	514.1013	5.5983	-0.2734	3	4.7874	-7.317			
JP	744.7718	7.6793	-0.3779	5	5.1419	-19.8143			
SP	944.9299	6.2428	-0.3087	5	5.3371	-19.3151	6.345117	-5.30026	-0.35264
WP	422.0948	6.0404	-0.4525	3	5.2649	-15.5907			
PP	1267.759	7.4995	-0.3286	2	5.382	-20.4097	7.181264	-5.90709	-0.27534
MP	113.7962	4.7726	-0.7601	3	4.7874	-7.317			
GP	79986.63	9.9284	-0.1013	2	4.6236	-13.0049			
WJ	60.6009	4.1543	-0.6277	3	4.7874	-7.317			
BR	91.7438	17.1081	-1.4429	3	4.7874	-7.317			
GS	595.1068	5.8103	-0.3821	3	5.3401	-15.9354			
PY	127.1698	4.8977	-0.4668	3	4.7874	-7.317	6.402691	-4.79802	-0.16318
OS	79986.63	9.9284	-0.1013	3	4.7874	-7.317			
LO	105.0771	5.6647	-0.6822	3	4.6618	-8.3312			
CY	105.0771	5.6647	-0.6822	3	4.6618	-8.3312	7.762149	-6.0476	-0.16308
BL	59.0941	6.1195	-1.0552	3	4.6618	-8.3312	5.020026	-2.51228	-0.42256

EO	59.0941	6.1195	-1.0552	3	4.6618	-8.3312			
WO	40.3812	3.7653	-1.1224	3	3.8314	-4.8221	4.697531	-3.51587	-0.57665
BO	120.2372	4.1713	-0.6113	3	4.4907	-7.703	4.90734	-3.18018	-0.46654
VO	126.7237	3.18	-0.6324	3	4.6618	-8.3312			
IO	55	5.5	-0.95	3	4.6618	-8.3312			
BM	143.9994	3.5124	-0.5511	3	4.6618	-8.3312			
BU	55	5.5	-0.95	3	4.6618	-8.3312			
RA	94.5048	4.0657	-0.9592	3	4.6618	-8.3312	5.597591	-3.19943	-0.38783
MA	117.741	4.0764	-0.6151	3	4.4809	-7.5989	5.424573	-3.56317	-0.36178
GC	1176.97	6.3245	-0.2739	3	4.6618	-8.3312	9.216003	-7.63409	-0.15346
DG	403.3221	4.3271	-0.2422	3	4.6618	-8.3312	5.597591	-3.19943	-0.38783
FL	97.7769	8.8202	-1.0534	3	4.6618	-8.3312			
WN	105.0771	5.6647	-0.6822	3	4.6618	-8.3312			
TO	679.1972	5.5698	-0.3074	3	4.6618	-8.3312	7.398142	-5.50993	-0.19081
SY	55	5.5	-0.95	3	4.6618	-8.3312			
AS	47.3648	15.6276	-1.9266	3	4.6618	-8.3312			
CW	179.0706	3.6238	-0.573	3	4.6618	-8.3312			
WI	149.5861	2.4231	-0.18	3	4.6618	-8.3312	3.862132	-1.52948	-0.62476
CN	55	5.5	-0.95	3	4.6618	-8.3312			
CL	114.1627	6.021	-0.7838	3	4.6618	-8.3312			
OH	40.3812	3.7653	-1.1224	3	4.6618	-8.3312			
RW	595.1068	5.8103	-0.3821	3	5.3401	-15.9354			

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 OC variant, bark ratio values are determined using estimates from DIB equations or by setting to a constant value. Equations used in the OC variant are shown in equations {4.2.1} – {4.2.3}. Coefficients (b_1 and b_2) and equation reference for these equations by species are shown in table 4.2.1.

{4.2.1} $DIB = b_1 * DBH\text{^}b_2$ where $BRATIO = DIB / DBH$

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

{4.2.3} $BRATIO = b_1$

where:

$BRATIO$ is species-specific bark ratio (bounded to $0.8 \leq BRATIO \leq 0.99$)
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} – {4.2.3} in the OC variant.

Species Code	b_1	b_2	Equation to use	Equation Source
PC	0.94967	1.0	{4.2.1}	Wykoff et al
IC	0.837291	1.0	{4.2.1}	ORGANON
RC	0.94967	1.0	{4.2.1}	Wykoff et al - ORGANON
GF	0.904973	1.0	{4.2.1}	ORGANON
RF	-0.1593	0.8911	{4.2.2}	Dolph PSW-368
SH	-0.1593	0.8911	{4.2.2}	Dolph PSW-368
DF	0.903563	0.989388	{4.2.1}	ORGANON
WH	0.93371	1	{4.2.1}	Wykoff et al - ORGANON
MH	0.93371	1	{4.2.1}	Wykoff et al
WB	0.9	0	{4.2.3}	Wykoff et al
KP	0.9329	0	{4.2.3}	Wykoff (avg. of AF, IC, ES, LP, WP)
LP	0.9	0	{4.2.3}	Wykoff et al
CP	-0.4448	0.8967	{4.2.2}	Dolph PSW-368
LM	0.9	0	{4.2.3}	Wykoff et al
JP	-0.4448	0.8967	{4.2.2}	Dolph PSW-368
SP	.859045	1	{4.2.1}	ORGANON
WP	-0.1429	0.8863	{4.2.2}	Dolph PSW-368
PP	0.809427	1.016866	{4.2.1}	ORGANON
MP	-0.4448	0.8967	{4.2.2}	Dolph PSW-368
GP	0.9329	0	{4.2.3}	Wykoff (avg. of AF, IC, ES, LP, WP)
WJ	0.94967	1.0	{4.2.1}	Wykoff et al
BR	0.9	0	{4.2.3}	Wykoff et al
GS	0.94967	1.0	{4.2.1}	Wykoff et al
PY	0.97	1	{4.2.1}	ORGANON
OS	-0.4448	0.8967	{4.2.2}	Dolph PSW-368
LO	-0.75739	0.93475	{4.2.2}	Pillsbury and Kirkley
CY	-0.19128	0.96147	{4.2.2}	Pillsbury and Kirkley
BL	-0.17324	0.94403	{4.2.2}	Pillsbury and Kirkley
EO	-0.78572	0.92472	{4.2.2}	Pillsbury and Kirkley
WO	0.878457	1.02393	{4.2.1}	ORGANON
BO	0.889703	1.017811	{4.2.1}	ORGANON
VO	-0.38289	0.93545	{4.2.2}	Pillsbury and Kirkley
IO	0.04817	0.92953	{4.2.2}	Pillsbury and Kirkley
BM	0.97059	0.993585	{4.2.1}	ORGANON
BU	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
RA	.947	1	{4.2.1}	ORGANON
MA	0.96317	1.0	{4.2.1}	ORGANON
GC	0.94448	0.987517	{4.2.1}	ORGANON
DG	0.94448	0.987517	{4.2.1}	ORGANON
FL	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
WN	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
TO	0.859151	1.017811	{4.2.1}	ORGANON
SY	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
AS	0.075256	0.94373	{4.2.2}	Pil. & Kirk.; Harlow & Harrar
CW	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
WI	0.94448	0.987517	{4.2.1}	ORGANON

CN	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
CL	0.910499	1.01475	{4.2.1}	ORGANON
OH	-0.26824	0.95767	{4.2.2}	Pillsbury and Kirkley
RW	0.7012	1.04862	{4.2.1}	Castle 2021

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 OC variant, crown ratios missing in the input data are predicted using different equations depending on tree species and size. For all species except giant sequoia and redwood, tree records representing dead trees, and tree records representing non-valid ORGANON live trees less than 1.0” in diameter use equations {4.3.1.1} and {4.3.1.2} to compute crown ratio. Equation coefficients are found in table 4.3.1.1. For non-valid ORGANON live trees over 1.0” in diameter see equations 4.3.1.3 through 4.3.1.6.

{4.3.1.1} $X = R_1 + R_2 * HT + R_3 * BA + N(0,SD)$

{4.3.1.2} $CR = ((X - 1) * 10.0 + 1.0) / 100$

where:

CR is crown ratio expressed as a proportion (bounded to $0.05 \leq CR \leq 0.95$)
HT is tree height
BA is total stand basal area
$N(0,SD)$ is a random increment from a normal distribution with a mean of 0 and a standard deviation of SD
$R_1 - R_3$ are species-specific coefficients shown in table 4.3.1.1

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

Species Code	R_1	R_2	R_3	SD
PC	7.55854	-0.01564	-0.00906	1.9658
IC	7.55854	-0.01564	-0.00906	1.9658
RC	7.55854	-0.01564	-0.00906	1.9658
GF	8.04277	0.0072	-0.01616	1.3167
RF	8.04277	0.0072	-0.01616	1.3167
SH	8.04277	0.0072	-0.01616	1.3167
DF	8.47703	-0.01803	-0.018140	1.3756
WH	7.55854	-0.01564	-0.00906	1.9658
MH	7.55854	-0.01564	-0.00906	1.9658
WB	6.48981	-0.02982	-0.00928	2.0426

Species Code	R_1	R_2	R_3	SD
KP	6.48981	-0.02982	-0.00928	2.0426
LP	6.48981	-0.02982	-0.00928	2.0426
CP	6.48981	-0.02982	-0.00928	2.0426
LM	6.48981	-0.02982	-0.00928	2.0426
JP	6.48981	-0.02982	-0.00928	2.0426
SP	6.48981	-0.02982	-0.00928	2.0426
WP	6.48981	-0.02982	-0.00928	2.0426
PP	6.48981	-0.02982	-0.00928	2.0426
MP	6.48981	-0.02982	-0.00928	2.0426
GP	6.48981	-0.02982	-0.00928	2.0426
WJ	9.000000	0.000000	0.000000	0.5
BR	8.04277	0.0072	-0.01616	1.3167
PY	6.48981	-0.02982	-0.00928	2.0426
OS	6.48981	-0.02982	-0.00928	2.0426
LO	5.000000	0.000000	0.000000	0.5
CY	5.000000	0.000000	0.000000	0.5
BL	5.000000	0.000000	0.000000	0.5
EO	5.000000	0.000000	0.000000	0.5
WO	5.000000	0.000000	0.000000	0.5
BO	5.000000	0.000000	0.000000	0.5
VO	5.000000	0.000000	0.000000	0.5
IO	5.000000	0.000000	0.000000	0.5
BM	5.000000	0.000000	0.000000	0.5
BU	5.000000	0.000000	0.000000	0.5
RA	5.000000	0.000000	0.000000	0.5
MA	5.000000	0.000000	0.000000	0.5
GC	5.000000	0.000000	0.000000	0.5
DG	5.000000	0.000000	0.000000	0.5
FL	5.000000	0.000000	0.000000	0.5
WN	5.000000	0.000000	0.000000	0.5
TO	5.000000	0.000000	0.000000	0.5
SY	5.000000	0.000000	0.000000	0.5
AS	5.000000	0.000000	0.000000	0.5
CW	5.000000	0.000000	0.000000	0.5
WI	5.000000	0.000000	0.000000	0.5
CN	5.000000	0.000000	0.000000	0.5
CL	5.000000	0.000000	0.000000	0.5

Species Code	R_1	R_2	R_3	SD
OH	5.000000	0.000000	0.000000	0.5

Non-valid ORGANON tree records with diameter 1.0” or greater use 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” in diameter or larger. To estimate crown ratio using this methodology, the average stand crown ratio is estimated from stand density index using equation {4.3.1.3}. Weibull parameters are then estimated from the average stand crown ratio using equations in equation set {4.3.1.4}. Individual tree crown ratio is then set from the Weibull distribution, equation {4.3.1.5} based on a tree’s relative position in the diameter distribution and multiplied by a scale factor, shown in equation {4.3.1.6}, 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. Coefficients for the Weibull distribution were fit to equations from the Klamath Mountains (NC) and West Cascades (WC) variants, with species being matched to the closest curve of another appropriate species. Species index mapping and equation coefficients for each species are shown in tables 4.3.1.2 and 4.3.1.3.

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

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

$A = a_0$
$B = b_0 + b_1 * \text{ACR} \quad (B \geq 3)$
$C = c_0 + c_1 * \text{ACR} \quad (C \geq 2)$

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

{4.3.1.6} $SCALE = 1.5 – RELSDI$

where:

ACR	is predicted average stand crown ratio for the species
RELSDI	is the relative site density index (Stand *SDI* / Maximum *SDI*)
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 $0.3 \leq SCALE \leq 1.0$)
CCF	is stand crown competition factor

a_0, $b_{0\text{-}1}$, $c_{0\text{-}1}$, and $d_{0\text{-}1}$ are species-specific coefficients shown in tables 4.3.1.2 and 4.3.1.3

Table 4.3.1.2 Mapped species index for the Weibull parameter equations {4.3.1.3} and {4.3.1.4} in the OC variant.

Species Code	Species Index
PC	6

Species Code	Species Index
LO	7

Species Code	Species Index
IC	6
RC	6
GF	4
RF	9
SH	9
DF	3
WH	12
MH	12
WB	13
KP	13
LP	17
CP	13
LM	13
JP	10
SP	2
WP	2
PP	10
MP	10
GP	10
WJ	1
BR	1
PY	1
OS	3
CY	7
BL	7
EO	7
WO	7
BO	7
VO	7
IO	7
BM	14
BU	16
RA	15
MA	5
GC	16
DG	16
FL	16
WN	16
TO	8
SY	16
AS	16
CW	16
WI	16
CN	16
CL	16
OH	16

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

Coefficient	Species Index								
	1	2	3	4	5	6	7	8	9
a_0	0	0	0	0	0	0	0	0	0
b_0	0.52909	0.25115	0.52909	0.48464	0.08402	0.29964	0.06607	0.25667	0.16601
b_1	1.00677	1.05987	1.00677	1.01272	1.10297	1.05398	1.10705	1.06474	1.0815
c_0	-3.48211	0.33383	-3.48211	-2.78353	0.91078	-1.0927	2.04714	0.11729	0.9142
c_1	1.3878	0.63833	1.3878	1.27283	0.45819	0.80687	0.1507	0.61681	0.45768
d_0	7.48846	6.92893	7.48846	7.44422	3.64292	5.12357	6.82187	5.95912	6.14578
d_1	-0.02899	-0.04053	-0.02899	-0.04779	-0.00317	-0.01042	-0.02247	-0.01812	-0.02781

Coefficient	Species Index							
	10	11	12	13	14	15	16	17
a_0	0	0	0	0	1	1	0	0
b_0	0.03685	0.25667	0.49085	0.16267	-0.81881	-1.11274	-0.2383	-0.13121
b_1	1.09499	1.06474	1.01414	1.0734	1.05418	1.12314	1.18016	1.15976

c_0	4.0134	0.11729	3.16456	3.2885	-2.36611	2.53316	3.04413	2.59824
c_1	0.04946	0.61681	0	0	1.20241	0	0	0
d_0	6.04928	5.95912	5.48853	6.48494	4.42	4.12048	4.62512	4.89032
d_1	-0.01091	-0.01812	-0.00717	-0.02325	-0.01066	-0.00636	-0.01604	-0.01884

For giant sequioa and redwood, equation {4.3.1.7} and equation {4.3.1.8} are used to compute crown ratio for live trees less than 1" and dead trees of all sizes. For live trees greater than 1", equation {4.3.1.7} and equation {4.3.1.9} are used to compute crown ratio.

{4.3.1.7} $X = -1.021064 + 0.309296 * \ln(H*12/D) + 0.869720 * PRD - 0.116274 * D/QMDPLT$

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

{4.3.1.9} $CR = 1 / (1 + \exp(X))$

where:

CR	is crown ratio expressed as a proportion (bounded to $0.05 \leq CR \leq 0.95$)
D	is tree diameter at breast height
H	is tree height
PRD	is relative density of the inventory point (point Zeide SDI / point SDI max)
QMDPLT	is quadratic mean diameter of the inventory point (constrained to minimum of 1")
N(0,SD)	is a random increment from a normal distribution with a mean of 0 and a standard deviation of SD (0.15)

All valid ORGANON tree records use equations {4.3.1.10} and {4.3.1.11}. Coefficients and references can be found in table 4.3.1.4

{4.3.1.10}
HCB=HT/(1.0+EXP(X0+X1*HT+X2*CCFL+X3*ALOG(BA)+X4*(DBH/HT)+X5*SITE+X6*OG**2))

{4.3.1.11} CR=1.0-HCB/HT

where:

CR	is predicted average stand crown ratio for the species
HCB	is the height to crown base
HT	tree height
CCFL	is stand crown competition factor for trees with DBH larger than subject tree's DBH
BA	Stand basal area
SITE	Douglas-for site Index, unless species is Ponderosa pine then use Ponderosa's.

X_{0-6}, are species-specific coefficients shown in tables 4.3.1.4

Table 4.3.1.4 Coefficients for the crown ratio equation {4.3.1.10} in the OC variant.

Species Code	X_0	X_1	X_2	X_3	X_4	X_5	X_6	Reference*
DF	1.990155	-0.00818	-0.0047	-0.39203	1.945708	0.007854	0.295594	1

GF	4.80009	0	-0.00327	-0.85874	0	0	0.275679	1
PP	2.024724	-0.00195	-0.00184	-0.56891	4.831887	0.001653	0	1
SP	3.582314	-0.00326	0	-0.76525	3.043846	0	0	1
IC	3.127731	-0.00439	-0.00356	-0.63793	0.977816	0.00585	0.25707	1
WH	0	0	0	0	3.246353	0	0	1
RC	4.49102	0	-0.00132	-1.01461	0	0.013406	0	2
PY	0	0	0	0	1.225565	0	0	1
MA	3.271131	0	0	-0.84133	1.7917	0	0.927163	1
GC	0.387913	-0.015	-0.0041	0	2.104871	0	0.352773	1
TO	0.448848	-0.00938	-0.00182	0	0	0	0.233233	1
CL	1.285466	-0.02446	-0.00399	0	0	0	0	1
BM	1.000364	-0.01064	-0.00595	0	0	0	0.310673	1
WO	1.057866	0	-0.00183	-0.28645	0	0	0	3
BO	2.672851	0	-0.0014	-0.60597	0	0	0.430989	1
RA	0.567138	-0.01038	-0.00207	0	1.397962	0	0	2
DG	0	0	-0.00484	-0.56799	0	0.028132	0	1
WI	0	0	-0.00484	-0.56799	0	0.028132	0	1

1: Hann et al 2000, 2: Hann and Hanus 2002, 3: Gould et al 2008

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 non-valid ORGANON live tree records using the Weibull distribution, equations {4.3.1.3}-{4.3.1.6}, for all species except giant sequoia and redwood. For giant sequoia and redwood, crown ratio predicted at the end of the projection cycle is estimated using equations {4.3.1.7) and {4.3.1.9}. Crown ratio at the end of the projection cycle for valid ORGANON tree records is predicted using equations {4.3.1.10} and {4.3.1.11}. Crown change is checked to make sure it doesn't exceed the change possible if all height growth produces new crown. Crown change is further bounded to 1% per year for the length of the cycle to avoid drastic changes in crown ratio. Equations {4.3.1.1} and {4.3.1.2} are not used when estimating crown ratio change.

4.3.3 Crown Ratio for Newly Established Trees

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

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

where:

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

4.4 Crown Width Relationships

In the OC variant all species use the FVS logic {4.4.1 – 4.4.6} to calculate 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*) calculations in the model. Within the ORGANON model routines, crown widths for stand density measures are calculated using ORGANON equations. However, ORGANON crown widths are not reported in any FVS output files or used outside the ORGANON routines so the equations are not reported here.

{4.4.1} Bechtold (2004); Equation 01

$DBH \geq MinD: CW = a_1 + (a_2 * DBH) + (a_3 * DBH^2)$
$DBH < MinD: CW = [a_1 + (a_2 * MinD) * (a_3 * MinD^2)] * (DBH / MinD)$

{4.4.2} Bechtold (2004); Equation 02

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

{4.4.3} Crookston (2003); Equation 03

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

{4.4.4} Crookston (2005); Equation 04

$DBH \geq MinD$: $CW = a_1 * DBH \verb|^| a_2$
$DBH < MinD$: $CW = [a_1 * MinD \verb|^| a_2] * (DBH / MinD)$

{4.4.5} Crookston (2005); Equation 05

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

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

{4.4.6} Donnelly (1996); Equation 06

$DBH \geq MinD$ $CW = a_1 * DBH \verb|^| a_2$
$DBH < MinD$ $CW = [a_1 * MinD \verb|^| a_2] * (DBH / MinD)$

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 4.4.1 Coefficients for crown width equations {4.4.1}-{4.4.6} in the OC variant.

Species Code	Equation Number*	a_1	a_2	a_3	a_4	a_5	a_6
PC	04105	4.6387	0.50874	-0.22111	0.17505	0.06447	-0.00602
IC	08105	5.0446	0.47419	-0.13917	0.1423	0.04838	-0.00616
RC	24205	6.2382	0.29517	-0.10673	0.23219	0.05341	-0.00787
GF	01703	1.03030	1.14079	0.20904	0.38787	0	0
RF	02006	3.1146	0.578	0	0	0	0
SH	02105	2.317	0.4788	-0.06093	0.15482	0.05182	0
DF	20205	6.0227	0.54361	-0.20669	0.20395	-0.00644	-0.00378

Species Code	**Equation Number***	**a₁**	**a₂**	**a₃**	**a₄**	**a₅**	**a₆**
WH	26305	6.0384	0.51581	-0.21349	0.17468	0.06143	-0.00571
MH	26403	6.90396	0.55645	-0.28509	0.2043	0	0
WB	10105	2.2354	0.6668	-0.11658	0.16927	0	0
KP	10305	4.0069	0.84628	-0.29035	0.13143	0	-0.00842
LP	10805	6.6941	0.8198	-0.36992	0.17722	-0.01202	-0.00882
CP	10805	6.6941	0.8198	-0.36992	0.17722	-0.01202	-0.00882
LM	11301	4.0181	0.8528	0	0	0	0
JP	11605	4.0217	0.66815	-0.11346	0.09689	-0.636	0
SP	11705	3.593	0.63503	-0.22766	0.17827	0.04267	-0.0029
WP	11905	5.3822	0.57896	-0.19579	0.14875	0	-0.00685
PP	12205	4.7762	0.74126	-0.28734	0.17137	-0.00602	-0.00209
MP	12702	-2.4909	1.0716	0	0.0648	0	-0.1127
GP	12702	-2.4909	1.0716	0	0.0648	0	-0.1127
WJ	06405	5.1486	0.73636	-0.46927	0.39114	-0.05429	0
BR	09204	2.8232	0.66326	0	0	0	0
GS	21104	3.7023	0.52618	0	0	0	0
PY	23104	6.1297	0.45424	0	0	0	0
OS	11605	4.0217	0.66815	-0.11346	0.09689	-0.636	0
LO	80102	-16.1696	1.7456	0	0.0925	0	-0.1956
CY	80502	0.2738	1.0534	0	0.035	0	-0.1385
BL	80702	2.711	1.5159	0	0.0415	-0.0271	0
EO	80702	2.711	1.5159	0	0.0415	-0.0271	0
WO	81505	2.4857	0.70862	0	0.10168	0	0
BO	81802	1.6306	0.9867	0	0.0556	0	-0.1199
VO	82102	-2.1068	1.9385	0	0.086	0	0
IO	83902	0.7146	1.546	0	0	0	-0.1121
BM	31206	7.5183	0.4461	0	0	0	0
BU	31206	7.5183	0.4461	0	0	0	0
RA	35106	7.0806	0.4771	0	0	0	0
MA	36102	4.9133	0.9459	0	0.0611	0	0.0523
GC	63102	3.115	0.7966	0	0.0745	-0.0053	0.0523
DG	35106	7.0806	0.4771	0	0	0	0
FL	31206	7.5183	0.4461	0	0	0	0
WN	31206	7.5183	0.4461	0	0	0	0
TO	63102	3.115	0.7966	0	0.0745	-0.0053	0.0523
SY	63102	3.115	0.7966	0	0.0745	-0.0053	0.0523
AS	74605	4.7961	0.64167	-0.18695	0.18581	0	0
CW	74705	4.4327	0.41505	-0.23264	0.41477	0	0
WI	31206	7.5183	0.4461	0	0	0	0
CN	98102	2.4247	1.3174	0	0.0786	0	0

Species Code	**Equation Number***	**a_1**	**a_2**	**a_3**	**a_4**	**a_5**	**a_6**
CL	98102	2.4247	1.3174	0	0.0786	0	0
OH	31206	7.5183	0.4461	0	0	0	0
RW	21104	3.7023	0.52618	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 {4.4.1}-{4.4.6} in the OC variant.

Species Code	**Equation Number***	***MinD***	**EL min**	***EL* max**	***HI* min**	***HI* max**	***CW* max**
PC	04105	1.0	2	52	n/a	n/a	49
IC	08105	1.0	5	62	n/a	n/a	78
RC	24205	1.0	1	72	n/a	n/a	45
GF	01703	1.0	n/a	n/a	n/a	n/a	40
RF	02006	1.0	n/a	n/a	n/a	n/a	65
SH	02105	1.0	n/a	n/a	n/a	n/a	65
DF	20205	1.0	1	75	n/a	n/a	80
WH	26305	1.0	1	72	n/a	n/a	54
MH	26403	n/a	n/a	n/a	n/a	n/a	45
WB	10105	1.0	n/a	n/a	n/a	n/a	40
KP	10305	1.0	12	49	n/a	n/a	46
LP	10805	1.0	1	79	n/a	n/a	40
CP	10805	1.0	1	79	n/a	n/a	40
LM	11301	5.0	n/a	n/a	n/a	n/a	25
JP	11605	1.0	n/a	n/a	n/a	n/a	39
SP	11705	1.0	5	75	n/a	n/a	56
WP	11905	1.0	10	75	n/a	n/a	35
PP	12205	1.0	13	75	n/a	n/a	50
MP	12702	5.0	n/a	n/a	-69	-4	54
GP	12702	5.0	n/a	n/a	-69	-4	54
WJ	06405	1.0	n/a	n/a	n/a	n/a	36
BR	09204	1.0	n/a	n/a	n/a	n/a	38
GS	21104	1.0	n/a	n/a	n/a	n/a	39
PY	23104	1.0	n/a	n/a	n/a	n/a	30
OS	11605	1.0	n/a	n/a	n/a	n/a	39
LO	80102	5.0	n/a	n/a	-73	-54	53
CY	80502	5.0	n/a	n/a	-60	-5	49
BL	80702	5.0	n/a	n/a	n/a	n/a	61
EO	80702	5.0	n/a	n/a	n/a	n/a	61
WO	81505	1.0	n/a	n/a	n/a	n/a	39
BO	81802	5.0	n/a	n/a	-47	-8	52
VO	82102	5.0	n/a	n/a	n/a	n/a	47
IO	83902	5.0	n/a	n/a	-60	-5	37

Species Code	**Equation Number***	***MinD***	**EL min**	***EL* max**	***HI* min**	***HI* max**	***CW* max**
BM	31206	1.0	n/a	n/a	n/a	n/a	30
BU	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
MA	36102	5.0	n/a	n/a	-55	15	43
GC	63102	5.0	n/a	n/a	-55	15	41
DG	35106	1.0	n/a	n/a	n/a	n/a	35
FL	31206	1.0	n/a	n/a	n/a	n/a	30
WN	31206	1.0	n/a	n/a	n/a	n/a	30
TO	63102	5.0	n/a	n/a	-55	15	41
SY	63102	5.0	n/a	n/a	-55	15	41
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
WI	31206	1.0	n/a	n/a	n/a	n/a	30
CN	98102	5.0	n/a	n/a	n/a	n/a	44
CL	98102	5.0	n/a	n/a	n/a	n/a	44
OH	31206	1.0	n/a	n/a	n/a	n/a	30
RW	21104	1.0	n/a	n/a	n/a	n/a	39

Table 4.4.2.3 *BF* values for equation {4.4.5} in the OC variant.

	Location Code	
Species Code	**610, 710, 711**	**611, 712**
IC	0.903	0.821
DF	1.000	0.961
WH	1.000	1.028
MH	0.900	0.900
LP	0.944	0.944
SP	1.048	1.000
WP	1.081	1.000
PP	0.918	0.951
RA	0.810	0.810

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

4.5 Crown Competition Factor

The OC variant uses crown competition factor (*CCF*) as a predictor variable in some growth relationships. Crown competition factor (Krajicek and others 1961) is a relative measurement of stand density that is based on tree diameters. Individual tree CCF_t values estimate the percentage of an acre that would be covered by the tree's crown if the tree were open-grown.

Stand *CCF* is the summation of individual tree (CCF_t) values. A stand *CCF* value of 100 theoretically indicates that tree crowns will just touch in an unthinned, evenly spaced stand.

Crown competition factor for use in ORGANON equations is computed using ORGANON crown width equations previously discussed. For FVS equations, crown competition factor for an individual tree is calculated using equation set {4.5.1}. All species coefficients are shown in table 4.5.1.

{4.5.1} CCF Equations

$CCF_t = 0.001803 * (MCW_t)^2$

$HT \leq 4.501$: $MCW_t = HT/4.5 * R_1$

$HT < 4.501''$: $MCW_t = R_1 + (R_2 * DBH) + (R_3 * DBH^2)$

where:

MCW_t	is maximum crown width for an individual tree
CCF_t	is crown competition factor for an individual tree
DBH	is tree diameter at breast height (if DBH is greater than MaxDBH, DBH=MaxDBH)
HT	is tree height
$R_1 – R_3$	are species-specific coefficients shown in table 4.5.1

Table 4.4.1.1 Coefficients and equation reference for equations {4.5.1} in the OC variant.

Species Code	R_1	R_2	R_3
DF	4.6366	1.6078	-0.00963
GF	6.188	1.0069	0
PP	3.4835	1.343	-0.00825
SP	4.660055	1.070186	0
IC	3.2837	1.2031	-0.00719
WH	4.5652	1.4147	0
RC	4	1.65	0
PY	4.5652	1.4147	0
MA	3.429863	1.35323	0
GC	2.97939	1.551244	-0.01416
TO	4.4443	1.704	0
CL	4.4443	1.704	0
BM	4.0953	2.3849	-0.01163
WO	3.078564	1.924221	0
BO	3.3625	2.0303	-0.00733
RA	8	1.53	0
DG	2.97939	1.551244	-0.01416
WI	2.97939	1.551244	-0.01416

4.6 Small Tree Growth Relationships

Non-valid ORGANON tree records are considered “small trees” for FVS modeling purposes when they are smaller than some threshold diameter. This threshold diameter is set to 3.0” for all species in the OC variant. All valid ORGANON tree records are considered “large trees” for FVS modeling purposes (see section 4.7).

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 height growth (*HTG*) for small trees. For all species except giant sequoia and redwood, height growth in the OC variant is estimated by using equations {4.6.1.1} – {4.6.1.4}, and then modified with equation {4.6.1.5} to account for differences in species, site index, and geographic area. Data was not available to fit small-tree height growth models for the OC variant. Equations {4.6.1.1}, {4.6.1.3}, and {4.6.1.4} were taken from the Western Sierras (WS) variant. Equation {4.6.1.2} was derived from equations in Hann and Scrivani (1987) and Ritchie and Hann (1986). Equation reference and adjustment factors are shown in table 4.6.1.1.

{4.6.1.1} Pines

$$POTHTG = 1.75 * \exp(0.7452 - (0.003271 * BAL) - (0.1632 * CR) + (0.0217 * CR^2) + (0.00536 * SI))$$

{4.6.1.2} Firs

$$POTHTG = 1.016605 * DOHTG * (1 - \exp(-0.426558 * CR)) * (\exp(2.54119 * (RELHT^{0.250537} - 1)))$$

$$DOHTG = (11.35 + 2.157 * SI) / (29 - 0.05 * SI)$$

{4.6.1.3} California black oak

$$POTHTG = \exp(3.817 - (0.7829 * \ln(BAL)))$$

{4.6.1.4} Tanoak

$$POTHTG = \exp(3.385 - (0.5898 * \ln(BAL)))$$

where:

POTHTG	is potential height growth
BAL	is total basal area in trees larger than the subject tree
CR	is crown ratio expressed as a percent divided by 10 for equations {4.6.1.1}, {4.6.1.3}, and {4.6.1.4}; is crown ratio expressed as a proportion for equation {4.6.1.2}
SI	is species site index

For all species except firs, the potential height growth is adjusted based on a species-specific adjustment factor (*X*), and by the site index of the geographic area using equation {4.6.1.5}. A small random deviation (bounded between -0.2 and 0.05) is then added to the predicted height growth to assure a good distribution of estimated height growths.

{4.6.1.5} $HTG = POTHTG * [0.8 + (0.004 * (SI - 50))] * X$

where:

HTG	is estimated height growth for the cycle
POTHTG	is potential height growth
SI	is species site index
X	is a species-specific adjustment factor shown in table 4.6.1.1

For redwood and giant sequoia, a potential height growth curve is used to estimate small tree height growth. Height growth is computed by subtracting the current predicted height from the predicted height 5 years in the future, as depicted in equation {4.6.1.6}.

{4.6.1.6} $POTHTG = 2.242202 * SI * [1.0 - \exp(-0.010742 * AGE1)]^{\wedge} 0.919076$

where:

POTHTG	is predicted tree height, used for current and future height growth
SI	is species site index
AGE1	is tree age $AGE1 = 1/ -0.010742 *(\ln(1-(HT/2.242202/SI)^{\wedge}(1/ 0.919076))$

Table 4.6.1.1 Equation reference, adjustment factors and diameter range where weighting between small and large tree models occurs in the OC variant.

Species Code	*POTHTG* Equation	Adjustment Factor (X)	X_{min}	X_{max}
PC	{4.6.1.2}	1.0	2.0	4.0
IC	{4.6.1.2}	1.0	2.0	4.0
RC	{4.6.1.2}	0.9	2.0	4.0
GF	{4.6.1.2}	1.1	2.0	4.0
RF	{4.6.1.2}	1.1	2.0	4.0
SH	{4.6.1.2}	1.1	2.0	4.0
DF	{4.6.1.2}	1.1	2.0	4.0
WH	{4.6.1.2}	0.8	2.0	4.0
MH	{4.6.1.2}	0.9	2.0	4.0
WB	{4.6.1.1}	0.9	2.0	4.0
KP	{4.6.1.1}	1.0	2.0	4.0
LP	{4.6.1.1}	1.0	2.0	4.0
CP	{4.6.1.1}	1.0	2.0	4.0
LM	{4.6.1.1}	1.0	2.0	4.0
JP	{4.6.1.1}	1.0	2.0	4.0
SP	{4.6.1.1}	1.1	2.0	4.0
WP	{4.6.1.1}	1.1	2.0	4.0

Species Code	*POTHTG* Equation	Adjustment Factor (X)	X_{min}	X_{max}
PP	{4.6.1.1}	1.0	2.0	4.0
MP	{4.6.1.1}	1.1	2.0	4.0
GP	{4.6.1.1}	0.9	2.0	4.0
WJ	{4.6.1.1}	1.0	2.0	4.0
BR	{4.6.1.2}	0.9	2.0	4.0
GS	{4.6.1.6}	1.0	2.0	10.0
PY	{4.6.1.2}	0.8	2.0	4.0
OS	{4.6.1.1}	1.0	2.0	4.0
LO	{4.6.1.3}	1.1	2.0	4.0
CY	{4.6.1.3}	0.9	2.0	4.0
BL	{4.6.1.3}	1.1	2.0	4.0
EO	{4.6.1.3}	1.1	2.0	4.0
WO	{4.6.1.3}	1.0	2.0	4.0
BO	{4.6.1.3}	1.1	2.0	4.0
VO	{4.6.1.3}	1.0	2.0	4.0
IO	{4.6.1.3}	1.1	2.0	4.0
BM	{4.6.1.4}	1.0	2.0	4.0
BU	{4.6.1.3}	1.0	2.0	4.0
RA	{4.6.1.3}	1.0	2.0	4.0
MA	{4.6.1.4}	1.0	2.0	4.0
GC	{4.6.1.3}	1.0	2.0	4.0
DG	{4.6.1.4}	1.0	2.0	4.0
FL	{4.6.1.3}	1.0	2.0	4.0
WN	{4.6.1.3}	1.1	2.0	4.0
TO	{4.6.1.4}	1.0	2.0	4.0
SY	{4.6.1.3}	1.1	2.0	4.0
AS	{4.6.1.3}	1.2	2.0	4.0
CW	{4.6.1.3}	1.2	2.0	4.0
WI	{4.6.1.3}	1.1	2.0	4.0
CN	{4.6.1.2}	0.8	2.0	4.0
CL	{4.6.1.4}	1.0	2.0	4.0
OH	{4.6.1.3}	1.0	2.0	4.0
RW	{4.6.1.6}	1.0	2.0	10.0

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 {4.6.1.7}, and applied as shown in equation {4.6.1.8}. The range of diameters where this weighting occurs for each species is shown above in table 4.6.1.1.

{4.6.1.7}

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

{4.6.1.8}

Estimated growth = $[(1 - XWT) * STGE] + [XWT * LTGE]$
Giant sequoia and redwood estimated growth = $[(1 - XWT) * ((STGE+LTGE)/2.0)] + [XWT * LTGE]$

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

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. Diameter growth is predicted with the height-diameter equations shown in section 4.1 for non-valid ORGANON tree records inverted so diameter is a function of height. In the OC variant, diameter growth of all non-valid ORGANON small trees is a weighted average of the small and large tree predictions when the *DBH* is between 1.5" and 3.0". Diameter growth estimates for giant sequoia and redwood are weighted with the diameter growth estimates from the large-tree model when DBH is between 2" and 7", in a similar manner to the weighting explained in section 4.6.1. By definition, diameter growth is zero for trees less than 4.5 feet tall.

4.7 Large Tree Growth Relationships

For non-valid ORGANON tree records, trees are considered “large trees” for FVS modeling purposes when they are equal to, or larger than, some threshold diameter. This threshold diameter is set to 3.0” for all species in the OC variant. In addition, all valid ORGANON tree records are considered large trees for FVS modeling purposes.

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). ORGANON based diameter growth equations are constructed similarly, they predict periodic change in diameter squared as well, however they include bark, where FVS does not.

In the OC variant, there are three primary equations that estimate large-tree diameter growth. The non-valid ORGANON tree records use equation {4.7.1.1} except for giant sequoia and redwood which use equation {4.7.1.2}. Coefficients for these equations are shown in tables 4.7.1.2 and 4.7.1.4. These equations yield a 10-year estimate, except for tanoak which is a 5-year estimate. Equation {4.7.1.3} is used for all species except tanoak to convert the 10-year estimate to a 5-year estimate.

All valid ORGANON tree records use equation {4.7.1.4}, these were developed by Hann and Hanus 2002.

In the OC variant, all non-valid ORGANON tree records are mapped into a species index as shown in table 4.7.1.1. The coefficients for each species for equation 4.7.1.1 will depend on the species index of the subject species.

{4.7.1.1} Used for all species except giant sequoia and redwood

$$\ln(DDS) = b_1 + (b_2 * EL) + (b_3 * EL^2) + (b_4 * \ln(SI)) + (b_5 * \sin(ASP)) + (b_6 * \cos(ASP)) + (b_7 * SL) + (b_8 * SL^2) + (b_9 * \ln(DBH)) + (b_{10} * CR) + (b_{11} * CR^2) + (b_{12} * DBH^2) + (b_{13} * BAL / (\ln(DBH + 1.0))) + (b_{14} * PCCF) + (b_{15} * RELHT) + (b_{16} * \ln(BA)) + (b_{17} * BAL)$$

{4.7.1.2} Used for giant sequoia and redwood

$$DI = \exp(-3.502444 + (0.185911 * \ln(DBH)) + (-0.000073 * DBH^2) + (-0.001796 * PBAL) + (-0.42078 * PRD) + (0.589318 * \ln(CR)) + (0.415435 * \ln(SI)) + (-0.000926 * SL) + (-0.002203 * (SL) * \cos(ASP)))$$

{4.7.1.3} Used for all species except tanoak

$$\ln(DDS) = \ln(\exp(DDS) / 2.0)$$

where:

DDS	is the square of the 10-year diameter growth increment
DI	is 10-year outside bark diameter growth increment
EL	is stand elevation in hundreds of feet
SI	is species site index (for mountain hemlock only, *SI* = *SI* * 3.281)
ASP	is stand aspect
SL	is stand slope
CR	is crown ratio expressed as a proportion
DBH	is tree diameter at breast height
BAL	is total basal area in trees larger than the subject tree
PBAL	is point basal area in trees larger than the subject tree
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
BA	is total stand basal area
PRD	is relative density of the inventory point (point Zeide SDI / point SDI max)
b_1	is a location-specific coefficient shown in table 4.7.1.2
b_2- b_{17}	are species-specific coefficients shown in table 4.7.1.4

Table 4.7.1.1 Mapped species index for each species for large-tree diameter growth on non-valid ORGANON tree records in the OC variant.

Alpha Code	Species Index
PC	1
IC	1
RC	1
GF	2
RF	3
SH	3
DF	4
WH	7
MH	7
WB	6
KP	5
LP	6
CP	5
LM	5
JP	9
SP	7
WP	8
PP	9
MP	9
GP	5
WJ	5
BR	2
LO	10
CY	10
BL	10
EO	10
WO	10
BO	10
VO	10
IO	10
BM	10
BU	10
RA	10
MA	11
GC	11
DG	11
FL	10
WN	10
TO	13
SY	10
AS	10
CW	10
WI	10
CN	5

Alpha Code	Species Index
GS	12
PY	5
OS	9

Alpha Code	Species Index
CL	10
OH	10
RW	12

Table 4.7.1.2 b_1 values by location class for equation {4.7.1.1} in the OC variant.

Location Class	Species Index						
	1	2	3	4	5	6	7
1	-3.428338	-2.108357	-2.073942	-1.877695	0.564402	-2.058828	-2.397678
2	-3.966547	0	-1.943608	-2.099646	0	-1.596998	0
3	0	0	0	-2.211587	0	0	0
4	0	0	0	-1.955301	0	0	0
5	0	0	0	-2.078432	0	0	0

Location Class	Species Index					
	8	9	10	11	12	13
1	-1.626879	-2.922255	-1.958189	-3.3447	0	-0.94563
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0

Table 4.7.1.3 Classification of location class by species index and location code in the OC variant.

Location Code	Species Index												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
610 – Rogue River 710 – BLM Roseburg, 711 – BLM Medford	1	1	1	4	1	1	1	1	1	1	1	1	1
611 - Siskiyou, 712 – BLM Coos Bay	1	1	1	5	1	1	1	1	1	1	1	1	1

Table 4.7.1.4 Coefficients (b_2- b_{17}) for equation {4.7.1.1} in the OC variant.

	Species Index												
Coefficient	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
b_2	0	0.0301	0.0248	-0.0141	0	0	0	0	-0.003784	0.0049	0	0	0
b_3	0	-0.00030732	-0.00033429	0.00024083	0	0	0	0	0.0000666	-0.00008781	0	0	0
b_4	0.820451	0.365679	0.492695	0.759305	0	0.566946	0.963375	0.7243	1.011504	0.213526	1.334008	0	0.00659
b_5	0	0.09735	0.13918	0.018681	0.951834	0	-0.014463	-0.562259	0	0	0	0	-0.03587
b_6	0	-0.315227	-0.444594	-0.151727	0.64987	0	-0.280294	-0.17951	0	0	0	0	-0.19935
b_7	0	-0.206267	0	-0.339369	0	0	-0.581722	-0.544867	0	0	0	0	0.7353
b_8	0	0	0	0	0	0	0	0	0	0	0	0	-0.99561
b_9	0.950418	1.182104	1.186676	0.716226	1.077154	1.218279	0.88615	0.825682	0.73875	1.310111	0.955569	0	0.99531
b_{10}	1.815305	2.856578	2.763519	3.272451	-0.276387	3.167164	1.47865	1.675208	3.454857	0.271183	0	0	2.08524
b_{11}	0	-1.093354	-0.871061	-1.642904	1.063732	-1.568333	0	0	-1.773805	0	0	0	-0.98396
b_{12}	-0.0002385	-0.0006362	-0.0004572	-0.0002723	0	-0.0014178	-0.0002528	-0.0000731	-0.0004708	-0.0003048	0	0	-0.000373
b_{13}	-0.005433	-0.005992	-0.003728	-0.008787	0	0	-0.006263	-0.002133	-0.013091	0	-0.005893	0	-0.00147
b_{14}	-0.000779	-0.001014	0	-0.000224	0	-0.000338	0	0	-0.000593	-0.000473	0	0	-0.00018
b_{15}	0	0	0	0	0	0	0	0	0	0	0	0	0.50155
b_{16}	-0.000016	-0.058039	-0.122905	-0.028564	0	-0.267873	-0.129146	-0.203636	-0.131185	0	-0.408462	0	0
b_{17}	0	0	0	0	-0.000893	0	0	0	0	0	0	0	0

Equation {4.7.1.4} predicts the change in square of the 5-year diameter outside bark. An adjustment factor is then applied to the final diameter growth value. All equations were developed by Hann and Hanus 2002, except white oak which was developed by Gould et al 2008.

{4.7.1.4} Used for all valid ORGANON tree records

ln(*DDS*)=X0 + X1*LOG(DBH+K1) + X2*DBH**K2 + X3*LOG((CR+0.2)/1.2) + X4*LOG(SITE) + X5*((BAL**K3)/LOG(DBH+K4)) + X6*SQRT(BA)

{4.7.1.5} Modifier to 5-year diameter growth

MOD=(1.0-EXP(-(25.0*CR)**2))*ADJ

DG=EXP(ln(DDS))*MOD

where:

DDS	is the square of the 5-year diameter outside bark growth increment
DG	is 5-year diameter growth outside bark
SI	is site index
CR	is crown ratio expressed as a proportion
DBH	is tree diameter at breast height
BA	is total stand basal area
BAL	is total basal area in trees larger than the subject tree
X_0- X_6 , K_1- K_4	are species-specific coefficients shown in table 4.7.1.5

Table 4.7.1.5 Coefficients (X_0- $X_6,$ K_1- $K_4,$) for equation {4.7.1.4} in the OC variant.

Species	X0	X1	X2	X3	X4	X5	X6	K1	K2	K3	K4	ADJ
DF	-5.3556	0.84053	-0.0427	1.1595	0.95471	-0.0089	0	5	1	1	2.7	0.8938
GF	-5.849	1.6682	-0.0853	1.21222	0.67935	-0.0081	0	5	1	1	2.7	0.8722
PP	-4.5196	0.814	-0.0494	1.1025	0.87944	-0.0109	-0.0334	5	1	1	2.7	0.8
SP	-4.1234	0.73499	-0.0425	1.05942	0.80866	-0.0108	0	5	1	1	2.7	0.7903
IC	-2.0855	0.59604	-0.0215	1.02735	0.38345	-0.0049	-0.0609	5	1	1	2.7	0.8
WH	-5.7005	0.86509	-0.0433	1.1086	0.97733	0	-0.0526	5	1	1	2.7	0.8
RC	-11.455	0.78413	-0.0261	0.70175	2.05724	-0.0042	0	5	1	1	2.7	0.8
PY	-9.1584	1	-4E-07	1.16688	0	0	-0.02	4000	4	1	2.7	0.8
MD	-8.8453	1.5	-0.0006	0.51226	0.41813	-0.0036	-0.0321	110	2	1	2.7	0.7923
GC	-7.7845	1.2	-0.07	0	1.01436	-0.0083	0	10	1	1	2.7	0.7259
TA	-3.3682	1.2	-0.07	0	0	0	-0.034	10	1	1	2.7	0.8
CL	-3.5933	1.2	-0.07	0.51637	0	0	-0.02	10	1	1	2.7	0.8
BL	-3.4145	1	-0.05	0	0.32435	0	-0.099	10	1	1	2.7	0.8

Species	X0	X1	X2	X3	X4	X5	X6	K1	K2	K3	K4	ADJ
WO	-7.8127	1.40562	-0.0603	0.64286	1.03769	0	-0.0787	5	1	1	2.7	1
BO	-4.4344	0.93093	-0.0466	0	0.51072	0	-0.0689	5	1	1	2.7	0.7667
RA	-4.3908	1	-0.0945	1.06867	0.68591	-0.0059	0	5	1	1	2.7	0.8
PD	-8.0835	1	-4E-07	0.31177	0	0	-0.0731	4000	4	1	2.7	0.8
WI	-8.0835	1	-4E-07	0.31177	0	0	-0.0731	4000	4	1	2.7	0.8

4.7.2 Large Tree Height Growth

For all species except giant sequoia and redwood, height growth estimates for non-valid ORGANON tree records in the OC 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.

In the OC variant, each non-valid ORGANON tree record is mapped into a species index as shown in table 4.7.2.1. The coefficients and equations used for each species will depend on the species index of the subject species.

Table 4.7.2.1 Mapped species index for each species for height growth in the OC variant.

Species Code	Species Index	Species Code	Species Index
PC	3	LO	9
IC	3	CY	9
RC	3	BL	9
GF	3	EO	9
RF	5	WO	7
SH	5	BO	7
DF	3	VO	7
WH	3	IO	9
MH	5	BM	10
WB	6	BU	7
KP	6	RA	10
LP	6	MA	9
CP	6	GC	9
LM	6	DG	7
JP	4	FL	7
SP	3	WN	10
WP	4	TO	8
PP	4	SY	10

Species Code	Species Index
MP	4
GP	4
WJ	6
BR	3
PY	7
OS	3

Species Code	Species Index
AS	10
CW	10
WI	10
CN	10
CL	10
OH	10

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. Estimated current height (ECH) and estimated future height (H10) are both obtained using the equations shown below. 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. Height increment is obtained by subtracting estimated current height from estimated future height, then adjusting the difference according to tree's crown ratio and height relative to other trees in the stand.

Region 6 Forests and BLM Administrative Units use equations 4.7.2.1 through 4.7.2.5 for all species.

{4.7.2.1} Used for species index 3 and 4

$$H = (((SI - 4.5) * TOPTRM / BOTTRM) + 4.5) * 1.05$$
$$TOPTRM = 1 - \exp(-\exp(b_0 + (b_1 * \ln(SI - 4.5)) + (b_2 * \ln(A))))$$
$$BOTTRM = 1 - \exp(-\exp(b_0 + (b_1 * \ln(SI - 4.5)) + (b_2 * \ln(50))))$$

{4.7.2.2} Used for species index 5

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

{4.7.2.3} Used for species index 6

$$H = SI * [b_0 + (b_1 * A) + (b_2 * A^2)] * 1.10$$

{4.7.2.4} Used for species index 7

$$H = [SI * (1 + (b_1 * TERM)) - (b_0 * TERM)] * 0.70$$
$$TERM = \mathrm{SQRT}(A) - 7.0711$$

{4.7.2.5} Used for species index 8, 9, and 10

$$H = [SI / (b_0 + (b_1 / A))] * 0.80$$

where:

H	is estimated height of the tree
SI	is species site index

A	is estimated age of the tree
$b_0 - b_5$	are species-specific coefficients shown in table 4.7.2.2

Table 4.7.2.2 Coefficients ($b_0 - b_5$) for height-growth equations in the OC variant.

	Species Index							
Coefficient	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
b_0	-6.21693	-6.54707	0	-0.0968	6.413	0.204	0.375	0.649
b_1	0.281176	0.288169	1.51744	0.02679	0.322	39.787	31.233	17.556
b_2	1.14354	1.21297	1.41512E-06	-9.309E-05	0	0	0	0
b_3	0	0	-0.0440853	0	0	0	0	0
b_4	0	0	-3049510.	0	0	0	0	0
b_5	0	0	0.000572474	0	0	0	0	0

For non-valid ORGANON tree records potential 5-year height growth (*POTHTG*) is calculated by using equation {4.7.2.8}. Then, modifiers are applied to the height growth based upon a tree's crown ratio (using equation {4.7.2.9}) and relative height (using equation {4.7.2.10}). Equation {4.7.2.11} calculates a height-growth modifier by combining the crown ratio and relative height modifiers. Final height growth is calculated using equation {4.7.2.12} as a product of the modifier and potential height growth. The final height growth is then adjusted to the length of the cycle.

{4.7.2.8} $POTHTG = H5 - ECH$

{4.7.2.9} $HGMDCR = 1 - \exp(-4.26558 * CR)$

{4.7.2.10} $HGMDRH = \exp [2.54119 * (RELHT\text{^}0.250537 - 1.0)]$

{4.7.2.11} $HTGMOD = 1.016605 * HGMDCR * HGMDRH$

{4.7.2.12} $HTG = POTHTG * HTGMOD$

where:

$POTHTG$	is potential height growth
$H5$	is estimated height of the tree in five years
ECH	is estimated height of the tree at the beginning of the cycle
$HGMDCR$	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 proportion
$RELHT$	is tree height divided by average height of the 40 largest diameter trees in the stand (bounded $RELHT \leq 1$; $RELHT = 1$ if crown competition factor on the inventory point where the tree is located is less than 100)

Equation {4.7.2.13} is used to predict 10-year height increment for giant sequoia and redwood and equation {4.7.2.14} is used to convert this estimate to 5-year height increment. The final height growth is then adjusted to the length of the cycle.

{4.7.2.13} $HTG = \exp(1.412947 + (-0.000204 * DBH\text{^}2) + (0.31971 * \ln(DBH)) + (0.394005 * \ln(SI))$
$+ (-(0.399888 * (\ln(DG10)) + (-0.451708 * \ln(HT))$

{4.7.2.14} $HTG = HTG * 0.5$

where:

HTG	is 10-year height growth increment
DBH	is diameter at breast height
SI	is species site index
DG10	is 10-year outside bark diameter growth increment
HT	is total tree height

A height growth bounding function is used to ensure tree heights do not exceed the height maximum of giant sequoia and redwood. The bounding function is applied using the following concepts. For a tree with height less than the lower height-bounding limit, the height growth modifier is set to 1.0. For a tree with a height greater than or equal to the lower height-bounding limit and less than the upper height-bounding limit, a height growth modifier is computed using equation {4.7.2.15}. For a tree with a height greater than the upper height-bounding limit, the height growth modifier is set to 0.1. The lower bounding limit was determined from the height growth fitting data and the upper bounding limit was determined from literature. The final height increment estimate is multiplied by the bounding function, equation {4.7.2.16}.

{4.7.2.15} $HGBND = 1.0 – ((HT - \mathrm{HTLO}) / (HTHI- HTLO))$

{4.7.2.16} $HTG = HTG * HGBND$

where:

HGBND	is height growth bounding modifier, limited to $0.1 \leq HGBND \leq 1.0$
HT	is total tree height (ft)
HTLO	is the lower height-bounding limit (217 ft)

HTHI is the upper height-bounding limit (380 ft)

Valid ORGANON tree records use equations {4.7.2.17} or {4.7.2.18} to estimate height growth. Equation {4.7.2.17} is used for the major conifer species (DF, GF/WF, PP, SP, and IC). It predicts potential height growth based on dominant height from the Hann and Scrivani site index curves, tree’s growth effective age, and modified. Other ORGANON grown trees (PY, RC, WH, BM, RA, PM, GC, DG, TO, CL, WO, BO, WI) use equation {4.7.2.18}, based on ORGANON height – diamater equations.

{4.7.2.17} ORGANON 5-year height growth for major conifer species

HG=PHTGRO*MODIFER*CRADJ

where:

PHTGRO=(4.5+(HT-4.5)*(XAI5/XAI))-HT) if AIA is less than 0, PHTGRO=0.

XAI=1.0-EXP(-1.0*EXP(B0+B1*LOG(SI)+B2*LOG(GEAGE)))

XAI5=1.0-EXP((-1.)*EXP(B0+B1*LOG(SI)+B2*LOG(GEAGE+5.)))

GEAGE=((-1.0*LOG(A1A))/(EXP(B0)*SI**B1))**(1.0/B2) if AIA is less than 0, GEAGE=500

A1A=1.0-(HT-4.5)*((1.0-EXP((-1.)*EXP((B0+B1*LOG(SI))+ B2*3.912023)))/SI)

MODIFER=P8*((P1*EXP(P2*TCCH))+((EXP(P3*TCCH**P4))-(EXP(P3*TCCH**P4))*EXP((-P5*(1.0-CR)**P6)*EXP(P7*TCCH**0.5)))

CRADJ=(1.0-EXP(-(25.0*CR)**2))

HG is predicted 5-year height growth
HT is height of the tree
SI is site index (Hann and Scrivani)
B_0 – B_2, P_1 – P_8 are coefficients in table 4.7.2.3

{4.7.2.18} ORGANON 5-year height growth for non-major species

HG= HT*((PRDHT2/ PRDHT1)-1)

where:

PRDHT1=4.5+EXP(X1+X2*DBH**X3)

PRDHT2=4.5+EXP(X1+X2*(DBH+DG)**X3)

HG is predicted 5-year height growth
HT is height of the tree
DBH is diameter of tree
DG is predicted 5-year diameter growth for the tree
X_1 – X_3 are coefficients shown in table 4.1.1

Table 4.7.2.3 Coefficients (B_0 – B_2, P_1 – P_8) for the major conifers species height-growth equations in ORGANON, OC variant

species	P1	P2	P3	P4	P5	P6	P7	P8	B0	B1	B2
DF	1	-0.02458	-0.00407	1	2.895563	2	0	1	-6.21693	0.281176	1.14354
GF	1	-0.01453	-0.00407	1	7.690236	2	0	1	-6.54707	0.288169	1.21297
PP	1	-0.1489	-0.00323	1	0.920718	2	0	1	-6.54707	0.288169	1.21297
SP	1	-0.1489	-0.00679	1	0.920718	2	0	1	-6.54707	0.288169	1.21297
IC	1	-0.01453	-0.00637	1	1.272286	2	0	1	-6.54707	0.288169	1.21297

5.0 Mortality Model

If there are valid ORGANON tree records in the tree list for a cycle, then all trees get mortality estimates using equations developed for ORGANON (Hann et al 2003, Hann and Hanus 2001 or Gould and Harrington 2008) with surrogate assignments for non-valid ORGANON tree records as shown in section 1.1. If all tree records for the projection cycle are non-valid ORGANON tree records, then all trees get mortality estimates using equations developed for the FVS CA variant.

For ORGANON, the annual mortality rate estimate, *RA*, predicts individual tree mortality based on trees size, stand density and other tree and stand attributes. The equations used to calculate the mortality rate are shown in equations 5.0.1 and 5.0.2.

{5.0.1} Mortality Equations:

$$DBH \geq 3.0'' \text{:}\quad RA=1-[((1-(1/(1+\exp(-Z))))^{0.2})*CRADJ]$$

For white oak:

$$Z= d_0 + d_1*DBH + d_2*DBH^2 + d_3*CR +*(XSITE1+4.5) + d_5*ALOG(BAL+5.0)$$

For all other species:

$$Z= d_0 + d_1*DBH + d_2*DBH^2 + d_3*CR + d_4*(XSITE2+4.5) + d_5*BAL + d_6*BAL*\exp(d_7*OG)$$

where:

RA	is the estimated annual mortality rate
DBH	is tree diameter at breast height
BAL	is total basal area in trees larger
CR	is crown ratio
CRADJ	crown adjustment =1.0-exp(-(25.0*CR)^2)
XSITE1	Douglas-fir site index
XSITE2	Ponderosa Pine site index
d_{0-7}	are species-specific coefficients shown in table 5.0.1

The annual mortality rates are adjusted for the length of cycle using a compound interest formula (Hamilton 1976), and then applied to each tree record.

{5.0.2} $RT = 1 – (1 – RA)^Y$

where:

RT	is the mortality rate applied to an individual tree record for the growth period
RA	is the annual mortality rate for the tree record
Y	is length of the current projection cycle in years

Table 5.0.1 Coefficients used in the individual tree mortality equation {5.0.1} in the OC variant.

Species	d0	d1	d2	d3	d4	d5	d6	d7	d8
PC	-0.76161	-0.52937	0	-4.74019	0.011959	0.007564	0	0	-5.4
IC	-1.92269	-0.13608	0.00248	-3.17812	0	0.004684	0	0	-2.2
RC	-0.76161	-0.52937	0	-4.74019	0.011959	0.007564	0	0	-5.4
GF	-2.21578	-0.1629	0.003317	-3.56144	0.014645	0	0	0	1
RF	-4.64848	-0.26656	0.003699	-2.11803	0.025499	0.003361	0.013554	-2.72347	1
SH	-4.64848	-0.26656	0.003699	-2.11803	0.025499	0.003361	0.013554	-2.72347	1
DF	-4.64848	-0.26656	0.003699	-2.11803	0.025499	0.003361	0.013554	-2.72347	1
WH	-1.16621	0	0	-4.60267	0	0	0	0	-3.8
MH	-1.16621	0	0	-4.60267	0	0	0	0	-3.8
WB	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
KP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
LP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
CP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
LM	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
JP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
SP	-1.53105	0	0	0	0	0	0	0	1
WP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
PP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
MP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
GP	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
WJ	-4.07278	-0.17643	0	-1.72945	0	0.012526	0	0	-7
BR	-2.21578	-0.1629	0.003317	-3.56144	0.014645	0	0	0	1

GS	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1
PY	-4.07278	-0.17643	0	-1.72945	0	0.012526	0	0	-7
OS	-4.07278	-0.17643	0	-1.72945	0	0.012526	0	0	-7
LO	-2.99045	0	0	0	0	0.002885	0	0	-13.4
CY	-2.99045	0	0	0	0	0.002885	0	0	-13.4
BL	-2.99045	0	0	0	0	0.002885	0	0	-13.4
EO	-2.99045	0	0	0	0	0.002885	0	0	-13.4
WO	-6.00031	-0.10491	0	-0.99542	0.009127	0.871157	0	0	-16.6
BO	-3.10862	-0.57037	0.018205	-4.58466	0.014926	0.012419	0	0	-18.2
VO	-2.99045	0	0	0	0	0.002885	0	0	-13.4
IO	-2.99045	0	0	0	0	0.002885	0	0	-13.4
BM	-2.97682	0	0	-6.22325	0	0	0	0	-15
BU	-2.97682	0	0	-6.22325	0	0	0	0	-15
RA	-2	-0.5	0.015	-3	0.015	0.01	0	0	-19.8
MA	-6.0896	-0.24562	0	-3.20827	0.033348	0.013571	0	0	-8.6
GC	-4.31755	-0.0577	0	0	0.004861	0.009981	0	0	-10.2
DG	-3.02035	0	0	-8.46788	0.013966	0.009462	0	0	-21.4
FL	-2.97682	0	0	-6.22325	0	0	0	0	-15
WN	-2.97682	0	0	-6.22325	0	0	0	0	-15
TO	-2.41076	0	0	-1.04935	0.008846	0	0	0	-11.8
SY	-2.97682	0	0	-6.22325	0	0	0	0	-15
AS	-2.97682	0	0	-6.22325	0	0	0	0	-15
CW	-2.97682	0	0	-6.22325	0	0	0	0	-15

WI	-1.38629	0	0	0	0	0	0	0	-23
CN	-3.02035	0	0	-8.46788	0.013966	0.009462	0	0	-21.4
CL	-3.02035	0	0	-8.46788	0.013966	0.009462	0	0	-21.4
OH	-3.02035	0	0	-8.46788	0.013966	0.009462	0	0	-21.4
RW	-1.05	-0.19436	0.003803	-3.5573	0.003972	0.005574	0	0	1

If all tree records for the projection cycle are non-valid ORGANON tree records, then the OC 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 {5.0.3}, and this is then adjusted to the length of the cycle by using a compound interest formula as shown in equation {5.0.4}. Species mapping and coefficients for these equations are shown in tables 5.0.2 and 5.0.3. The overall amount of mortality calculated for the stand is the summation of the final mortality rate (*RIP*) across all live tree records.

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

{5.0.4} $RIP = 1 – (1 – RI)^Y$

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 5.0.2

Table 5.0.2 Mapped species index for each species for the mortality model in the OC variant.

Species Code	Species Index
PC	3
IC	3
RC	3
GF	3

Species Code	Species Index
LO	3
CY	3
BL	3
EO	3

Species Code	Species Index
RF	3
SH	3
DF	2
WH	4
MH	4
WB	1
KP	1
LP	5
CP	1
LM	1
JP	6
SP	1
WP	1
PP	6
MP	6
GP	6
WJ	3
BR	4
GS	7
PY	3
OS	3
WO	3
BO	3
VO	3
IO	3
BM	3
BU	3
RA	3
MA	3
GC	3
DG	3
FL	3
WN	3
TO	3
SY	3
AS	3
CW	3
WI	3
CN	3
CL	3
OH	3
RW	7

Table 5.0.3 Coefficients used in the background mortality equation {5.0.3} in the OC variant.

Species Index	p_0	p_1
1	6.5112	-0.00525
2	7.2985	-0.01291
3	5.1677	-0.00777
4	9.6943	-0.01273
5	5.9617	-0.03401
6	5.5877	-0.00535
7	2.5968	0.51261

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 {5.0.5}. 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 {5.0.6}.

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.

{5.0.5} $MR = 0.84525 - (0.01074 * PCT) + (0.0000002 * PCT^3)$

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

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 5.0.4

Table 5.0.4 *MWT* values for the mortality equation {5.0.6} in the OC variant.

Species Code	*MWT*
PC	0.6
IC	0.6
RC	0.6
GF	0.55
RF	0.5
SH	0.5
DF	0.65
WH	0.65
MH	0.75
WB	0.9
KP	0.9
LP	0.9
CP	1.1
LM	0.9
JP	0.85
SP	0.7
WP	0.75
PP	0.85
MP	0.85
GP	1.1
WJ	1.1
BR	0.65
GS	0.8
PY	0.55
LO	1.0
CY	1.0
BL	1.0
EO	1.0
WO	1.0
BO	1.0
VO	1.0
IO	1.0
BM	0.8
BU	0.8
RA	1.0
MA	0.8
GC	0.8
DG	0.8
FL	0.8
WN	0.8
TO	0.55
SY	0.8
AS	0.8
CW	0.8
WI	1.0
CN	1.0
CL	1.0
OH	1.0

Species Code	*MWT*
OS	0.65

Species Code	*MWT*
RW	0.8

6.0 Regeneration

The OC 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 OC variant.

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
PC	No	0.2	0.5	20.0
IC	No	0.2	0.5	20.0
RC	No	0.2	0.3	20.0
GF	No	0.2	0.8	20.0
RF	No	0.2	0.8	20.0
SH	No	0.2	0.8	20.0
DF	No	0.2	0.8	20.0
WH	No	0.2	0.3	20.0
MH	No	0.2	0.5	20.0
WB	No	0.5	1.2	20.0
KP	No	0.5	1	20.0
LP	No	0.4	1	20.0
CP	No	0.5	1	20.0
LM	No	0.5	1	20.0
JP	No	0.5	1	20.0
SP	No	0.5	0.8	20.0
WP	No	0.3	0.8	20.0
PP	No	0.5	1	20.0
MP	No	0.5	0.8	20.0
GP	No	0.5	1.2	20.0
WJ	No	0.3	1	20.0
BR	No	0.3	0.5	20.0

Species Code	Sprouting Species	Minimum Bud Width (in)	Minimum Tree Height (ft)	Maximum Tree Height (ft)
GS	No	0.3	1	20.0
PY	Yes	0.3	0.3	20.0
OS	No	0.3	0.8	20.0
LO	Yes	0.2	1	20.0
CY	Yes	0.2	0.5	20.0
BL	Yes	0.2	1	20.0
EO	Yes	0.2	1	20.0
WO	Yes	0.2	0.8	20.0
BO	Yes	0.2	1	20.0
VO	Yes	0.2	0.8	20.0
IO	Yes	0.2	1	20.0
BM	Yes	0.2	0.5	20.0
BU	Yes	0.3	0.8	20.0
RA	Yes	0.1	0.8	20.0
MA	Yes	0.1	0.5	20.0
GC	Yes	0.2	0.8	20.0
DG	Yes	0.1	0.5	20.0
FL	Yes	0.3	0.8	20.0
WN	Yes	0.4	1	20.0
TO	Yes	0.2	0.5	20.0
SY	Yes	0.2	1	20.0
AS	Yes	0.1	1.2	20.0
CW	Yes	0.1	1.2	20.0
WI	Yes	0.1	1	20.0
CN	Yes	0.2	0.3	20.0
CL	Yes	0.2	0.5	20.0
OH	No	0.2	0.75	20.0
RW	Yes	0.3	1	20.0

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

Users wanting to modify or turn off automatic sprouting can do so with the SPROUT or NOSPROUT keywords, respectively. Sprouts are not subject to maximum and minimum tree heights found in table 6.0.1 and do not need to be grown to the end of the cycle because estimated heights and diameters are end of cycle values.

{6.0.1} For stump sprouting hardwood species

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

{6.0.2} For root suckering hardwood species

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

{6.0.3} $TPA_s = TPA_i * PS$

{6.0.4} $PS = ((70.7857 - 2.6071 * DSTMP_i) / 100)$

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

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

{6.0.7} $PS = ((93.2669 - 0.4303 * DSTMP_i) / 100)$

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 CA variant.

Species Code	Sprouting Probability	Number of Sprout Records	Source
PY	0.4	1	Minore 1996 Ag. Handbook 654
LO	0.5	{6.0.1}	See canyon live oak (CY)
CY	0.5	{6.0.1}	Conard 1987 Thornburgh 1990 Paysen et al. 1991
BL	{6.0.4}	{6.0.1}	McCreary et al. 2000 Standiford et al. 2011
EO	0.9	{6.0.1}	Caprio and Zwolinski 1992 Howard 1992
WO	0.9	{6.0.1}	Roy 1955 Gucker 2007

BO	0.9	{6.0.1}	McDonald 1978 McDonald 1990
VO	0.9	{6.0.1}	Howard 1992
IO	0.5	{6.0.1}	See canyon live oak (CY)
BM	0.9	{6.0.2}	Roy 1955 Tappenier et al. 1996 Ag. Handbook 654
BU	0.8	{6.0.1}	Howard 1992
RA	{6.0.5}	1	Harrington 1984 Uchytil 1989
MA	0.9	{6.0.2}	McDonald et al. 1983 McDonald and Tappenier 1990
GC	0.9	{6.0.2}	Harrington et al. 1992 Meyer 2012
DG	0.9	{6.0.1}	Gucker 2005
FL	0.8	{6.0.1}	Sterrett 1915 Ag. Handbook 654
WN	0.8 for DBH < 8”, 0.5 for DBH > 8”	1	Schlesinger 1977 Schlesinger 1989
TO	0.9	{6.0.2}	Harrington et al. 1992 Wilkinson et al. 1997 Fryer 2008
SY	0.7	1	Davis et al. 1989 Esser 1993
AS	{6.0.6}	2	Keyser 2001
CW	0.9	{6.0.2}	Gom and Rood 2000 Steinberg 2001
WI	0.9	1	Ag. Handbook 654
CN	0.8	1	Burke 1975 Howard 1992
CL	0.9	{6.0.2}	Paysen et al. 1991 Ag. Handbook 654
RW	{6.0.7}	{6.0.2}	Neal 1967 Boe 1975 Griffith 1992

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 OC variant, volume is calculated for three merchantability standards: total stem cubic feet, merchantable stem cubic feet, and merchantable stem board feet (Scribner (R6 and BLM)). 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 OC variant are shown in tables 7.0.1-7.0.4.

Table 7.0.1 Volume merchantability standards for the OC variant.

Merchantable Cubic Foot Volume Specifications:		
Minimum DBH / Top Diameter	KP	All Other Species
Region 5	6.0 / 6.0 inches	7.0 / 6.0 inches
Region 6 and BLM	6.0 / 4.5 inches	7.0 / 4.5 inches
Stump Height	1.0 foot	1.0 foot
Merchantable Board Foot Volume Specifications:		
Minimum DBH / Top Diameter	KP	All Other Species
Region 5	6.0 / 6.0 inches	7.0 / 6.0 inches
Region 6 and BLM	6.0 / 4.5 inches	7.0 / 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 in the OC variant.

Common Name	Location Code	Equation Number	Reference
Port Orford cedar	505, 506, 508, 511, 514	500WO2W081	Wensel and Olsen Profile Model
Port Orford cedar	610, 611	616BEHW000	Behre's Hyperbola
Port Orford cedar	710, 711, 712	B00BEHW081	Behre's Hyperbola
incense cedar	505, 506, 508, 511, 514	500WO2W081	Wensel and Olsen Profile Model
incense cedar	610, 611	616BEHW081	Behre's Hyperbola
incense cedar	710, 711, 712	B00BEHW081	Behre's Hyperbola
western redcedar	505, 506, 508, 511, 514	500WO2W081	Wensel and Olsen Profile Model
western redcedar	610, 611	616BEHW242	Behre's Hyperbola
western redcedar	710, 711, 712	B00BEHW242	Behre's Hyperbola
white fir	505, 506, 508, 511, 514	500WO2W015	Wensel and Olsen Profile Model
white fir	610, 611	I00FW2W093	Flewelling's 2-Point Profile Model
white fir	710, 711, 712	B00BEHW015	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
California red fir	505, 506, 508, 511, 514	500WO2W020	Wensel and Olsen Profile Model
California red fir	610, 611	616BEHW020	Behre's Hyperbola
California red fir	710, 711, 712	B00BEHW021	Behre's Hyperbola
Shasta red fir	505, 506, 508, 511, 514	500WO2W020	Wensel and Olsen Profile Model
Shasta red fir	610, 611	616BEHW021	Behre's Hyperbola
Shasta red fir	710, 711, 712	B00BEHW021	Behre's Hyperbola
Douglas-fir	505, 506, 508, 511, 514	500WO2W202	Wensel and Olsen Profile Model
Douglas-fir	610, 611	F06FW2W202	Flewelling's 2-Point Profile Model
Douglas-fir	710, 711	B01BEHW202	Behre's Hyperbola
Douglas-fir	712	B02BEHW202	Behre's Hyperbola
western hemlock	505, 506, 508, 511, 514	500WO2W015	Wensel and Olsen Profile Model
western hemlock	610, 611	616BEHW263	Behre's Hyperbola
western hemlock	710, 711, 712	B00BEHW263	Behre's Hyperbola
mountain hemlock	505, 506, 508, 511, 514	500WO2W015	Wensel and Olsen Profile Model
mountain hemlock	610, 611	616BEHW264	Behre's Hyperbola
mountain hemlock	710, 711, 712	B00BEHW260	Behre's Hyperbola
whitebark pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
whitebark pine	610, 611	616BEHW101	Behre's Hyperbola
whitebark pine	710, 711, 712	B00BEHW119	Behre's Hyperbola
knobcone pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
knobcone pine	610, 611	616BEHW103	Behre's Hyperbola
knobcone pine	710, 711, 712	B00BEHW108	Behre's Hyperbola
lodgepole pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
lodgepole pine	610, 611	616BEHW108	Behre's Hyperbola
lodgepole pine	710, 711, 712	B00BEHW108	Behre's Hyperbola
Coulter pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
Coulter pine	610, 611	616BEHW000	Behre's Hyperbola
Coulter pine	710, 711, 712	B00BEHW108	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
limber pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
limber pine	610, 611	616BEHW113	Behre's Hyperbola
limber pine	710, 711, 712	B00BEHW108	Behre's Hyperbola
Jeffrey pine	505, 506, 508,511, 514	500WO2W116	Wensel and Olsen Profile Model
Jeffrey pine	610, 611	616BEHW116	Behre's Hyperbola
Jeffrey pine	710, 711, 712	B00BEHW116	Behre's Hyperbola
sugar pine	505, 506, 508, 511, 514	500WO2W117	Wensel and Olsen Profile Model
sugar pine	610, 611	616BEHW117	Behre's Hyperbola
sugar pine	710, 711, 712	B00BEHW117	Behre's Hyperbola
western white pine	505, 506, 508, 511, 514	500WO2W117	Wensel and Olsen Profile Model
western white pine	610, 611	616BEHW119	Behre's Hyperbola
western white pine	710, 711, 712	B00BEHW119	Behre's Hyperbola
ponderosa pine	505, 506, 508, 511, 514	500WO2W122	Wensel and Olsen Profile Model
ponderosa pine	610, 611	I00FW2W073	Flewelling's 2-Point Profile Model
ponderosa pine	710, 711, 712	B00BEHW122	Behre's Hyperbola
Monterey pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
Monterey pine	610, 611	616BEHW000	Behre's Hyperbola
Monterey pine	710, 711, 712	B00BEHW108	Behre's Hyperbola
California foothill pine	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
California foothill pine	610, 611	616BEHW000	Behre's Hyperbola
California foothill pine	710, 711, 712	B00BEHW108	Behre's Hyperbola
western juniper	505, 506, 508, 511, 514	500DVEW060	Pillsbury and Kirkley Equations
western juniper	610, 611	616BEHW064	Pillsbury and Kirkley Equations
western juniper	710, 711, 712	B00BEHW242	Behre's Hyperbola
Brewer spruce	505, 506, 508, 511, 514	500WO2W015	Wensel and Olsen Profile Model
Brewer spruce	610, 611	616BEHW000	Behre's Hyperbola
Brewer spruce	710, 711, 712	B00BEHW093	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
giant sequoia	505, 506, 508, 511, 514	500DVEW212	Pillsbury and Kirkley Equations
giant sequoia	610, 611	616BEHW000	Behre's Hyperbola
giant sequoia	710, 711, 712	B00BEHW211	Behre's Hyperbola
Pacific yew	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
Pacific yew	610, 611	616BEHW231	Behre's Hyperbola
Pacific yew	710, 711, 712	B00BEHW231	Behre's Hyperbola
other softwood	505, 506, 508, 511, 514	500WO2W108	Wensel and Olsen Profile Model
other softwood	610, 611	616BEHW299	Behre's Hyperbola
other softwood	710, 711, 712	B00BEHW999	Behre's Hyperbola
coast live oak	505, 506, 508, 511, 514	500DVEW801	Pillsbury and Kirkley Equations
coast live oak	610, 611	616BEHW000	Behre's Hyperbola
coast live oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
canyon live oak	505, 506, 508, 511, 514	500DVEW805	Pillsbury and Kirkley Equations
canyon live oak	610, 611	616BEHW000	Behre's Hyperbola
canyon live oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
blue oak	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
blue oak	610, 611	616BEHW000	Behre's Hyperbola
blue oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
Engelmann oak	505, 506, 508, 511, 514	500DVEW811	Pillsbury and Kirkley Equations
Engelmann oak	610, 611	616BEHW000	Behre's Hyperbola
Engelmann oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
Oregon white oak	505, 506, 508, 511, 514	500DVEW815	Pillsbury and Kirkley Equations
Oregon white oak	610, 611	616BEHW815	Behre's Hyperbola
Oregon white oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
California black oak	505, 506, 508, 511, 514	500DVEW818	Pillsbury and Kirkley Equations
California black oak	610, 611	616BEHW818	Behre's Hyperbola
California black oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
valley oak	505, 506, 508, 511, 514	500DVEW821	Pillsbury and Kirkley Equations
valley oak	610, 611	616BEHW000	Behre's Hyperbola

Common Name	Location Code	Equation Number	Reference
valley oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
interior live oak	505, 506, 508, 511, 514	500DVEW839	Pillsbury and Kirkley Equations
interior live oak	610, 611	616BEHW000	Behre's Hyperbola
interior live oak	710, 711, 712	B00BEHW800	Behre's Hyperbola
bigleaf maple	505, 506, 508, 511, 514	500DVEW312	Pillsbury and Kirkley Equations
bigleaf maple	610, 611	616BEHW312	Behre's Hyperbola
bigleaf maple	710, 711, 712	B00BEHW312	Behre's Hyperbola
California buckeye	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
California buckeye	610, 611	616BEHW000	Behre's Hyperbola
California buckeye	710, 711, 712	B00BEHW800	Behre's Hyperbola
red alder	505, 506, 508, 511, 514	500DVEW351	Pillsbury and Kirkley Equations
red alder	610, 611	616BEHW351	Behre's Hyperbola
red alder	710, 711, 712	B00BEHW351	Behre's Hyperbola
Pacific madrone	505, 506, 508, 511, 514	500DVEW361	Pillsbury and Kirkley Equations
Pacific madrone	610, 611	616BEHW361	Behre's Hyperbola
Pacific madrone	710, 711, 712	B00BEHW361	Behre's Hyperbola
giant chinquapin	505, 506, 508, 511, 514	500DVEW431	Pillsbury and Kirkley Equations
giant chinquapin	610, 611	616BEHW431	Behre's Hyperbola
giant chinquapin	710, 711, 712	B00BEHW431	Behre's Hyperbola
Pacific dogwood	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
Pacific dogwood	610, 611	616BEHW492	Behre's Hyperbola
Pacific dogwood	710, 711, 712	B00BEHW999	Behre's Hyperbola
Oregon ash	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
Oregon ash	610, 611	616BEHW000	Behre's Hyperbola
Oregon ash	710, 711, 712	B00BEHW312	Behre's Hyperbola
walnut	505, 506, 508, 511, 514	500DVEW818	Pillsbury and Kirkley Equations
walnut	610, 611	616BEHW000	Behre's Hyperbola
walnut	710, 711, 712	B00BEHW999	Behre's Hyperbola
tanoak	505, 506, 508, 511, 514	500DVEW631	Pillsbury and Kirkley Equations

Common Name	Location Code	Equation Number	Reference
tanoak	610, 611	616BEHW631	Behre's Hyperbola
tanoak	710, 711, 712	B00BEHW631	Behre's Hyperbola
California sycamore	505, 506, 508, 511, 514	500DVEW818	Pillsbury and Kirkley Equations
California sycamore	610, 611	616BEHW000	Behre's Hyperbola
California sycamore	710, 711, 712	B00BEHW800	Behre's Hyperbola
quaking aspen	505, 506, 508, 511, 514	500DVEW818	Pillsbury and Kirkley Equations
quaking aspen	610, 611	616BEHW746	Behre's Hyperbola
quaking aspen	710, 711, 712	B00BEHW999	Behre's Hyperbola
black cottonwood	505, 506, 508, 511, 514	500DVEW818	Pillsbury and Kirkley Equations
black cottonwood	610, 611	616BEHW747	Behre's Hyperbola
black cottonwood	710, 711, 712	B00BEHW747	Behre's Hyperbola
willow	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
willow	610, 611	616BEHW920	Behre's Hyperbola
willow	710, 711, 712	B00BEHW999	Behre's Hyperbola
California nutmeg	505, 506, 508, 511, 514	500DVEW807	Pillsbury and Kirkley Equations
California nutmeg	610, 611	616BEHW000	Behre's Hyperbola
California nutmeg	710, 711, 712	B00BEHW231	Behre's Hyperbola
California laurel	505, 506, 508, 511, 514	500DVEW981	Pillsbury and Kirkley Equations
California laurel	610, 611	616BEHW000	Behre's Hyperbola
California laurel	710, 711, 712	B00BEHW631	Behre's Hyperbola
other hardwoods	505, 506, 508, 511, 514	500DVEW801	Pillsbury and Kirkley Equations
other hardwoods	610, 611	616BEHW998	Behre's Hyperbola
other hardwoods	710, 711, 712	B00BEHW999	Behre's Hyperbola
redwood	505, 506, 508, 511, 514	500WO2W211	Wensel and Olsen Profile Model
redwood	610, 611	616BEHW211	Behre's Hyperbola
redwood	710, 711, 712	B00BEHW211	Behre's Hyperbola

Table 7.0.3 Citations by Volume Model in the OC variant

Model Name	Citation
Behre's Hyperbola	USFS-R6 Sale Preparation and Valuation Section of Diameter and Volume Procedures - R6 Timber Cruise System. 1978.
Flewelling 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.

Table 7.0.4 Species-specific default form class values for the OC variant.

Species Code	Behre's Hyperbola Equation Number	Form Class				
		0<DBH<11	11<=DBH<21	21<=DBH<31	31<=DBH<41	DBH>=41
Rogue River NF (610)						
PC	616BEHW000	95	82	76	74	74
IC	616BEHW081	94	94	78	75	74
RC	616BEHW242	95	82	76	75	74
GF*	616BEHW017	96	91	84	83	82
RF	616BEHW020	95	82	76	74	74
SH	616BEHW021	94	90	84	82	81
DF*	616BEHW202	94	87	82	81	81
WH	616BEHW263	91	82	79	78	78
MH	616BEHW264	96	83	79	77	76
WB	616BEHW101	92	92	92	92	87
KP	616BEHW103	95	79	78	78	78
LP	616BEHW108	95	79	78	78	76
CP	616BEHW000	95	95	95	82	82
LM	616BEHW113	95	95	95	82	82
JP	616BEHW116	93	93	86	83	81
SP	616BEHW117	94	90	84	82	82
WP	616BEHW119	94	87	83	82	81
PP*	616BEHW122	93	93	83	81	80
MP	616BEHW000	95	82	79	78	78

Species Code	Behre's Hyperbola Equation Number	Form Class				
		0<DBH<11	11<=DBH<21	21<=DBH<31	31<=DBH<41	DBH>=41
GP	616BEHW000	95	95	82	79	78
WJ	616BEHW064	95	95	95	95	95
BR	616BEHW000	93	89	86	84	84
GS	616BEHW000	95	82	76	74	74
PY	616BEHW231	98	98	98	98	88
OS	616BEHW298	95	95	82	79	78
LO	616BEHW000	95	95	86	82	82
CY	616BEHW000	94	94	85	80	80
BL	616BEHW000	95	95	95	86	86
EO	616BEHW000	95	95	95	86	86
WO	616BEHW815	89	89	89	89	89
BO	616BEHW818	98	88	84	81	81
VO	616BEHW000	95	79	78	76	76
IO	616BEHW000	95	95	95	95	95
BM	616BEHW312	98	84	81	80	79
BU	616BEHW000	95	95	95	95	95
RA	616BEHW351	98	84	81	80	80
MA	616BEHW361	95	86	82	79	79
GC	616BEHW431	95	86	78	76	75
DG	616BEHW492	94	94	85	80	80
FL	616BEHW000	98	88	81	81	80
WN	616BEHW000	95	95	86	82	82
TO	616BEHW631	98	88	80	78	77
SY	616BEHW000	95	95	95	95	95
AS	616BEHW746	98	98	98	98	98
CW	616BEHW747	98	80	78	77	77
WI	616BEHW920	98	98	98	98	98
CN	616BEHW000	95	95	95	95	95
CL	616BEHW000	95	86	82	79	78
OH	616BEHW998	95	95	95	95	95
RW	616BEHW211	82	82	79	78	78
Siskiyou NF (611)						
PC	616BEHW000	94	90	84	82	81
IC	616BEHW081	89	89	75	71	71
RC	616BEHW242	96	83	78	76	76

Species Code	Behre's Hyperbola Equation Number	Form Class				
		0<DBH<11	11<=DBH<21	21<=DBH<31	31<=DBH<41	DBH>=41
GF*	616BEHW017	93	93	86	85	85
RF	616BEHW020	92	87	82	80	79
SH	616BEHW021	96	96	90	87	87
DF*	616BEHW202	93	86	81	80	80
WH	616BEHW263	93	93	90	89	88
MH	616BEHW264	93	89	84	82	81
WB	616BEHW101	91	91	91	91	86
KP	616BEHW103	96	88	86	86	86
LP	616BEHW108	96	88	86	86	85
CP	616BEHW000	91	91	91	86	86
LM	616BEHW113	91	91	91	86	86
JP	616BEHW116	93	93	86	83	81
SP	616BEHW117	96	91	85	84	83
WP	616BEHW119	96	88	84	83	82
PP*	616BEHW122	93	93	83	81	80
MP	616BEHW000	91	86	84	82	82
GP	616BEHW000	91	91	86	84	82
WJ	616BEHW064	91	91	91	91	91
BR	616BEHW000	93	89	86	84	84
GS	616BEHW000	91	86	81	79	78
PY	616BEHW231	88	88	88	88	80
OS	616BEHW298	91	91	86	84	82
LO	616BEHW000	95	95	86	82	82
CY	616BEHW000	95	95	86	82	82
BL	616BEHW000	95	95	95	86	86
EO	616BEHW000	95	95	95	86	86
WO	616BEHW815	95	95	95	95	95
BO	616BEHW818	98	88	84	81	81
VO	616BEHW000	95	79	78	76	76
IO	616BEHW000	95	95	95	95	95
BM	616BEHW312	98	84	81	80	79
BU	616BEHW000	95	95	95	95	95
RA	616BEHW351	91	86	84	82	82
MA	616BEHW361	98	88	84	81	81
GC	616BEHW431	95	86	78	76	75

Species Code	Behre's Hyperbola Equation Number	Form Class				
		0<DBH<11	11<=DBH<21	21<=DBH<31	31<=DBH<41	DBH>=41
DG	616BEHW492	98	98	88	84	84
FL	616BEHW000	98	88	81	81	80
WN	616BEHW000	95	95	86	82	82
TO	616BEHW631	91	91	82	80	79
SY	616BEHW000	95	95	95	95	95
AS	616BEHW746	95	95	95	95	95
CW	616BEHW747	92	83	81	80	80
WI	616BEHW920	92	92	92	92	92
CN	616BEHW000	95	95	95	95	95
CL	616BEHW000	95	86	82	79	78
OH	616BEHW998	95	95	95	95	95
RW	616BEHW211	82	82	79	78	78

*Species whose default volume equation at this location code is not Behre's Hyperbola (see Table 7.0.2).

BLM Locations:		**710**	**711**	**712**
PC	B00BEHW081	73	70	70
IC	B00BEHW081	86	78	78
RC	B00BEHW242	80	78	78
GF	B00BEHW017	87	91	91
RF	B00BEHW021	76	78	75
SH	B00BEHW021	76	78	75
DF	B02BEHW202	89	87	87
WH	B00BEHW263	91	91	92
MH	B00BEHW260	76	70	72
WB	B00BEHW119	80	73	80
KP	B00BEHW108	80	68	80
LP	B00BEHW108	80	68	80
CP	B00BEHW108	80	68	80
LM	B00BEHW108	80	68	80
JP	B00BEHW116	80	70	75
SP	B00BEHW117	91	84	91
WP	B00BEHW119	80	76	80
PP	B00BEHW122	88	85	88
MP	B00BEHW108	80	68	80
GP	B00BEHW108	80	68	80
WJ	B00BEHW242	76	70	60

BLM Locations:		**710**	**711**	**712**
BR	B00BEHW093	76	74	76
GS	B00BEHW211	76	70	75
PY	B00BEHW231	76	76	70
OS	B00BEHW999	76	70	74
LO	B00BEHW800	80	80	80
CY	B00BEHW800	80	80	80
BL	B00BEHW800	80	80	80
EO	B00BEHW800	80	80	80
WO	B00BEHW800	80	80	80
BO	B00BEHW800	80	80	80
VO	B00BEHW800	80	80	80
IO	B00BEHW800	80	80	80
BM	B00BEHW312	84	84	84
BU	B00BEHW800	80	80	80
RA	B00BEHW351	88	88	91
MA	B00BEHW361	81	81	86
GC	B00BEHW431	83	83	86
DG	B00BEHW999	83	83	83
FL	B00BEHW312	84	84	84
WN	B00BEHW999	83	83	83
TO	B00BEHW631	84	84	86
SY	B00BEHW800	80	80	80
AS	B00BEHW999	76	72	75
CW	B00BEHW747	76	72	74
WI	B00BEHW999	75	75	75
CN	B00BEHW231	76	76	70
CL	B00BEHW631	84	84	86
OH	B00BEHW999	76	70	74
RW	B00BEHW211	75	75	75

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 OC variant, refer to the CA variant details in the updated FFE-FVS model documentation (Rebain, comp. 2010) available on the FVS website.

9.0 Insect and Disease Extensions

The FVS Insect and Pathogen model for dwarf mistletoe has been developed for the base variant of the OC variant through the participation and contribution of various organizations led by Forest Health Protection. This model is currently maintained by the Forest Management Service Center and regional Forest Health Protection specialists. Additional details regarding this 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: Plant Association Codes

Table 11.1.2 Region 6 plant association codes recognized in the OC variant.

FVS Sequence Number = Plant Association Description	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
407 = PSME-ABCO-PIJE Douglas-fir-white fir-Jeffrey pine	CDC411	DF	85	899	H	Aztet and Wheeler (1984)
408 = PSME-ABCO-PIPO Douglas-fir-white fir-ponderosa pine	CDC412	DF	87	1155	H	Aztet and Wheeler (1984)
409 = PSME-ABCO Douglas-fir-white fir	CDC421	DF	72	720	C	Aztet and Wheeler (1984)
410 = PSME-ABCO/HODI Douglas-fir-white fir/creambush oceanspray	CDC431	DF	96	765	C	Aztet and Wheeler (1984)
411 = PSME-ABCO/BENE Douglas-fir-white fir/dwarf Oregongrape	CDC432	DF	93	1193	H	Aztet and Wheeler (1984)
412 = PSME-PIPO Douglas-fir-ponderosa pine	CDC511	DF	101	735	C	Aztet and Wheeler (1984)
413 = PSME-PIJE Douglas-fir-Jeffrey pin	CDC521	DF	71	595	C	Aztet and Wheeler (1984)
414 = PSME/DEPAUPERATE Douglas-fir/depauperate	CDF911	DF	70	670	C	Aztet and Wheeler (1984)
415 = PSME-LIDE3/GASH Douglas-fir-tanoak/salal	CDH111	DF	86	845	H	Aztet and Wheeler (1984)
416 = PSME/RHMA Douglas-fir/Pacific rhododendron	CDH112	DF	92	800	C	Aztet and Wheeler (1984)
417 = PSME-LIDE3-PILA Douglas-fir-tanoak-sugar pine	CDH121	DF	97	720	C	Aztet and Wheeler (1984)
418 = PSME-LIDE3 Douglas-fir-tanoak	CDH131	DF	81	1098	H	Aztet and Wheeler (1984)
419 = PSME-LIDE3-QUCH Douglas-fir-tanoak-canyon live oak	CDH141	DF	86	780	C	Aztet and Wheeler (1984)
420 = PSME-LIDE3/RHDI Douglas-fir-tanoak/poison oak	CDH142	DF	82	1050	C	Aztet and Wheeler (1984)
421 = PSME-QUSA Douglas-fir-Sadler oak	CDH511	DF	95	1087	H	Aztet and Wheeler (1984)
422 = PSME/RHDI-BEPI Douglas-fir/poison oak-Piper's Oregongrape	CDS111	DF	77	655	C	Aztet and Wheeler (1984)
423 = PSME/RHDI Douglas-fir/poison oak	CDS112	DF	67	630	C	Aztet and Wheeler (1984)
424 = PSME/BENE Douglas-fir/dwarf Oregongrape	CDS511	DF	93	635	C	Aztet and Wheeler (1984)
425 = PSME/BERE Douglas-fir/creeping Oregongrape	CDS521	DF	85	670	C	Aztet and Wheeler (1984)
426 = TSHE-CHLA Western hemlock-Port Orford cedar	CHC111	DF	117	1215	C	Aztet and Wheeler (1984)
427 = TSHE-THPL/HIGH ELEV Western hemlock-western redcedar/high elevation	CHC412	DF	108	945	C	Aztet and Wheeler (1984)
428 = TSHE-THPL Western hemlock-western redcedar	CHC461	DF	146	1105	C	Aztet and Wheeler (1984)
429 = TSHE-ABCO Western hemlock-white fir	CHC611	DF	119	890	C	Aztet and Wheeler (1984)
430 = TSHE-UMCA Western hemlock-California laurel	CHH111	DF	106	650	C	Aztet and Wheeler (1984)
431 = TSHE-QUSA Western hemlock-Sadler oak	CHH511	DF	108	1152	H	Aztet and Wheeler (1984)

FVS Sequence Number = Plant Association Description	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
432 = TSHE/GASH Western hemlock/salal	CHS131	DF	61	1050	C	Aztet and Wheeler (1984)
433 = TSHE/RHMA Western hemlock/Pacific rhododendron	CHS331	DF	102	1145	C	Aztet and Wheeler (1984)
434 = TSME/POPU Mountain hemlock/skunkleaf polemonium	CMF211	SH	74	555	C	Aztet and Wheeler (1984)
435 = PIPO-PSME Ponderosa pine-Douglas-fir	CPC411	DF	76	720	H	Aztet and Wheeler (1984)
436 = PIJE-PIMO Jeffrey pine-western white pine	CPC511	JP	52	420	C	Aztet and Wheeler (1984)
437 = PIJE/FEID Jeffrey pine/Idaho fescue	CPG141	JP	57	200	C	Aztet and Wheeler (1984)
438 = PIJE-QUVA Jeffrey pine-huckleberry oak	CPH411	JP	60	470	C	Aztet and Wheeler (1984)
439 = PIJE/CEPU Jeffrey pine/dwarf ceanothus	CPS321	JP	58	364	H	Aztet and Wheeler (1984)
440 = PIJE/GRASS Jeffrey pine/grass	CPS611	JP	57	340	H	Aztet and Wheeler (1984)
441 = PIMO/XETE Western white pine/beargrass	CQF111	WF	33	436	H	Aztet and Wheeler (1984)
442 = ABMAS/POPU Shasta red fir/skunkleaf polemonium	CRF211	SH	57	675	C	Aztet and Wheeler (1984)
443 = ABMAS/SHEEP Shasta red fir/sheep(grazing destroyed understory plants)	CRF311	SH	50	319	H	Aztet and Wheeler (1984)
444 = ABMAS-QUSA Shasta red fir-Sadler oak	CRH111	SH	81	470	C	Aztet and Wheeler (1984)
445 = ABMAS/SYMO Shasta red fir/creeping snowberry	CRS211	SH	91	755	C	Aztet and Wheeler (1984)
446 = CHLA-QUVA Port Orford cedar-huckleberry oak	CTH111	DF	87	1309	H	Aztet and Wheeler (1984)
447 = CHLA-ACMA Port Orford cedar-bigleaf maple	CTH211	DF	87	760	C	Aztet and Wheeler (1984)
448 = CHLA/BENE/ACTR Port Orford cedar/dwarf Oregongrape/vanillaleaf	CTS111	DF	85	1348	H	Aztet and Wheeler (1984)
449 = CHLA/BENE/LIBOL Port Orford cedar/dwarf Oregongrape/western twinflower	CTS112	DF	92	370	C	Aztet and Wheeler (1984)
450 = CHLA/GASH Port Orford cedar/salal	CTS211	DF	83	990	C	Aztet and Wheeler (1984)
451 = CHLA/GABU Port Orford cedar/box-leaved silktassle	CTS311	DF	87	660	C	Aztet and Wheeler (1984)
452 = ABCO-PSME White fir-Douglas-fir	CWC221	DF	92	815	C	Aztet and Wheeler (1984)
453 = ABCO-PSME/BENE White fir-Douglas-fir/dwarf Oregongrape	CWC231	DF	95	785	C	Aztet and Wheeler (1984)
454 = ABCO-PSME/HODI White fir-Douglas-fir/creambush oceanspray	CWC232	DF	89	675	C	Aztet and Wheeler (1984)
455 = ABCO-PSME/DEPAUPERATE White fir-Douglas-fir/depauperate	CWC233	DF	78	988	H	Aztet and Wheeler (1984)
456 = ABCO-PIPO White fir-ponderosa pine	CWC241	DF	84	930	C	Aztet and Wheeler (1984)
457 = ABCO-PIBR/VAME White fir-Brewer spruce/thin-leaved huckleberry	CWC521	DF	57	899	H	Aztet and Wheeler (1984)
458 = ABCO-PIBR/GAOV White fir-Brewer spruce/slender salal	CWC522	DF	95	874	H	Aztet and Wheeler (1984)
459 = ABCO-PIBR/CHUM White fir-Brewer spruce/western prince's-pine	CWC523	DF	69	335	C	Aztet and Wheeler (1984)
460 = ABCO-CHLA White fir-Port Orford cedar	CWC611	DF	99	1399	H	Aztet and Wheeler (1984)
461 = ABCO-CHLA/DEPAUPERATE White fir-Port Orford cedar/depauperate	CWC612	DF	99	1399	H	Aztet and Wheeler (1984)

FVS Sequence Number = Plant Association Description	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
462 = ABCO-ABMAS/RIBES White fir-Shasta red fir/currant	CWC721	WF	77	665	C	Aztet and Wheeler (1984)
463 = ABCO-ABMAS/ROGY White fir-Shasta red fir/baldhip rose	CWC722	DF	89	1349	H	Aztet and Wheeler (1984)
464 = ABCO-ABMAS/SYMO White fir-Shasta red fir/creeping snowberry	CWC723	DF	81	945	C	Aztet and Wheeler (1984)
465 = ABCO-TABR White fir-Pacific yew	CWC811	DF	96	695	C	Aztet and Wheeler (1984)
466 = ABCO-CHNO White fir-Alaska cedar	CWC911	WF	65	1641	H	Aztet and Wheeler (1984)
467 = ABCO/HERB White fir/herb	CWF911	DF	89	670	C	Aztet and Wheeler (1984)
468 = ABCO-LIDE3 White fir-tanoak	CWH312	DF	93	815	C	Aztet and Wheeler (1984)
469 = ABCO-ACGL White fir-Rocky Mountain maple	CWH413	DF	108	654	H	Aztet and Wheeler (1984)
470 = ABCO-QUSA/CHUM White fir-Sadler oak/western prince's-pine	CWH511	DF	93	1337	H	Aztet and Wheeler (1984)
471 = ABCO-QUSA/BENE-PAMY White-fir Sadler oak/dwarf Oregongrape-Oregon boxwood	CWH521	DF	96	470	C	Aztet and Wheeler (1984)
472 = ABCO-QUSA/BENE White fir-Sadler oak/dwarf Oregongrape	CWH522	DF	105	560	C	Aztet and Wheeler (1984)
473 = ABCO-QUSA-CACH White fir-Sadler oak-golden chinquapin	CWH531	DF	94	810	C	Aztet and Wheeler (1984)
474 = ABCO/SYMO White fir/creeping snowberry	CWS331	DF	92	695	C	Aztet and Wheeler (1984)
475 = ABCO/BENE White fir/dwarf Oregongrape	CWS523	DF	101	900	C	Aztet and Wheeler (1984)
476 = LIDE3-SESE2 Tanoak-coast redwood	HTC111	DF	125	820	C	Aztet and Wheeler (1984)
477 = LIDE3-TSHE Tanoak-western hemlock	HTC211	DF	103	870	C	Aztet and Wheeler (1984)
478 = LIDE3-CHLA Tanoak-Port Orford cedar	HTC311	DF	98	890	C	Aztet and Wheeler (1984)
479 = LIDE3-ABCO-ACCI Tanoak-white fir-vine maple	HTC411	DF	90	865	C	Aztet and Wheeler (1984)
480 = LIDE3-ABCO Tanoak-white fir	HTC412	DF	99	970	C	Aztet and Wheeler (1984)
481 = LIDE3-QUCH Tanoak-canyon live oak	HTH111	DF	96	735	C	Aztet and Wheeler (1984)
482 = LIDE3-QUCH/BENE Tanoak-canyon live oak/dwarf Oregongrape	HTH112	DF	83	650	C	Aztet and Wheeler (1984)
483 = LIDE3-UMCA Tanoak-California laurel	HTH211	DF	110	810	C	Aztet and Wheeler (1984)
484 = LIDE3-ACCI Tanoak-vine maple	HTH311	DF	104	595	C	Aztet and Wheeler (1984)
485 = LIDE3/VAOV2-GASH Tanoak/evergreen huckleberry-salal	HTS111	DF	107	910	C	Aztet and Wheeler (1984)
486 = LIDE3/VAOV2 Tanoak/evergreen huckleberry	HTS112	DF	116	915	C	Aztet and Wheeler (1984)
487 = LIDE3/RHMA Tanoak/Pacific rhododendron	HTS221	DF	111	830	C	Aztet and Wheeler (1984)
488 = LIDE3/RHMA-VAOV2 Tanoak/Pacific rhododendron-evergreen huckleberry	HTS222	DF	93	815	C	Aztet and Wheeler (1984)
489 = LIDE3/RHMA-GASH Tanoak/Pacific rhododendron-salal	HTS223	DF	68	840	C	Aztet and Wheeler (1984)
490 = LIDE3/BENE Tanoak/dwarf Oregongrape	HTS311	DF	95	805	C	Aztet and Wheeler (1984)
491 = LIDE3/BENE-RHDI Tanoak/dwarf Oregongrape-poison oak	HTS312	DF	96	785	C	Aztet and Wheeler (1984)

FVS Sequence Number = Plant Association Description	Alpha Code	Site Species	Site Index*	Max. SDI*	Source*	Reference
492 = LIDE3/GASH Tanoak/salal	HTS321	DF	102	970	C	Aztet and Wheeler (1984)
493 = LIDE3/GASH-RHMA Tanoak/salal-Pacific rhododendron	HTS331	DF	90	610	C	Aztet and Wheeler (1984)
494 = LIDE3/GASH-BENE Tanoak/salal-dwarf Oregongrape	HTS341	DF	109	935	C	Aztet and Wheeler (1984)
495 = LIDE3/RHDI-LOHI Tanoak/poison oak-hairy honeysuckle	HTS411	DF	79	730	C	Aztet and Wheeler (1984)
496 = LIDE3/RHCA Tanoak/California coffeeberry	HTS511	DF	50	450	C	Aztet and Wheeler (1984)

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