**Generating FCCS fuelbeds to represent LANDFIRE disturbance pathways**

We will have close to 400 base fuelbeds to change and have decided that the most realistic and repeatable approach will be to modify fuelbed input values by using rulesets that involve percent changes. LANDFIRE maps FCCS fuelbeds by associating a fuelbed to an Existing Vegetation Type and sometimes applies different FCCS fuelbeds for a single EVT by map zone.

To create a systematic rule set for updating fuelbeds, we first classified EVTs into broad physiognomic classes (aka FCCS vegetation forms) including conifer forest, hardwood forest, mixed conifer-hardwood forest, shrubland, and grassland. *We also classified them into working groups including… Need to discuss with LANDFIRE team before finalizing…*

**Wildfire scenarios**

LANDFIRE supports three wildfire severity classes including low, moderate and high, which are compiled from Monitoring Trends in Burn Severity data on recent large wildfires. Source images are differenced Normalized Burn Ratio layers for recent large wildfires that have been classified into broad burn severity classes based on detected changes in soil and vegetation reflectance. For our application, we are assuming that severity is associated with similar levels of vegetation mortality, regardless of whether a fire occurs in fire-resistant pine forests, multi-layered mixed conifer forests, broadleaf deciduous forests or shrublands.

Although LANDFIRE often changes EVT for recently disturbed pixels, we have decided not to change species and relative cover assignments for fuelbeds. This would require specific assignments for each individual fuelbed and would make it very difficult to auto-generate fuelbeds.

Agee (1993) and Perry et al. (2015) definitions

* Low severity 0-20% mortality (10% midpoint)
* Moderate (mixed) severity 20-70% (45% midpoint)
* High severity > 70% (85% midpoint)

LANDFIRE definitions:

* Low severity: light burn over total area or patchy burn resulting in < 25% mortality of aboveground vegetation.
* Moderate severity: >25 to < 75% mortality of aboveground vegetation including mixed severity sites.
* High severity: >75% aboveground mortality including some mixed and stand-replacement sites.

Time since disturbance:

* Step 1: Immediately post disturbance
* Step 2: 2-5 years post disturbance – second growing season
* Step 3: 5-10 years post disturbance.

Because the SE and Hawaii have much faster recovery rates due to high productivity and rapid vegetation growth:

* 2: 0-3 years post disturbance
* 3: 3-10 years post disturbance

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** | **Severity** | **Time step** | **DistCode** |
| Fire | Low Severity | 1 | 111 |
|  |  | 2 | 112 |
|  |  | 3 | 113 |
| Fire | Moderate Severity | 1 | 121 |
|  |  | 2 | 122 |
|  |  | 3 | 123 |
| Fire | High Severity | 1 | 131 |
|  |  | 2 | 132 |
|  |  | 3 | 133 |

**Canopy updates (for forested fuelbeds)**

111: Low Severity Time Step 1 (immediately post fire):

* 10% of overstory and midstory trees die. Changes to the overstory and midstory canopy layers include a 10% reduction in canopy cover and density and a 10% increase in Height to Live Crown.
* Height and DBH are stand averages and are assumed to not change.
* We assume a greater proportion of understory trees die with a 20% reduction in understory tree cover and density. No changes are expected in Understory height, HLC or DBH at this severity.
* Because 10% of overstory and midstory trees died, and the fire was likely a surface fire that did not consume crowns, we assume that Class 1 Snags increase by the 10% of trees that died. This will require a recalculation of Class 1 Snag Foliage inputs including addition of 10% cover and increase in density equal to the reduction of overstory and midstory trees.
* Class 1 Snag density and percent cover increase concomitantly with tree mortality. A simple rule is to simply increase the Class 1 Snag with foliage density and percent cover by 10%.
* Height, Height to Live Crown and DBH of class 1 snags with foliage ideally would be recalculated based on weighted averages between existing snags in this category and the addition of overstory and midstory trees (note: in cases where class 1 snags with foliage were not present, then overstory and midstory tree characteristics will be input).

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* *No additional tree mortality – or we could choose to add 5% to account for delayed mortality.*
* *Move Class 1 Snags with foliage to Class 1 Snags*

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* No additional tree mortality.
* Move Class 1 Snags to Class 2 Snags.

121: Moderate Severity Time Step 1 (immediately post fire):

* 40% of overstory and midstory trees die (45% is the midpoint between the broad 20-70% class – we expect an additional 10% mortality in time step 2).
* This results in a 40% reduction in cover and density for overstory and midstory trees and a 20% increase in HLC.
* In reality, fires would likely disproportionally kill smaller-diameter trees and shorter trees and possibly increase average height and DBH. However, because these rules will serve a wide range of forest types, we are assuming no change for lack of guiding rules by forest type.
* We assume much higher mortality of understory trees with a 60% reduction in understory cover and density and 30% increase in HLC.
* For moderate severity fires, we assume that most trees died from scorch rather than crown fire, so Class 1 Snags with Foliage percent cover and density increase by the reduction in cover and density of overstory and midstory trees.

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* An additional 10% of overstory, midstory, and understory trees die. This results in another 10% reduction in cover and density for overstory, midstory, and understory trees with no increase in average HLC.
* Because 40% of overstory and midstory trees died, Class 1 Snags with Foliage increase by the 40% of trees that died. This will require a recalculation of Class 1 Snag Foliage inputs including addition of 10% cover and increase in density equal to the reduction of overstory and midstory trees. *Did not implement – too complicated.*
* In addition to the above changes, move Class 1 Snags with Foliage from Time Step 1 (DistCode 121) to Class 1 Snags without foliage.

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No additional tree mortality.
* Move Class 1 Snags with Foliage (from time step 2) to Class 1 Snags without Foliage

131: High Severity Time Step 1 (immediate post disturbance)

* 75% of overstory and midstory trees die (midpoint between 70 and 100% is 85% - expect additional 10% mortality in time step 2).
* This results in a 75% reduction in cover and density for overstory and midstory trees and a 50% increase in HLC.
* *Should we increase tree height and dbh by 10-20% to account for fires disproportionally killing smaller trees? (Didn’t implement yet)*
* We assume 95% of understory trees die with a 95% reduction in cover and density and an 80% increase in HLC.
* We assume that half of the dead trees are scorched (creating Class 1 snags with foliage) and half are burned by crown fire (creating Class 1 snags without foliage).

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* An additional 10% of overstory, midstory, and understory trees die. This results in another 10% reduction in cover and density for overstory, midstory, and understory trees with no increase in average HLC.
* Because 10% of overstory and midstory trees died, Class 1 Snags with Foliage increase by the 10% of trees that died. This will require a recalculation of Class 1 Snag Foliage inputs including addition of 10% cover and increase in density equal to the reduction of overstory and midstory trees.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No additional tree mortality.
* Move Class 1 Snags with Foliage (from time step 2) to Class 1 Snags without Foliage

**Shrub updates (for forested fuelbeds)**

For low severity fires, we assume at least 25% patch burns or 100% light intensity understory burn. For mixed severity fires, we assume at variable fire with some patchy mortality and/or 100% moderate intensity understory burn. For high severity fires, we assume the entire shrub stratum burns. The following rules should be applied to primary and secondary shrub layers (if present).

111: Low Severity Time Step 1 (immediately post fire):

* 50% reduction in shrub cover, height, and percent live.
* If an optional shrub loading is specified, reduce loading by 50%

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 25% increase shrub cover, height, percent live.
* If an optional shrub loading is specified, increase loading by 25%.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* Restore shrub inputs to pre-fire settings.

121: Moderate Severity Time Step 1 (immediately post fire):

* 75% reduction in shrub cover, height, and percent live.
* If an optional shrub loading is specified, reduce loading by 75%

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 50% increase shrub cover, height, percent live.
* If an optional shrub loading is specified, increase loading by 50%.

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* Restore shrub inputs to pre-fire settings. *We could also consider making them 50% greater to reflect more open canopy conditions.*

131: High Severity Time Step 1 (immediate post disturbance)

* 95% reduction in shrub cover, height, and percent live.
* If an optional shrub loading is specified, reduce loading by 95%

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 50% recovery of original cover and height.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* 50% greater cover than original fuelbed to reflect more open light conditions.

**Herb updates (for forested fuelbeds)**

For low severity fires, we assume at least 25% patch burns or 100% light intensity understory burn. LANDFIRE assumes little change in fire behavior fuel models for low severity fires. However, I’m interpreting an immediate reduction in herbaceous fuels and then rapid recovery in time step 2. For mixed severity fires, there is a substantial change expected in surface fire behavior in time steps 1 and 2. For high severity fires, we assume all herbaceous are burned. The following rules should be applied to primary and secondary herb layers (if present).

111: Low Severity Time Step 1 (immediately post fire):

* 50% reduction in herb cover, height, percent live and loading.

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* Restore herb inputs to pre-fire settings.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* No change.

121: Moderate Severity Time Step 1 (immediately post fire):

* 75% reduction in herb cover, height, percent live and loading.

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* Restore herb inputs to pre-fire settings. *Consider making them 50% greater than pre-fire to reflect more open canopy conditions.* (For now implemented simple scenario)

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* Restore herb inputs to pre-fire settings. *Consider making them 50% greater than pre-fire to reflect more open canopy conditions.* (For now implemented simple scenario)

131: High Severity Time Step 1 (immediate post disturbance)

* 95% reduction in herb cover, height, percent live and loading.

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 300% increase in herbaceous cover

*Note: LANDFIRE assigns a grass fuel model with 50-59% cover. DISCUSS. This assumption makes for immediately highly flammable fuelbed, which isn’t realistic in most forested fuelbeds.*

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* *No change?*

**Downed Wood updates (for forested fuelbeds)**

For low severity fires, we assume at least 25% patch burns or 100% light intensity understory burn. LANDFIRE assumes little change in fire behavior fuel models for low severity fires. However, I’m interpreting an immediate reduction in herbaceous fuels and then rapid recovery in time step 2. For mixed severity fires, there is a substantial change expected in surface fire behavior in time steps 1 and 2 with full recovery expected at time step 3. For high severity fires, we assume all surface fuels are burned.

111: Low Severity Time Step 1 (immediately post fire):

* 50% reduction in fine downed wood cover, depth and loadings (1, 10, 100hr).
* 10% reduction in coarse sound wood, rotten wood, rotten stumps and lightered-pitchy stumps.

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 25% increase in fine wood cover, depth and loadings (1, 10, 100hr).
* \* I would transfer 50% sound wood to rotten wood here.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* Restore downed wood inputs to pre-fire settings.

121: Moderate Severity Time Step 1 (immediately post fire):

* 75% reduction in fine downed wood cover, depth and loadings (1, 10, 100hr).
* 25% reduction in coarse sound wood, rotten wood, rotten stumps and lightered-pitchy stumps.

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 25% increase in fine wood cover, depth and loadings (1, 10, 100-hr).

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* Restore downed wood inputs to pre-fire settings.
* \* I would add 50% sound wood to rottn wood here.

*Note: I don’t agree with this but am following LANDFIRE assumptions for FBFMs.*

131: High Severity Time Step 1 (immediate post disturbance)

* 95% reduction in fine wood cover, depth and loadings (1, 10, 100hr).
* 50% reduction in coarse sound wood, rotten wood, rotten stumps and lightered-pitchy stumps.

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 50% increase in fine wood cover, depth and loadings (1, 10, 100hr). Assume greater accumulation due to fine wood fall from dead trees.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* 75% increase in fine wood cover, depth and loadings (1, 10, 100r).
* I would add 50% sound wood to rotten wood again.

**Pile updates (for forested fuelbeds)**

111: Low Severity Time Step 1 (immediately post fire):

* 25% reduction in pile density.

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* No change. *Assume revert to original fuelbed > 10 years.*

121: Moderate Severity Time Step 1 (immediately post fire):

* 50% reduction in pile density.

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No change.

131: High Severity Time Step 1 (immediate post disturbance)

* 75% reduction in density

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No change.

**Litter-Lichen-Moss updates**

111: Low Severity Time Step 1 (immediately post fire):

* 25% reduction in litter, lichen or moss cover and depth.
* If an optional LLM loading is specified, decrease loading by 25%

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* Restore LLM inputs to pre-fire settings.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* No change.

121: Moderate Severity Time Step 1 (immediately post fire):

* 75% reduction in litter, lichen or moss cover and depth.
* If an optional LLM loading is specified, decrease loading by 75%

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 50% increase in litter, lichen or moss cover and depth.
* If an optional LLM loading is specified, increase loading by 50%.

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* Restore LLM inputs to pre-fire settings.

131: High Severity Time Step 1 (immediate post disturbance)

* 95% reduction in litter, lichen or moss cover and depth.
* If an optional LLM loading is specified, decrease loading by 95%

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* 50% recovery in litter, lichen or moss cover and depth based on prefire values.
* If an optional LLM loading is specified, increase loading by 50%.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* 50% recovery in litter, lichen or moss cover and depth based on prefire values.

**Ground Fuel updates**

111: Low Severity Time Step 1 (immediately post fire):

* 25% reduction in upper and lower duff cover and depth.
* 25% reduction in depth and density of basal accumulations and squirrel middens.
* If an optional loading is specified, decrease loading by 25%

112: Low severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

113: Low severity Time Step 3 (5-10 years post disturbance or 3-10 years for Hawaii and SE US)

* No change.

121: Moderate Severity Time Step 1 (immediately post fire):

* 75% reduction in upper and lower duff cover and depth.
* 75% reduction in depth and density of basal accumulations and squirrel middens.
* If an optional duff loading is specified, decrease loading by 75%

122: Moderate Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

123: Moderate Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No change.

131: High Severity Time Step 1 (immediate post disturbance)

* 95% reduction in upper and lower duff cover and depth.
* 95% reduction in depth and density of basal accumulations and squirrel middens.
* If an optional duff loading is specified, decrease loading by 100%

132: High Severity Time Step 2 (2-5 years post disturbance or 0-3 years for Hawaii and SE US)

* No change.

133: High Severity Time Step 3 (5-10 years post fire or 3-10 years for Hawaii and SE US)

* No change.