10320
Mediterranean California Red Fir Forest

BpS Model/Description Version: Aug. 2020

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Vegetation Type
Forest and Woodland

Map Zones
2, 3, 7

Geographic Range
This model also covers the portion of map zone (MZ) 7 that falls within the Klamath and West Cascade ecoregions, and the portions of MZ05 and MZ06 that fall within the Klamath ecoregion.

Occurs from Diamond Lake Oregon south through the Cascade and Klamath mountains and into the Sierra Nevada, extending to about Sunday Peak in northern Kern County. An arm also extends south through the Coast Range to Snow Mountain in Lake County (Potter et al. 1992). This particular model and description applies within the Klamath Mountains, West Cascades, and California North Coast ecoregions.

Biophysical Site Description
Occurs in the upper montane zone at elevations ranging from 4,500-7000ft (1,800-2,100m) in northern California and southern Oregon, and at 7,900-9,200ft (2,400-2,800m) in southern California in cool, moist to cold, moist microclimates. Precipitation ranges from 30-70in (76-175cm), primarily as snowfall. Geology is highly variable. Soils are typically deep and well drained. This type is more dominant in the Southern Cascades of California and the northern Sierra Nevada. Fuels are relatively continuous.

Vegetation Description
These forests are dominated by *Abies magnifica* var. *magnifica* (California red fir), *Abies magnifica* var. *shastensis* (Shasta red fir), and/or *Abies procera*. Shasta red fir is found from about Crane Prairie Reservoir in Deschutes County, Oregon, southward to between Mt. Shasta and Mt. Lassen, where California red fir begins and extends southward. *A. concolor* can co-dominate, especially at warmer and lower sites of the Coast Range and Sierra Nevada. *P. monticola* can be dominant or co-dominant in some areas. *Pinus jeffreyi* (in California), *P. contorta*, and *Tsuga mertensiana* can also be present in lesser amounts. *Calocedrus decurrens* and *Pinus attenuata* are occasional.

Shrubs and herbs contribute <30% cover each, but more in the southern end of its range (MZ03). If shrub cover is higher, the shrubs are short or prostrate. Common understory species include *Arctostaphylos nevadensis*, *Quercus vacciniifolia*, *Ribes viscosissimum*, *Chrysolepis*

sempervirens, *Ceanothus cordulatus* (in seral stands), *Vaccinium membranaceum*, *Symphoricarpos mollis*, *Symphoricarpos rotundifolius*, and *Xerophyllum tenax*. Characteristic forbs include *Eucephalus breweri*, *Pedicularis semibarbata*, and *Hieracium albiflorum*.

Southwest Oregon Plant Association Groups (SWOPAG, Atzet et al. 1996) included in this type are:

SWOPAG	Blue Book Plant Association	P/A Blue Book PAG Name
2101	ABMAS-ABCO/SYMO/CHUM	Shasta Red Fir - Cascade Province
2101	ABMAS-PICO/ARNE/CHUM	Shasta Red Fir - Cascade Province
2101	ABMAS-TSME/ARNE/CHUM	Shasta Red Fir - Cascade Province
2101	ABMAS/PAMY/PYSE	Shasta Red Fir - Cascade Province
2101	ABMAS/VAME/CHUM	Shasta Red Fir - Cascade Province
2103	ABMAS-ABCO/QUSA2/CHUM	Shasta Red Fir - Siskiyou Province
2103	ABMAS-ABCO/QUSA2/PYSE	Shasta Red Fir - Siskiyou Province
2103	ABMAS-ABCO/ROGY/PYSE	Shasta Red Fir - Siskiyou Province
2103	ABMAS/OSCH	Shasta Red Fir - Siskiyou Province
1701	PIMO3/XETE	Western White Pine - SWO

BpS Dominant and Indicator Species

Symbol	Scientific Name	Common Name
ABMA	*Abies magnifica*	California red fir
ABMAS	*Abies magnifica var. shastensis*	Shasta red fir
ABCO	*Abies concolor*	White fir
PIJE	*Pinus jeffreyi*	Jeffrey pine
PICO	*Pinus contorta*	Lodgepole pine
PIMO3	*Pinus Monticola*	Western white pine

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

Fire was a key disturbance shaping red fir forests -- primarily fire regime groups I and III. Most fires occur during the late season, during tree dormancy, likely due to heavy and late melting snowpacks that preclude fires from spring and early summer. Fire complexity is moderate to high, and fire size averages ~400ac. It is very difficult to determine the replacement fire return interval (FRI) in this type. Replacement fire likely varies with slope position (upper slope > mid slope > lower slope), and landscapes with greater topography are likely to experience more stand-replacement fires. Mixed-regime fire is common.

A considerable range of fire frequency values has been reported in the sample of literature that follows. Skinner and Taylor (2006) caution that FRIs based solely on sampling visibly fire-scarred trees may underestimate fire frequency. For example, in red fir-white fir stands, Taylor and Halpern (1991) calculated a 41- to 42-yr FRI from sampling primarily visible cat faces whereas Taylor (1993), sampling in an adjacent stand from cut stumps, calculated FRIs from 18.6-26.3yrs.

- In their summary of pre-settlement fire regimes for California, Van de Water and Safford (2011) report a mean FRI of 40yrs and a median FRI of 33yrs, and a range of 15-130yrs for red fir based on review of 29 studies.

- In the Klamath Mountains of northern California, Skinner (2003) reported a composite (of all fires at the site scale in each basin) mean FRI of 23.0yrs (range, 2-122yrs) and 14.4yrs (range, 1-118yrs) at the Crater Creek and Mumbo Basin collections sites, respectively, each of which had fire-scarred red fir trees. The longest interval between fires at Crater Creek was 47yrs; at Mumbo Basin, it was 43yrs. Most fires occurred during the dormant season and were of low to moderate intensity.

- In the Thousand Lakes Wilderness, California, Bekker and Taylor (2001) calculated fire intervals based on predicted fire extent. They reported pre-settlement (before 1850) mean composite FRIs of 23.0yrs and 33.5yrs for red fir-white fir and red fir-mountain hemlock sites, respectively. They found that high- and moderate-severity fires burned more area than low-severity fires and that fires occurred most often during the dormant season.

- In Lassen National Park, California, Taylor (2000) reported a pre-settlement (before 1850) mean composite FRI of 15.3yrs for red fir-western white pine forest sites. They found that 98% of fires occurred during the dormant season.

- In the Caribou Wilderness, California, Taylor and Solem (2001) reported mean FRIs of 41-66yrs for lodgepole pine-red fir, red fir-western white pine, and red fir-white fir forest compositional groups prior to 1930. Most plots burned with moderate fire severity. For the red fir-white fir group plots specifically, they reported 43% low-severity, 44% moderate-severity, and 13% high-severity fire.

- In the Swain Mountain Experimental Forest, Taylor (1993) reported average fire-free intervals of 18.6yrs and 15.7yrs for two 3.0-ha plots, and 12.9yrs (range, 1-57yrs) for the entire 400-ha study area. Based on Taylor's "near-plot" fire scar data (Table 3), a mean FRI of 14yrs (range, 3-81yrs) was calculated from 1740-1945. Taylor noted that because fires did not often scar multiple trees, fire severity was inferred to be low.

- Taylor and Halpern (1991) reported a mean fire-free interval of 40yrs (range, 17-65yrs) and 42yrs (range, 5-65yrs) for two red fir-dominated plots in the Swain Mountain Experimental Forest in northeast California.

Fire frequency has decreased likely as a result of fire suppression in red fir-dominated forests of the Klamath and southern Cascades regions (Taylor 1993; Taylor 2000; Skinner 2003). As a result, species composition in some red fir forests have also begun to shift. In the south Cascades, for example, Bekker and Taylor (2010) documented a shift in red fir-white fir sites toward more fire-intolerant and shade-tolerant species and increasing understory density -- changes consistent with a history of fire suppression. However, this shift was more pronounced in lower elevation mixed-conifer sites in the study area. Taylor and Solem (2001) noted compositional shifts from lodgepole pine to red fir in lodgepole pine-red fir forests and from

ponderosa pine to white and red fir in red fir-white fir forests. Forest composition was stable in red fir-western white pine forests.

Other disturbances include insects, which have greatest effect on the late- and mid-closed stands. Wind-/ice storms impact mid and late stands by creating tree-size gaps that release already established individuals in the understory. Wind in this biophysical setting has greatest impact on mid-closed stands due to their low structural development. Late-closed stands have wind-resistant upper canopy, but less so in the mid canopy, and the open stands are most resistant to wind damage due to their constant exposure to it. Another part of the problem is the true fir susceptibility to disease. Flagging on the crown is common in the late-seral stages, and root disease can weaken root strength and increase susceptibility to wind events.

Fire Frequency

Severity	Avg FI	Percent of All Fires	Min FI	Max FI
Replacement	189	13	70	500
Moderate (Mixed)	58	44	20	200
Low (Surface)	58	43	10	90
All Fires	25	100		

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

Fire sizes range from 30-1,800ac, with the average being 405ac (Bekker and Taylor 2001). Extent increases with latitude. Burned landscapes in southwest Oregon, the northern end of the range, can be several thousand acres.

Adjacency or Identification Concerns

The lower elevation edge of this type mixes with mixed-conifer types, especially mixed conifer dominated by *Abies concolor*. The upper elevation mixes with white pine and mountain hemlock.

Issues or Problems

One reviewer suggested that Class B should start at a height of 5m.

Native Uncharacteristic Conditions

Proliferation of PICO or CADE27 with soil disturbance, harvest, or recreational activities. Also, canopy closures >40% and <10m in height are unusual, but may be natural *Ceanothus* stands (<5m) that occurred in large patches following severe fire. These patches would not have been more than an estimated 4% of the landscape. Taller shrubs with full canopy closure are uncharacteristic.

Lauvaux et al. (2016) suggest that climate changes that are likely to increase fire frequency and severity may lead to more areas of chaparral dominance in the landscape in the future where, historically, chaparral was interspersed with mixed-conifer forest. They conclude that “if the decades needed for trees to re-establish from seeds from forest at the chaparral edges exceed the new fire return interval, chaparral may emerge as an alternative stable state to forest.”

Comments

During the 2016 model review, Kerry Metlen and Kori Blankenship made changes to the state-and-transition model, and Carl Skinner reviewed the description document. Kori Blankenship revised the description based on review comments, literature, and NatureServe Ecological Systems description.

The fire frequency was changed during the 2016 review based on these assumptions:

- Reported fire frequencies from the Klamath Mountains and the southern Cascades (e.g., Skinner [2003] reported mean FRIs of 23yrs and 14yrs, respectively, with a range of 1-122yrs, and Taylor [1993] reported a mean FRI of 14yrs and a range of 3–81yrs) seem to be slightly shorter that the estimated mean FRI of 40yrs for California (Van de Water and Safford 2011). Therefore, in this model a mean FRI of about 30yrs was targeted.
- Taylor and Solem (2001) reported these fire severity proportions: 43% low-, 44% mixed-, and 13% high-severity fire. Skinner (2003) suggests that the proportion of high-severity fire could be lower in the Klamath Mountains, but the difference could be largely driven by topography, with steeper gradients breaking up fires that on the broad slopes of the southern Cascades develop into moving crown fires. Although this model covers both the southern Cascades and the Klamath Mountains, more red fir was mapped by LANDFIRE in the southern Cascades, so the Taylor and Solem (2001) severity proportions were targeted.

Reviewers commented on the differences between this type in the Sierra Nevada versus the Klamath and Cascade mountains. Safford, describing Sierra data, suggested that lower elevation red fir might have a total fire frequency closer to 30-35yrs, whereas higher elevations might see intervals in the 55-yr to 70-yr range. Also, his data show about half of the landscape composed of trees >25in, which might agree with this model's results, putting about half of the landscape >33in. Skinner stated that the Sierra Nevada has landscapes quite interrupted by rocky outcrops, etc., that limit the ability of fires to move easily over larger areas and interrupt the flow of fire that would affect the patterns of severity. In contrast, the Cascade and Klamath mountains have more connectivity with the lower elevation mixed-conifer fuel types and less inhibition of fire to move about. This could greatly affect the patterns of severity and the frequency of fires. This may be why more frequent fires are found in the northern areas compared, especially, to the central and southern Sierra Nevada.

Succession Classes

Mapping Rules

Upper Layer Lifeform	Height (m)	Canopy Cover (%)									
		0-10	11-20	21-30	31-40	41 - 50	51-60	61-70	71-80	81-90	91-100
Herb	0-0.5	A	A	A	A	A	A	A	A	A	A
Herb	0.5-1.0	A	A	A	A	A	A	A	A	A	A
Herb	>1.0	A	A	A	A	A	A	A	A	A	A
Shrub	0-0.5	A	A	A	A	A	A	A	A	A	A
Shrub	0.5-1.0	A	A	A	A	A	A	A	A	A	A
Shrub	1.0-3.0	A	A	A	A	A	A	A	A	A	A
Shrub	>3.0	A	A	A	A	A	A	A	A	A	A

Tree	0-5	A	A	A	A	A	A	A	A	A	A
Tree	5-10	A	A	A	A	A	A	A	A	A	A
Tree	10-25	C	C	C	C	B	B	B	B	B	B
Tree	25-50	C	C	C	C	B	B	B	B	B	B
Tree	>50	D	D	D	D	E	E	E	E	E	E

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

Description

Class A 13 Early Development 1 - All Structures

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ABMA	Abies magnifica	California red fir	Upper
PIMO3	Pinus Monticola	Western white pine	Upper
ABCO	Abies concolor	White fir	Mid-Upper
TSME	Tsuga mertensiana	Mountain hemlock	Mid-Upper

Description

Regeneration of *Abies magnifica* and *A. concolor* and perhaps *Pinus monticola* from seed, following a severe or stand-replacing fire. Shrub cover is variable and can be extensive and enduring during this phase, but is eventually overtopped by trees. PICO and TSME (clumps and/or fingers) can be associated in the Cascades and Klamath mountains. PILA is a less likely associate in the higher latitudes. ABMAS can be an early- or late-comer to the species mix. It thrives in full sun and can tolerate dense shade.

Maximum Tree Size Class

Sapling >4.5ft; <5" DBH

Class B 19 Mid Development 1 - Closed

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ABMA	Abies magnifica	California red fir	Upper
PIMO3	Pinus Monticola	Western white pine	Upper
ABCO	Abies concolor	White fir	Mid-Upper
TSME	Tsuga mertensiana	Mountain hemlock	Mid-Upper

Description

Mid-mature *Abies magnifica* saplings, poles, and small trees with various amounts of other species including *A. concolor* or *Pinus monticola*. PICO is an important associate in the Cascades and Klamath mountains. PICO, PIJE are not likely to come in during the post-

regeneration period if they are not established simultaneously after openings are created in the closed stand structure. Shrub cover varies.

Maximum Tree Size Class
Large 21-33" DBH

Class C 22 Mid Development 1 - Open

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ABMA	Abies magnifica	California red fir	Upper
PIMO3	Pinus Monticola	Western white pine	Upper
ABCO	Abies concolor	White fir	Mid-Upper
TSME	Tsuga mertensiana	Mountain hemlock	Mid-Upper

Description
Scattered, mid-mature *Abies magnifica* with various amounts of other species including *A. concolor* or *Pinus monticola*. Shrub cover varies.

Maximum Tree Size Class
Large 21-33" DBH

Class D 26 Late Development 1 - Open

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ABMA	Abies magnifica	California red fir	Upper
PIMO3	Pinus Monticola	Western white pine	Upper
ABCO	Abies concolor	White fir	Mid-Upper
TSME	Tsuga mertensiana	Mountain hemlock	Mid-Upper

Description
Scattered, mature *Abies magnifica*, *Abies concolor*, *Pinus monticola*, and other species.

Maximum Tree Size Class
Very Large >33" DBH

Class E 20 Late Development 1 - Closed

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ABMA	Abies magnifica	California red fir	Upper
PIMO3	Pinus Monticola	Western white pine	Upper
ABCO	Abies concolor	White fir	Mid-Upper
TSME	Tsuga mertensiana	Mountain hemlock	Mid-Upper

Description
Mature *Abies magnifica* dominates in pure to mixed stands. *A. concolor*, *Pinus monticola*, and other species are present.

Maximum Tree Size Class
Very Large >33" DBH

Model Parameters

Deterministic Transitions

From Class	Begins at (yr)	Succeeds to	After (years)
Early1:ALL	0	Mid1:CLS	29
Mid1:OPN	30	Late1:OPN	89
Mid1:CLS	30	Late1:CLS	89
Late1:OPN	90	Late1:OPN	999
Late1:CLS	90	Late1:CLS	999

Probabilistic Transitions

Disturbance Type	Disturbance occurs In	Moves vegetation to	Disturbance Probability	Return Interval (yrs)	Reset Age to New Class Start Age After Disturbance?	Years Since Last Disturbance
Replacement Fire	Early1:ALL	Early1:ALL	0.01	100	Yes	0
Surface Fire	Early1:ALL	Early1:ALL	0.0154	65	No	0
Mixed Fire	Early1:ALL	Early1:ALL	0.025	40	No	0
Alternative Succession	Mid1:OPN	Mid1:CLS	1	1	Yes	30
Wind or Weather or Stress	Mid1:OPN	Mid1:OPN	0.005	200	No	0
Replacement Fire	Mid1:OPN	Early1:ALL	0.005	200	Yes	0
Surface Fire	Mid1:OPN	Mid1:OPN	0.0154	65	No	0
Mixed Fire	Mid1:OPN	Mid1:OPN	0.025	40	No	0
Insects or Disease	Mid1:CLS	Mid1:OPN	0.005	200	Yes	0
Replacement Fire	Mid1:CLS	Early1:ALL	0.005	200	Yes	0
Wind or Weather or Stress	Mid1:CLS	Mid1:OPN	0.01	100	Yes	0
Surface Fire	Mid1:CLS	Mid1:OPN	0.01	100	Yes	0
Surface Fire	Mid1:CLS	Mid1:CLS	0.01	100	No	0
Mixed Fire	Mid1:CLS	Mid1:OPN	0.0154	65	Yes	0
Alternative Succession	Late1:OPN	Late1:CLS	1	1	Yes	30
Wind or Weather or Stress	Late1:OPN	Late1:OPN	0.005	200	No	0
Replacement Fire	Late1:OPN	Early1:ALL	0.005	200	Yes	0

Mixed Fire	Late1:OPN	Late1:OPN	0.01	100	No	0
Surface Fire	Late1:OPN	Late1:OPN	0.0154	65	No	0
Replacement Fire	Late1:CLS	Early1:ALL	0.0033	303	Yes	0
Wind or Weather or Stress	Late1:CLS	Late1:OPN	0.007	143	Yes	0
Surface Fire	Late1:CLS	Late1:OPN	0.01	100	Yes	0
Insects or Disease	Late1:CLS	Late1:OPN	0.01	100	Yes	0
Surface Fire	Late1:CLS	Late1:CLS	0.01	100	No	0
Mixed Fire	Late1:CLS	Late1:OPN	0.0154	65	Yes	0

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