## Red Fir (RFR)

**General Information**

**Cover Type Overview**

**Red Fir (RFR)**

* Project Area: 40,419 acres / 16,357 hectares
* Project Area + Buffer: 74,053 acres / 29,968 hectares
* Crosswalks
  + EVeg: Regional Dominance Type 1 = Red Fir
  + EVeg: Regional Dominance Type 2 = Any
  + Presettlement Fire Regime Type = Red Fir
* Crosswalks for Modifiers
  + Mesic (24,627 acres)
    - BpS Model: 0610322 Mediterranean California Red Fir Forest – Southern Sierra
  + Xeric (48,492 acres)
    - BpS Model: 0610321 Mediterranean California Red Fir Forest - Cascades
  + Ultramafic (797 acres)
    - This type is created by intersecting an ultramafic geology layer with the existing vegetation layer. Where cells intersect with RFR they are assigned to the ultramafic modifier.

**Red Fir with Aspen (RFR-ASP)**

* Project Area: 77 acres / 31 hectares
* Project Area + Buffer: 85 acres / 34 hectares
* This type is created by overlaying the NRIS TERRA Inventory of Aspen on top of the EVeg layer. Where it intersects with RFR it is assigned to RFR-ASP.

**Vegetation Description**

**Red Fir (RFR)** TheRed Fir landcover type is characterized by the presence of *Abies magnifica*. Other conifer species such as *Pinus monticola, Pinus contorta* ssp. *murrayana*, *Tsuga mertensiana, Abies concolor,* and *Pinus jeffreyi* occur at varying densities (LandFire 2007a, LandFire 2007b). Mature *A. magnifica* stands are frequently monotypic, with very few other plant species in any layer. Heavy shade and a thick layer of duff tends to inhibit understory vegetation, especially in dense stands (Barrett 1988).

Stand-replacing disturbances such as lightning-caused fires, windthrows, insect outbreaks, and disease kill groups of trees (Barrett 1988). Stand structure is complex. Most current (fire-suprressed) *A. magnifica* stands that were logged in the 19th century have an even-aged structure. In contrast, current unlogged and fire-suppressed stands have an uneven-aged or irregular age structure. Lastly, presettlement stands with an active fire regime had a relatively flat age-class structure that did not fit a classic even- or uneven-aged distribution (Meyer pers. comm.). That is, frequent small-scale disturbance led to small patches of even-aged trees within the average “stand,” and most age classes in a given stand are represented by some of these small patches (Taylor and Halpern 1991). After fire, *A. magnifica* seedlings may establish in canopy gaps, especially if they are small to moderate in size. *P. contorta* ssp. *murrayana*, as well as *P. jeffreyi* and *P. monticola,* may also function as post-fire pioneer species (Meyer pers. comm., Chappell and Agee 1996).

Mature *A. magnifica* stands on productive sites are frequently monotypic, with very few other plant species in any layer. Heavy shade and a thick, compact layer of duff tends to inhibit most understory vegetation, especially in dense stands (Barrett 1998). However, there are many open or patchy stands on less productive soils that are not monotypic, but rather codominant with other tree species. These sites may have substantial shrub cover (Meyer pers. comm.).

In openings resulting from tree mortality or logging, and under open stands on poor sites, many species are possible depending on location. *Ribes*, *Arctostaphylos*, and *Ceanothus* are the most commonly found shrubs. Large shrubfields can dominate areas after severe fire, although conifers eventually will reclaim these sites. In some cases, particularly xeric sites with significant shrub cover, reforestation can be effectively delayed for decades (Laacke 1990). Other associated shrubs include, *Symphoricarpos rotundifolius, Lonicera conjugialis,* and *Quercus vaccinifolia* (Meyer pers. comm.). Associated herbaceous genera include *Carex, Lupinus, Xerophyllum, Eucephalus, Pedicularis, Gayophytum, Pyrola* and *Monardella* (Cope 1993).

* **Mesic Modifer** In addition to *A. magnifica*, mesic regions within the RFR landcover type are associated with the presence of *P. monticola* and *P. contorta* ssp. *murrayana*. *T. mertensiana* may occur on northern aspects. *A. concolor* is uncommon, except at lower elevations (LandFire 2007b).
* **Xeric Modifier** These sites often include and are occasionally codominated by *A. concolor*, *P. jeffreyi*, and *P. contorta* ssp. *marayanna*, although other conifer species (e.g. *P. lambertiana*)can also be present in lesser amounts at lower elevations. *A. concolor* is more prevalent at lower elevations. *P. jeffreyi* is more common on shallow soils or when disturbance is frequent. Shrubs and herbs generally contribute less than 30% cover each. If shrub cover is higher, the shrubs are short or prostrate (LandFire 2007a).
* **Ultramafic Modifier** Ultramafic soils, support a number of endemic plant species. Slowly growing and often stunted *P. contorta* ssp. *murrayana* and *P. jeffreyi* occur in combinations or in nearly pure open stands. Hardwoods are usually sparse, but shrubs such as *Arctostaphylos*, *Quercus*, *Rhamnus*, *Lithocarpus*, *Rhododendron,* and *Ceanothus* may occur on these sites. Often, a dramatic landscape shift occurs across abrupt discontinuities between ultramafics and other rock types. For example, regional stands of dense conifer forests are replaced by stunted and open stands of other conifers, by chaparral or even by barrens on which woody vegetation is absent (“CalVeg Zone 1” 2011).

**Red Fir with Aspen (RFR-ASP)** When *Populus tremuloides* co-occurs with RFR on the west side of the Sierran crest, it is typically found in smaller patches, often less than 2 ha (5 acres) in size. This variant is not subject to the modifiers described above because it is only found on mesic sites with deeper soils. Mature stands in which *P. tremuloides* are still dominant are usually relatively open. Average canopy closures range from 35-95%. The open nature of the stands results in substantial light penetration to the ground (Meyer pers. comm., Verner 1988).

**Distribution**

**Red Fir** This cover type occupies the elevational band from about 1900 to 2750 m (6000 to 9000 ft). It is bounded and integrades with Sierran Mixed Conifer at lower elevations. The upper elevations may grade into the Subalpine Conifer, Western White Pine, or Lodgepole Pine landcover types (Barrett 1988).

A xeric-mesic gradient was developed based on four variables: 1) aspect, 2) potential evapotranspiration, 3) topographic wetness index, and 4) soil water storage. The variables were standardized by z-score such that higher values correspond to more mesic environments. Thus, potential evapotranspiration was inverted to maintain this balance. The four variables were combined with equal weights. This final variables was split into xeric vs. mesic, with xeric occupying the negative end of the range up to ¼ standard deviation below the mean (zero) and mesic occupying the remaining portion of the spectrum.

* **Mesic Modifer** These sites generally receive more moisture, either from precipitation, by virtue of being positioned on middle or lower slopes or drainage bottoms, or both. They may be adjacent ot meadows or riparian areas. They are found at the highest elevations and north-facing aspects.
* **Xeric Modifier** These sites are typically drier and tend to occupy the lower portion of the RFR zone. They are also more likely to exist on south-facing aspects and steeper slopes.
* **Ultramafic Modifier** Ultramafics have been mapped at various spatial densities throughout the elevational range of the Red Fir landcover type. Low to moderate elevations in ultramafic and serpentinized areas often produce soils low in essential minerals such as calcium and magnesium or have excessive accumulations of heavy metals such as nickel and chromium. These sites vary widely in the degree of serpentization and effects on their overlying plant communities (“CalVeg Zone 1”). Note, the terms “ultramafic rock” and “serpentine” are broad terms used to describe a number of different but related rock types, including serpentinite, peridotite, dunite, pyroxenite, talc and soapstone, among others (O’Geen et al. 2007).

**Red Fir with Aspen** Sites supporting *P. tremuloides* are associated with added soil moisture, i.e., azonal wet sites. These sites are found throughout the RFR zone, often close to streams and lakes. Other sites include meadow edges, rock reservoirs, springs and seeps. Terrain can be simple to complex. At lower elevations, topographic conditions for this type tends toward positions resulting in relatively colder, wetter conditions within the prevailing climate, e.g., ravines, north slopes, wet depressions, etc. (LandFire 2007c). In general, these sites lie on lower slope positions, and are associated with slopes under 25% (Potter 1998).

**Disturbances**

**Wildfire**

**Red Fir** Fires in high-elevation *A. magnifica* forests are generally not as intense as those in the Rocky Mountains and are typically less intense than those at lower elevations. Lesser annual fuel accumulation, less severe fire weather conditions, and compact and patchy fuels are all factors (Meyer pers. comm.). Still, fire has an important role in maintaining species diversity within *A. magnifica* forests. Fire creates canopy openings by killing mature pioneer species such as *P. contorta* ssp. *murrayana* or *P. jeffreyi* and some mature *A. magnifica*. Where these pioneering types occurs under an *A. magnifica* canopy, they will not outcompete it over the long term (Cope 1993).

Data on fire return intervals (FRIs) are available from a few review papers. Skinner and Chang (1996) aggregated FRIs from the Sierra Nevada and separated pre-1850 data from overall data. Van de Water and Safford’s 2011 review paper aggregates hundreds of articles, conference proceedings, and LandFire data on fire return intervals, with an emphasis on Californian sources. Meyer’s Red Fir NRV assessment aggregated FRI data from multiple studies (2013). We also include here data from the pertinent individual LandFire BpS models (2007a, 2007b, 2007c, 2007d, 2007e).

The estimated fire frequency ranges from 10 to 65 years. Fires are usually patchy and of low severity. Stand-replacing fires are uncommon (Cope 1993). Van de Water and Safford (2011) calculated mean fire return interval of 40 years, with a median of 33, mean minimum of 15, and mean maximum of 130. Meyer (2013) reports a mean FRI of 51 years in the Southern Cascades/Northern Sierra and 33 years in the Southern & Central Sierra. Mid-elevation red fir (most likely to be monotypic) were found to have a mean FRI of 48 years, median of 16 years, min of 5 years, and max of 49 years (2013). These numbers are applicable to all *A. magnifica* types. Skinner and Chang (1996) found median FRIs ranging from 16-20 years, minimums of 7-8 years, and a maximum of 35 years for red fir forests in the southern Cascades. The LandFire zone 7 model for Mediterranean California Red Fir Forest (2007d) estimated fire intervals of 140 years for replacement fire, 90 years for mixed fire, and 50 years for surface fire, with an overall interval of 26 years. We recalculated these numbers using condition-specific information and using only high and low mortality fire categories, which resulted in a mean FRI of 140 years for high mortality fire, 36 years for low mortality fire, and 29 years for any fire.

The LandFire models for red fir forest in zone 6 did not include any stage-by-stage information on return intervals for any type of disturbance, or information on succession transitions without disturbance. The BPS model for zone 6 was split into 2 parts reflecting the northern and southern Sierra. The “parent” model was not included in the overall package. However, in zone 7, which abuts zone 6 to the north, the “parent” model is available (LandFire 2007d). Since many of these models were constructed or reviewed by similar people, for now I am using the numbers from zone 7. I used the proportion of land per stage from the zone 6 model. We can adjust them as per the input of our own experts. It should also be noted that the zone 7 model itself was originally derived from the zone 3 model for a similar vegetation assemblage.

* **Mesic Modifier** For red fir-white pine forests in the southern Cascades, Skinner and Chang (1996) reported a median FRI of 57 years, with a minimum of 14 years, and a maximum of 109 years. Meyer (2013) reports median FRIs as low as 27 and as high as 76. The mean FRI for high-elevation red fir is 83 years, median is 66 years, min is 18 years and max is 78 years (2013). The LandFire model for Mediterranean California Red Fir Forest – Southern Sierra estimated fire intervals of 300 years for replacement fire, 320 years for mixed fire, and 80 years for surface fire, with an overall interval of 53 years (2007b). We recalculated these numbers using condition-specific information and using only high and low mortality fire categories, which resulted in a mean FRI of 150 years for high mortality fire, 32 years for low mortality fire, and 26 years for any fire.
* **Xeric Modifier** For red fir-white fir forests in the central Sierra, Skinner and Chang (1996) reported a median FRI of 11 years, with a minimum of 5 years, and a maximum of 69 years. Meyer (2013) reports median FRIs as low as 8 years and as high as 24 years. The mean FRI for low-elevation red fir is 27 years, median is 14 years, min is 7 years, and max is 61 years (2013). The LandFire model for Mediterranean California Red Fir Forest – Cascades estimated fire intervals of 150 years for replacement fire, 180 years for mixed fire, and 60 years for surface fire, with an overall interval of 35 years (2007a). We recalculated these numbers using condition-specific information and using only high and low mortality fire categories, which resulted in a mean FRI of 140 years for high mortality fire, 36 years for low mortality fire, and 29 years for any fire.
* **Ultramafic Modifier** Skinner and Chang (1996) reported fire intervals for *P. jeffreyi* in the Klamath Mountains. They found a median FRI of 13 years, with a minimum of 4 and a maximum of 157. This is a surprisingly short FRI, but these results are consistent with the general consensus that fire intervals on ultramafic sites are somewhat longer (due to lower productivity) and more variable than on adjacent non-ultramafic sites. Van de Water and Safford (2011) predict the same fire intervals on ultramafic sites as described above for mesic sites. The LandFire model for Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland (2007e) gave an overall mean FRI of 10 years, which is likely too short. Most fires are predicted to be low mortality surface fires occurring frequently, about every 12 years ranging from 3-35 years. High mortality fires were modeled to recur between 100 and 400 years, with a mean FRI of 250 years. We recalculated these numbers using condition-specific information, and using only high and low mortality fire categories. This resulted in a mean FRI of 50 years for high mortality fire, 11 years for low mortality fire, and 9 years for any fire. Safford (pers. comm. 2013) suggested that the value for mean high mortality FRI was too low; in the table below mean FRI for high mortality fire is 180 years. Safford (pers. comm. 2013) suggested that these values were too low; in the table below mean FRI for high mortality fire is 250 years, mean FRI for low mortality fire is 40 years, mean FRI for all fires is 30 years, and the relative proportion of high mortality to low mortality fire assigned to 5:95.

**Red Fir with Aspen** Sites supporting *P. tremuloides* are maintained by stand-replacing disturbances that allow regeneration from below-ground suckers. Upland clones are impaired or suppressed by conifer ingrowth and overtopping and intensive grazing that inhibits growth. In a reference condition scenario, a few stands will advance toward conifer dominance, but in the current landscape scenario where fire has been reduced from reference conditions there are many more conifer-dominated mixed aspen stands (LandFire 2007c, Verner 1988).

Van de Water and Safford (2011) found a mean fire return interval of 19 years, median of 20 years, mean min interval of 10 years and mean max of 90 years. The LandFire model for northern Sierra Nevada aspen that is seral to conifers predicts a mean FRI of 37 years. Replacement FRI has a mean of 150 years with a range of 50-300 years, while mixed severity FRI is 250 years, and low severity fire FRI is 60 years (2007c). We reconceptualized the successional stages and converted fire activity to high and low mortality categories, which resulted in a mean FRI of 92 years for high mortality fire, 91 years for low mortality fire, and 46 years for any fire.

Table 1. Fire return intervals (years) and percentage of high versus low mortality fires in relation to soil type modifier and the presence of *Populus tremuloides*. Numbers for RFR on mesic sites were derived from BpS model 0610322 (2007b) and Skinner and Chang (1996). Numbers for RFR on xeric sites were derived from BpS model 0610321 (2007aand Skinner and Chang (1996). Numbers for RFR on ultramafic sites were derived from BpS model 0710220. Numbers for RFR-ASP were derived from BpS model 0610610 (2007c) and Safford (pers. comm. 2013).

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| --- | --- | --- | --- | --- | --- | --- |
| **Variant** | **Modifier** | **Fire Mortality** | **Mean** | **Min** | **Max** | **% of Fires** |
| RFR | Mesic | High | 209 | – | – | 13 |
| Low | 32 | – | – | 87 |
| All Fires | 28 | 14 | 109 | 100 |
| Xeric | High | 180 | – | – | 17 |
| Low | 36 | – | – | 83 |
| All Fires | 30 | 5 | 69 | 100 |
| Ultramafic | High | 50 | – | – | 18 |
| Low | 11 | – | – | 82 |
| All Fires | 9 | 4 | 157 | 100 |
| RFR-ASP | n/a | High | 92 | – | – | 50 |
| Low | 91 | – | – | 50 |
| All Fires | 46 | 20 | 200 | 100 |

**Other Disturbance**

Other disturbances are not currently modeled, but may, depending on the condition affected and mortality levels, reset patches to early development, maintain existing condition classes, or shift/accelerate succession to a more open condition.

**Vegetation Condition Classes**

We recognize five separate condition classes for RFR and RFR-ASP. The condition classes described below are based on the classes described in the pertinent LandFire Biophysical Setting model descriptions, which in turn were based on a “5-box” state and transition models describing major successional stages related to fire regime condition classification. According to the Fire Regime Condition Class guidebook, up to five successional classes may be utilized to describe age, size, canopy cover, and vegetation composition, ranging from early seral (post-disturbance) to late seral (such as old growth) (Barrett et al. 2010).

The RFR variant is assigned to five separate condition classes: Early Development (ED), Mid Development Open (MDO), Mid Development Closed (MDC), Late Development Open (LDO, and Late Development Closed (LDC). The RFR-ASP variant is also assigned to five condition classes: Early Development – Aspen (ED-A), Mid Development – Aspen (MD-A), Mid Development – Aspen with Conifer (MD-AC), Late Development Closed (LDC), and Late Development – Conifer with Aspen (LD-CA).

**Red Fir Variant**

**Early Development (ED)**

**Description** This condition is characterized by the recruitment of a new cohort of early successional, shade-intolerant tree species into an open area created by a stand-replacing disturbance. Conifer associates regenerate from seed. Occasionally, large brush fields may develop after hot wildfires and are dominated by *Ceanothus*, *Arctostaphylos*, *Chrysolepsis*, or other shrub species for many years (Barrett 1988). On mesic sites, *P. monticola* and *P. contorta* ssp. *murrayana* regenerate from seed. *A. magnifica* comes in over time. Shrub cover is an important component; herb cover varies (LandFire 2007b). On xeric sites, there is regeneration of *A. magnifica* and *A. concolor*, perhaps *P. jeffreyi* or *P. lambertiana* from seed. Shrub and herb cover varies. (LandFire 2007a). Ultramafic sites will have similar species composition, especially at edges, but *P. jeffreyi*, are relatively more common. Shrubs and herbs are sparse (O’Geen et al. 2007).

##### **Succession Transition**

* **Mesic Modifier** In the absence of disturbance, this condition will begin transitioning to MDC at age 30 at a rate of 0.6 per timestep. After 70 years, all stands will have succeeded to MDC.
* **Xeric Modifier** Transition to mid development conditions may be somewhat delayed. In the absence of disturbance, this condition will begin transitioning to MDO after 50 years and may be delayed in the ED condition class for as long as 150 years. A stand in this condition succeeds at a rate of 0.3 per timestep.
* **Ultramafic Modifier** Transition to mid development conditions may be substantially delayed. Thus, in the absence of disturbance, this condition class will begin transitioning to MDO after 80 years and may be delayed in the ED condition for as long as 150 years. A stand in this condition class succeeds at a rate of 0.2 per timestep.

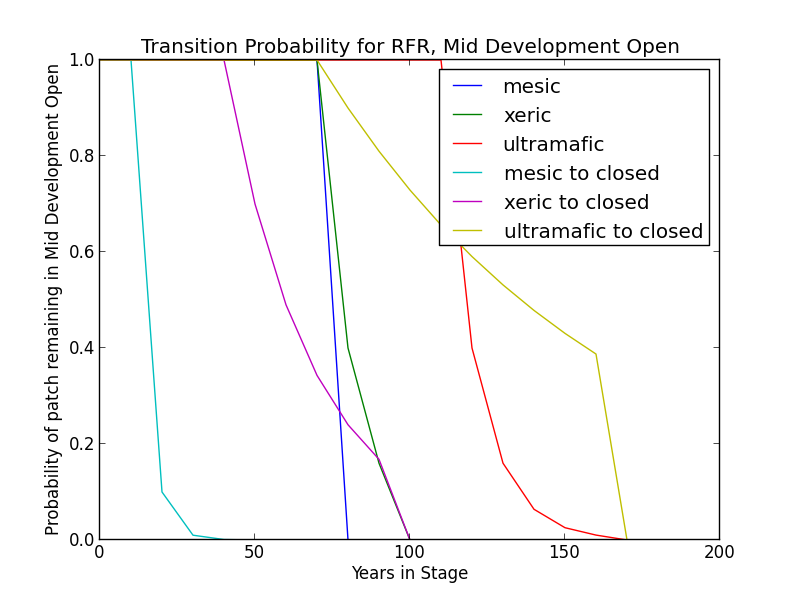
**Wildfire Transition** High mortality wildfire (100% of fires in this condition) recycles the condition through the Early Development condition class, regardless of soil type. Low mortality wildfire is not modeled for this condition class.

**Mid Development - Open (MDO)**

**Description** The pole/medium tree condition class produces dense stands of young red fir that grow slowly with little mortality for many years (Barrett 1988). Cover of grasses, forms, and shrubs is on the decline as conifer canopy cover ranges from 10-40%. *A. magnifica* either is or is transitioning to become the dominant tree species. Canopy cover is less than 40% (LandFire 2007a, LandFire 2007b).

On mesic sites, *P. monticola* and *P. contorta* ssp. *murrayana* are present in varying amounts. Grasses, forbs, and shrubs are declining, although chaparral type shrubs, such as *Arctostaphylos* or *Chrysolepsis* can contribute to a dense understory. On xeric sites, *A. concolor* and *P. jeffreyi* are present in varying amounts, and shrub cover varies (LandFire 2007a, LandFire 2007b). Ultramafic sites will have similar species composition, especially at edges, but *P. jeffreyi* is relatively more common (O’Geen et al. 2007).

**Succession Transition**

* **Mesic Modifier**  In the absence of low mortality disturbance, MDO will begin transitioning to MDC after 20 years at a rate of 0.9 per timestep. Succession to LDO takes place after 80 years since entering a middle development condition.
* **Xeric Modifier** In the absence of low mortality disturbance, MDO will begin transitioning to MDC after 50 years at a rate of 0.3 per timestep. Succession to LDO takes place variably beginning at 80 years since transition to middle development at a rate of 0.6 per timestep. All patches succeed to a late condition class by 100 years.
* **Ultramafic Modifier** In the absence of low mortality disturbance, MDO will begin transitioning to MDC after 80 years at a rate of 10%. Succession to LDO takes place variably beginning at 120 years since transition to middle development at a rate of 0.6 per timestep, and all patches succeed by 180 years.

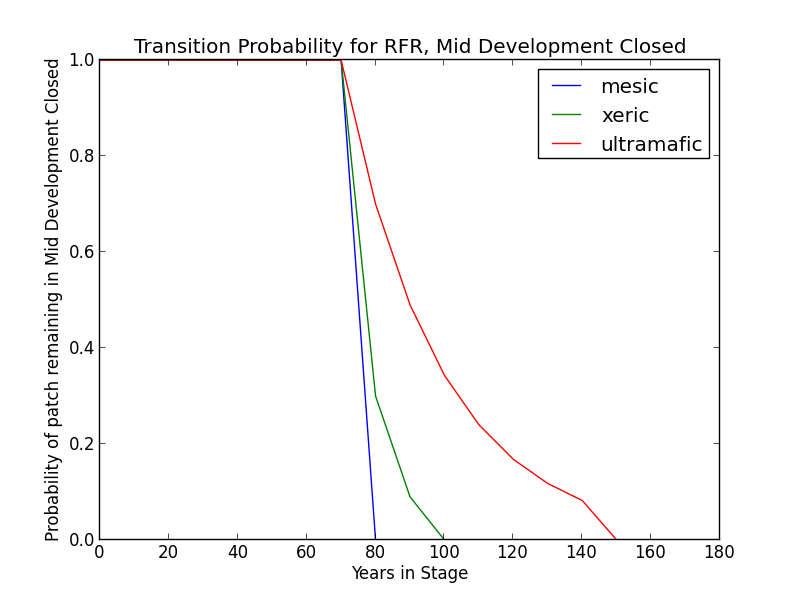
**Wildfire Transition**

* **Mesic Modifier** High mortality wildfire (7.4% of fires in this condition) returns the patch to Early Development. Low mortality fire (92.6%) maintains the MDO condition and allows for succession to LDO.
* **Xeric Modifier** High mortality wildfire (7.4% of fires in this condition) returns the patch to Early Development. Low mortality fire (92.6%) maintains the MDO condition and allows for succession to LDO.
* **Ultramafic Modifier** High mortality wildfire (5.6% of fires in this condition) returns the patch to Early Development. Low mortality fire (94.4%) maintains the MDO condition and allows for succession to LDO.

**Mid Development – Closed (MDC)**

**Description** The pole/medium tree condition class produces dense stands of young red fir that grow slowly with little mortality for many years (Barrett 1988). Cover of grasses, forms, and shrubs is on the decline as conifer canopy cover exceeds 40%. *A. magnifica* either is or is transitioning to become the dominant tree species. On mesic sites, *P. monticola* and *P. contorta* ssp. *murrayana* are present in varying amounts, while on xeric sites *P. jeffreyi* and *A. concolor* are associates (LandFire 2007a, LandFire 2007b). *P. jeffreyi* is the most likely associate on ultramafic sites (O’Geen et al. 2007).

**Succession Transition**

* **Mesic Modifier** The MDC condition persists for 80 years in the absence of fire, at which point all patches transition to LDC. Stands that transitioned to MDC from MDO transition to LDC once the time since transition to an MD conditionis at least 80 years.
* **Xeric Modifier** Transition to late seral conditions may be delayed. Thus, in the absence of disturbance, patches in this condition will begin transitioning to LDC after 80 years in MD at a rate of 0.7 per timestep and may be delayed in the MDC condition for up to 100 years.
* **Ultramafic Modifier** Transition to late seral conditions may be substantially delayed. Thus, in the absence of disturbance, patches in this condition will begin transitioning to LDC after 80 years at a rateof 0.3 per time step and may be delayed in the MDC condition for up to 150 years.

**Wildfire Transition**

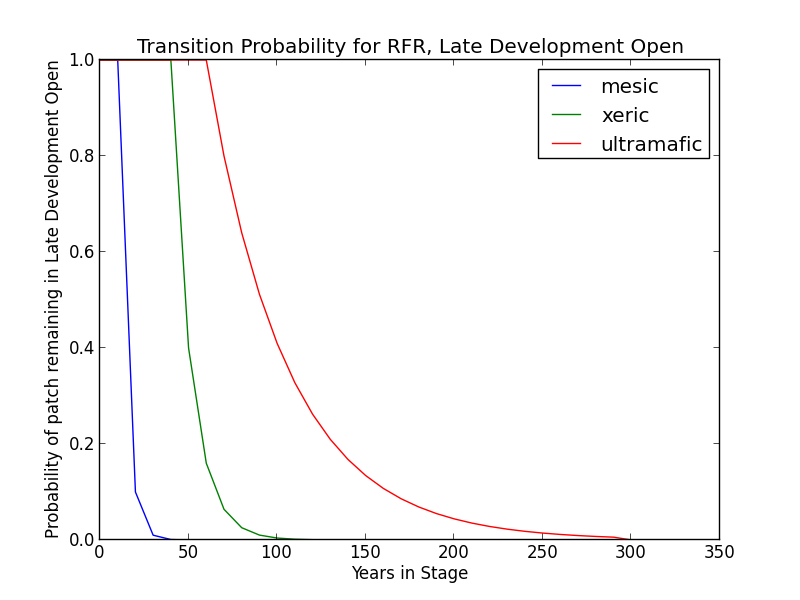
* **Mesic Modifier** High mortality wildfire (9.6% of fires in this condition) returns the patch to ED. Low mortality wildfire (90.4%) opens the stand up to MDO 66.7% of the time; otherwise, the patch remains in MDC.
* **Xeric** **Modifier** High mortality wildfire (9.6% of fires in this condition) returns the patch to ED. Low mortality wildfire (90.4%) opens the stand up to MDO 66.7% of the time; otherwise, the patch remains in MDC.
* **Ultramafic Modifier** High mortality wildfire (5.3% of fires in this condition) returns the patch to ED. Low mortality wildfire (94.7%) opens the stand up to MDO 7.4% of the time; otherwise, the patch remains in MDC.

### Late Development – Open (LDO)

##### **Description** In the large tree condition class, subdominant trees die and add to a growing layer of duff and downed woody material, and dominant trees continue to grow for several hundred years. *A. magnifica* is the most common tree species. The understory of mature stands may be limited to less than 5% cover (e.g. *Chimaphila menziesii, Pyrola picta*).This condition develops when low mortality disturbance is fairly frequent; it persists as long as low mortality fires continue to occur periodically. *Ceanothus* and *Arctostaphylos* populate disturbance-generated gaps. Canopy cover is less than 40% (LandFire 2007a, LandFire 2007b).

On mesic sites, *P. monticola* and *P. contorta* ssp. *murrayana* may comprise up to 20% of tree cover each. *P. contorta* ssp. *murrayana* acts as the pioneering conifer. On xeric sites, *A. concolor* and *P. jeffreyi* are the common associates and pioneer conifer species after disturbance (Barrett 1988, LandFire 2007a, LandFire 2007b). Ultramafic sites will have similar species composition, especially at edges, but *P. jeffreyi* is relatively more common (O’Geen et al. 2007).

##### **Succession Transition**

* **Mesic Modifier**  In the presence of low mortality disturbance, this patches in this condition can self-perpetuate, but after 20 years with no fire, patches in this condition will begin transitioning to LDC at a rate of 0.9 per timestep.
* **Xeric Modifier** Patches occurring on low productivity soils may succeed to LDC after 50 years with no fire; the rate is 0.6 per timestep.
* **Ultramafic Modifier** Patches occurring on ultramafic soils may succeed to LDC after 70 years with no fire, but the rate is just 0.2 per timestep.

##### **Wildfire Transition**

* **Mesic Modifier** High mortality wildfire (11.2% of fires in this condition) returns the patch to early development. Low mortality wildfire (88.8%) maintains LDO.
* **Xeric Modifier** High mortality wildfire (11.2% of fires in this condition) returns the patch to early development. Low mortality wildfire (88.8%) maintains LDO.
* **Ultramafic Modifier** High mortality wildfire (2.3% of fires in this condition) returns the patch to early development. Low mortality wildfire (97.7%) maintains LDO.

**Late Development – Closed (LDC)**

**Description** In the large tree condition class, subdominant trees die and add to a growing layer of duff and downed woody material, and dominant trees continue to grow for several hundred years to heights of 40 m (130 ft). Overall conifer cover exceeds 40%. *A. magnifica* is the most common tree species. The understory of mature stands is limited to less than 5 percent cover of shade tolerant forbs (e.g., *Chimaphila menziesii*, *Pyrola picta*).

On mesic sites, *P. monticola* is the primary associate, with some *P. contorta* ssp. *murrayana* occuring in the understory. On xeric sites, *A. magnifica* occurs in pure to mixed stands, and *A. concolor* and *P. jeffreyi* are the primary associates (Barrett 1988, LandFire 2007a, LandFire 2007b). Ultramafic sites will have similar species composition, especially at edges, but *P. jeffreyi* is relatively more common. (O’Geen et al. 2007)

**Succession Transition** In the absence of disturbance, this condition will maintain, regardless of soil characteristics.

**Wildfire Transition**

* **Mesic Modifier** High mortality wildfire (14.5% of fires in this condition) will return the patch to Early Development. Low mortality wildfire (85.5%) opens the stand up to LDO 50% of the time; otherwise, the patch remains in LDC.
* **Xeric Modifier** High mortality wildfire (14.5% of fires in this condition) will return the patch to Early Development. Low mortality wildfire (85.5%) opens the stand up to LDO 50% of the time; otherwise, the patch remains in LDC.
* **Ultramafic Modifier** High mortality wildfire (10% of fires in this condition) will return the patch to Early Development. Low mortality wildfire (90%) usually has little effect, although 7.4% of the time it opens the stand up to LDO.

**Aspen Variant**

**Early Development – Aspen (ED–A)**

**Description** Grasses, forbs, low shrubs, and sparse to moderate cover of tree seedlings/saplings (primarily *P. tremuloides*) with an open canopy. This condition is characterized by the recruitment of a new cohort of early successional, shade-intolerant tree species into an open area created by a stand-replacing disturbance.

Following disturbance, succession proceeds rapidly from an herbaceous layer to shrubs and trees, which invade together (Barrett 1988). *P. tremuloides* suckers over 6ft tall develop within about 10 years (LandFire 2007c).

**Succession Transition** Unless it burns, a patch in ED–A persists for 10 years, at which point it transitions to MDC-A.

**Wildfire Transition** High mortality wildfire (100% of fires in this condition) recycles the patch through the ED–A condition. Low mortality wildfire is not modeled for this condition.

**Mid Development – Aspen (MD–A)**

**Description** *P. tremuloides* trees 5-16” DBH. Canopy cover is highly variable, and can range from 40-100%. These patches range in age from 10 to 110 years. Some understory conifers, including *P. contorta* ssp. *murrayana, A. concolor*, and *A. magnifica* are encroaching, but *P. tremuloides* is still the dominant component of the stand (LandFire 2007c).

**Succession Transition** MD-A persists for at least 50 years in the absence of fire, after which stands begin transitioning to MD-AC at a rate of 0.6 per timestep. After 100 years since entering MD-A, any remaining patches transition to MD-AC.

**Wildfire** **Transition** High mortality wildfire (100% of fires in this condition) recycles the patch through the ED–A condition class. Low mortality wildfire is not modeled for this condition class.

**Mid Development – Aspen with Conifer (MD–AC)**

**Description** These stands have been protected from fire since the last stand-replacing disturbance. *P. tremuloides* trees are predominantly 16in DBH and greater. Conifers are present and overtopping the *P. tremuloides*. *A. concolor* is a typical conifer that is successional to *P. tremuloides*, and is depicted here, but other conifers including *P. ponderosa* and *P. lambertiana* are also possible. Conifers are pole to medium-sized, and conifer cover is at least 40% (LandFire 2007c).

**Succession Transition** MD-AC persists for 100 years in the absence of fire, after which stands transition to LDC.

**Wildfire Transition** High mortality wildfire (55.6% of fires in this condition) returns the patch to ED-A. Low mortality wildfire (44.4%) maintains the patch in MD–AC.

**Late Development – Closed (LDC)**

**Description** Some *P. tremuloides* continue to be present in the understory, but large conifers are now the dominant tree species, having overtopped the *P. tremuloides.* Smaller conifers are present in the midstory as well. Conifer species likely present include *A. concolor, A. magnifica,* and *P. contorta* ssp. *murrayana*. (LandFire 2007a). This condition class is analogous to the LDC condition for the RFR variant.

**Succession Transition** In the absence of disturbance, this condition will maintain, regardless of soil characteristics.

**Wildfire Transition** High mortality wildfire (9% of fires in this condition) will return the patch to ED–A. Low mortality wildfire (91%) usually has little effect, although 15% of the time it opens the stand up to LD-CA.

**Late Development – Conifer with Aspen (LD–CA)**

**Description** If stands are sufficiently protected from fire such that conifer species overtop *P. tremuloides* and become large, they may be able to withstand some fire that more sensitive *P. tremuloides* cannot. When this occurs, it creates a patch characterized by late development conifers, such as *A. concolor* or *A. magnifica*, and early seral *P. tremuloides*.

**Succession Transition** LD-CA persists for 70 years in the absence of fire, after which stands transition to LDC.

**Wildfire Transition** High mortality wildfire (20% of fires in this condition) returns the patch to ED-A. Low mortality wildfire (80%) maintains the stand in LD-CA.

**Condition Classification**

Table 2. Classification of cover condition for RFR. Diameter at Breast Height (DBH) and Cover From Above (CFA) values taken from EVeg polygons. DBH categories are: null, 0-0.9”, 1-4.9”, 5-9.9”, 10-19.9”, 20-29.9”, 30”+. CFA categories are null, 0-10%, 10-20%, … , 90-100%. Each row in the table below should be read with a boolean AND across each column of a row.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cover Condition | Overstory Tree  Diameter 1 (DBH) | Overstory Tree  Diameter 2 (DBH) | Total Tree  CFA (%) | Conifer  CFA (%) | Hardwood  CFA (%) |
| Early All | null | any | any | any | any |
| Early All | 0-4.9” | any | any | any | any |
| Mid Open | 5-19.9” | any | null | null | null |
| Mid Open | 5-19.9” | any | <40 | any | any |
| Mid Open | 5-19.9” | any | null | <40 | null |
| Mid Closed | 5-19.9” | any | >40 | any | any |
| Mid Closed | 5-19.9” | any | null | >40 | any |
| Late Closed | 20”+ | any | >40 | any | any |
| Late Closed | 20”+ | any | null | >40 | any |
| Late Open | 20”+ | any | null | null | null |
| Late Open | 20”+ | any | <40 | any | any |
| Late Open | 20”+ | any | null | <40 | null |

Methodology for assigning condition classes to RFR-ASP is still under development.

**Draft Models**

See PDF – Disturbance-Succession model for RFR and RFR-ASP

**References**

Barrett, Reginald H. “Red Fir (RFR).” *A Guide to Wildlife Habitats of California*, edited by Kenneth E. Mayer and William F. Laudenslayer. California Deparment of Fish and Game, 1988. <http://www.dfg.ca.gov/biogeodata/cwhr/pdfs/RFR.pdf>. Accessed 4 December 2012.

“CalVeg Zone 1.” Vegetation Descriptions. *Vegetation Classification and Mapping*. 11 December 2008. U.S. Forest Service. <http://www.fs.usda.gov/Internet/FSE\_DOCUMENTS/fsbdev3\_046448.pdf>. Accessed 2 April 2013.

Chappell, Christopher B. and James K. Agee. “Fire Severity and Tree Seedling Establishment in Abies Magnifica Forests, Southern Cascades, Oregon.” *Ecological Applications* 6.2 (1996): 628-640.

Cope, Amy B. “Abies magnifica.” *Fire Effects Information System*, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, 1993. <http://www.fs.fed.us/database/feis/> [Accessed 4 December 2012].

Laacke, Robert J. “California Red Fir.” Russell M. Burns and Barbara H. Honkala, tech. coords. Silvics of North America, vol 1. Conifers; Glossary. Agriculture handbook no. 654. Washington, D.C.: U.S. Dept. of Agriculture, Forest Service, 1990.

LandFire. “Biophysical Setting Models.” Biophysical Setting 0610321: Mediterranean California Red Fir Forest - Cascades. 2007a. LANDFIRE Project, U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior. <http://www.landfire.gov/national\_veg\_models\_op2.php>. Accessed 9 November 2012.

LandFire. “Biophysical Setting Models.” Biophysical Setting 0610322: Mediterranean California Red Fir Forest – Southern Sierra. 2007b. LANDFIRE Project, U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior. <http://www.landfire.gov/national\_veg\_models\_op2.php>. Accessed 9 November 2012.

LandFire. “Biophysical Setting Models.” Biophysical Setting 0610610: Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland. 2007c. LANDFIRE Project, U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior. <http://www.landfire.gov/national\_veg\_models\_op2.php>. Accessed 7 January 2013.

LandFire. “Biophysical Setting Models.” Biophysical Setting 0710320: Mediterranean California Red Fir Forest. 2007d. LANDFIRE Project, U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior. <http://www.landfire.gov/national\_veg\_models\_op2.php>. Accessed 30 November 2012.

LandFire. “Biophysical Setting Models.” Biophysical Setting 0710220: Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland. 2007e. LANDFIRE Project, U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior. <http://www.landfire.gov/national\_veg\_models\_op2.php>. Accessed 30 November 2012.

Meyer, Marc D. Personal communication, 19 June 2013.

Meyer, Marc D. “Natural Range of Variation of Red Fir Forests in the Bioregional Assessment Area” (unpublished paper, Ecology Group, Pacific Southwest Research Station, 2013).

O’Geen, Anthony T., Randy A. Dahlgren, and Daniel Sanchez-Mata. “California Soils and Examples of Ultramafic Vegetation” In *Terrestrial Vegetation of California, 3rd Edition*, edited by Michael Barbour, Todd Keeler-Wolf, and Allan A. Schoenherr, 71-106. Berkeley and Los Angeles: University of California Press, 2007.

Potter, Donald A. “Forested Communities of the Upper Montane in the Central and Southern Sierra Nevada.” Gen. Tech. Rep. PSW-GTR-169. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture, 1998.

Safford, Hugh S. Personal communication, 5 May 2013.

Skinner, Carl N. and Chi-Ru Chang. “Fire Regimes, Past and Present.” *Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options*. Davis: University of California, Centers for Water and Wildland Resources, 1996.

Taylor, XXX and XXX Halpern. (1991)

Van de Water, Kip M. and Hugh D. Safford. “A Summary of Fire Frequency Estimates for California Vegetation Before Euro-American Settlement.” *Fire Ecology* 7.3 (2011): 26-57. doi: 10.4996/fireecology.0703026.

Verner, Jared. “Aspen (ASP).” *A Guide to Wildlife Habitats of California*, edited by Kenneth E. Mayer and William F. Laudenslayer. California Deparment of Fish and Game, 1988. <http://www.dfg.ca.gov/biogeodata/cwhr/pdfs/ASP.pdf>. Accessed 4 December 2012.